VOLUME 1

South Tarawa Sanitation Improvement Project

TA-7359(KIR):

Republic of Kiribati

South Tarawa Water Supply Options Assessment Desalination Feasibility Study

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TA-7359 KIR: TARAWA SANITATION IMPROVEMENT PROJECT

SOUTH TARAWA WATER SUPPLY OPTIONS ASSESSMENT:
DESALINATION FEASIBILITY STUDY

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Acronyms

ADB	Asian Development Bank
AIDAB	Australian International Development Assistance Bureau (now AusAID)
AusAID	Australian Agency for International Development
BOQ	bill of quantities
BTC	Betio Town Council
CAD	computer aided drafting
CEO	Chief Executive Officer
CIP	clean-in-place
CO_2	carbon dioxide
DBL	design, build, lease
EA	executing agency
EARF	environment assessment and review framework
EC	electrical conductivity (units µS/cm) – a proxy for salinity of groundwater
EM34	electromagnetic surveying equipment manufactured by Geonics, used to carry out the freshwater lens surveys
EIRR	economic internal rate of return
ENSO	El Niño – Southern Oscillation
EU	European Union
GCM	global climate model
GLUP	general land use plan
GoK	Government of Kiribati
GW	groundwater
IA	implementing agency
ICI	institutional, commercial and industrial
IDA	International Desalination Association
IEE	initial environmental examination
EMP	environmental management plan
IPCC	Intergovernmental Panel on Climate Change
KAP	Kiribati Adaption Project (Phases I, II and III)
KDP	Kiribati Development Plan
MED	multiple-effect distillation
MELAD	Ministry of Environment, Lands and Agricultural Development
MFED	Ministry of Finance and Economic Development
MHMS	Ministry of Health and Medical Services
MISA	Ministry of Internal and Social Affairs
MSF	multistage distillation
NASC	National Adaption Steering Committee
NGO	nongovernment organizations
NSO	National Statistics Office
NZ	New Zealand
NZAP	New Zealand Aid Program
MPWU	Ministry of Public Works and Utilities
msl	mean sea level
mth	month
NWSCC	National Water and Sanitation Coordination Committee
PPTA	project preparation technical assistance for the Tarawa sanitation

	improvement project
PV	photovoltaic
OB	Office Te Beretitenti (Office of the President)
O&M	operations and maintenance
per	person
PIAC	Pacific Infrastructure Advisory Centre
PLC	Programmed logical controller
PPP	public private partnership
PRIF	Pacific Region Infrastructure Facility
PUB	Public Utilities Board
RO	reverse osmosis
SAPHE	sanitation, public health and environmental improvement project
SMF	sustainable maintenance fund
SOE	state owned enterprise
SOPAC	Applied Geoscience and Technology Division, Secretariat of the Pacific Community
SS	stainless steel
STSISP	South Tarawa Sanitation Improvement Sector Project
SWRO	sea water reverse osmosis
TA	technical assistance
TDS	total dissolved salts
TOR	terms of reference
TWMP	Tarawa Master Water Plan
TUC	Teinainano Urban Council
UN	United Nations
UNICEF	United Nations Children’s Fund
UPC	unit production cost
WB	World Bank
WEU	water engineering unit (within MPWU)
WHO	World Health Organization
WSSW	water, sanitation and solid waste program (Government Task Force)

Note

In this report, $ refers to Australian Dollars unless otherwise stated.

Units of Measurement

ha	hectare (= 10,000 m^2)
kL	kilolitre (= 1,000 L = 1 m^3)
kL/day	kilolitre per day (= 1 m^3/day)
km	kilometer
km^2	square kilometer
L	litre
L/day	litres per day
L/pers/day	litres per person per day (water use)
m	metre
mm	millimeter (one thousand of a metre)
m^2	square metre
m^3	cubic metre
mbgl	metres below ground level
µS/cm	measurement of electric conductivity

TA-7359 KIR: TARAWA SANITATION IMPROVEMENT PROJECT

SOUTH TARAWA WATER SUPPLY OPTIONS ASSESSMENT: DESALINATION FEASIBILITY STUDY

1. INTRODUCTION

1.1 Background

1. The draft South Tarawa Water Supply and Sanitation Roadmap 2011-2030 prepared under TA-7359 KIR finds that primary and secondary groundwater lenses for South Tarawa are at considerable risk, that water abstraction from freshwater galleries at Bonriki is 20% above the estimated sustainable capacity of the Bonriki reserves, and the Bonriki water treatment plant requires upgrading and improvement. The distribution system beyond the main transmission pipeline and service reservoirs is failing with leaks and high wastage within household systems, resulting in estimated 67% losses. Of greater concern is the growing demand for safe water supplies associated with population growth. This requires immediate provision of additional water supply for South Tarawa from 2011, in order to ensure that at least 50 litres per person per day is available to meet the needs of the community, with progressive increases to balance supply against increasing demand.

2. The situation requires an alternative source of water for South Tarawa that can be established quickly, at an affordable capital cost, and with the ability to be expanded as the population increases. The supply must also be capable of providing 24-hour pressurized service for efficient operation of the piped water system. The Roadmap identifies leak detection and control of wastage as being the first priority for addressing shortages in available water supply with any additional water supplies being conditional upon leak detection to reduce unaccounted for water to 25% or less and 20% by 2020. This work should start immediately but comments on the Roadmap have noted the approximate time scale of 3-5 years needed to achieve this goal and have stressed the view that the alternative water source is required now.

3. All tests on the urban groundwater lenses in South Tarawa have confirmed the unsuitability of water for potable uses. Increasing demand for non-potable uses and predicted population growth will eventually place the secondary lenses under pressure and compromise their ability to provide water for bathing and washing. Communities remain dependent on the lenses for these secondary uses

4. Rainwater harvesting will assist overall supplies during “wet” weather but it cannot be relied on as a continuous source of water and because of the severe ENSO-related droughts in Tarawa, the limited roof catchment areas, the rain tank volumes that can be made available economically and the large and increasing number of people per household. As more frequent and longer periods of drought are foreseen, associated with climate change, the provision of additional supplies to reduce dependency on rainwater sources is an important climate change adaptation measure.

1.2 Tarawa Water and Sanitation Roadmap 2011-2030

5. The Roadmap considered a wide range of options for future supply and a comparison of unit production costs in the Roadmap confirms seawater reverse osmosis (SWRO) or desalination as the most cost-effective water supply option, (if the SWRO modules remain in use for at least 10 years), after the present supplies from Bonriki and Bouta. SWRO is not only the most affordable supply; it is also the only available future supply of sufficient quantity to serve community needs beyond 2020. Previous water supply

projects in South Tarawa have however rejected the use of SWRO to supplement water supply because of its cost, energy consumption and complexity. Recent technological advances and development have improved operations, costs and economic life of SWRO plants.

6. The strengths of SWRO systems are that they can be installed and started quickly, are of small size and can be modularized with a relatively small land footprint, do not require lengthy negotiations with communities or excessive land resettlement or rental payments, and can be installed close to areas of most need. In addition, modular units can be added as demand increases.

7. SWRO modules can be manufactured in various combinations and installed as modular units in 20-foot containers. The Roadmap provides initially for four desalination plants consisting of multiple SWRO modules (three SWRO modules make up one desalination plant) with each desalination plant capable of producing some 528kL (m^3) of freshwater daily and the four desalination plants giving a total production of 2,112kL (m^3) daily.

8. The Roadmap suggests the desalination plants be sited in Betio (2), Bairiki (1) and Nanikai/Teaoraereke/Antemai (1). From their freshwater reservoirs, they will be connected to the existing transmission main, then the existing service reservoirs and networks. The present system on South Tarawa will be divided into service areas (zones) for efficient operation, management and loss control, with the zone in the western area of South Tarawa between Betio and Antemai being balanced to align with the capacity of the desalination plants. The remainder of South Tarawa from Antemai to Bonriki in the east will continue to be supplied from the Bonriki and Buota groundwater reserves.

1.3 SWRO - Primary Considerations

9. The Tarawa Water Master Plan[1] recommended filtering out marine organisms from the seawater by drawing the feed waters for the desalination plants from the fractured karst limestone formations underlying South Tarawa. The initial work of the desalination feasibility study agrees with this approach and it is therefore proposed that the feed waters will be drawn from boreholes sunk into the karst limestone, which will act as a natural filter for the intake waters. Seawater will be drawn from below the freshwater lens and the approach will not have an impact on the freshwater lens. The filtering action through the limestone will remove extraneous materials and as the abstraction is well below sea-level all marine organisms will either not be present or filtered out. This will overcome difficulties experienced with previous SWRO plants where marine organisms drawn into plants from shallow seawater intakes were a constant cause of blockage of the membranes. The brine discharge and backwash from the plant can be directed back to the ocean for dilution.

10. The greatest risk of the desalination option is the ability to effectively operate and maintain the plants for an economic operating life of at least 10 years and in all circumstances probably considerably longer. Five SWRO plants have been installed previously in South Tarawa and Banaba since 1999. These earlier desalination plants were introduced to address water shortages during severe droughts. Problems with maintenance and the sourcing of spare parts have limited the life of these desalination plants, yet desalination plants installed in the neighboring state of Nauru have operated successfully for over ten years. A factor in this has been the continuing involvement of the

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[1] Tarawa Water Master Plan 2011, Prof Ian White, Fenner School of Environment and Society, Australian National University

manufacturer/supplier in the maintenance of the units, especially the routine timing of the chemical washing and descaling of the membranes and the training of the plant operators.

11. In Kiribati, the inability of the Public Utilities Board to effectively operate and maintain the existing water supply system has resulted in poor service quality. The Tarawa Water and Sanitation Roadmap has proposed several operations and maintenance options for the SWRO plants with varying degrees of private sector participation, ranging from extended maintenance contracts, to build, operate and maintain arrangements that are examined in greater detail later in this feasibility study report to ensure the sustainability of the investments in SWRO and to safeguard South Tarawa's water supply.

12. Investments in SWRO also need to be accompanied with supporting reforms that promote financial sustainability of water supply operations and promote effective demand management. Without these reforms, PUB will have insufficient funds to operate and maintain the SWRO plants over time. As an interim measure, while tariff reforms are being introduced, the creation of a sustainable operations and maintenance fund may be necessary. The existing flat rate water tariff of $10/month for residential customers is not sufficient in the longer term to ensure adequate cost recovery, nor does it provide consumers with an incentive to conserve scarce water supplies. Furthermore, due to the poor quality of service, collection rates are low.

1.4 Desalination Feasibility Study

1.4.1 Compliance with Terms of Reference

13. The four proposed desalination units have been sited on available government land to avoid resettlement issues. Site selection has followed consultation with the stakeholder communities and the development of a network model using EPANET to optimize location within the distribution networks. Consultation has also taken place with a leading SWRO plant manufacturer to assess the desalination process and requirements for South Tarawa, and to discuss possible contract arrangements for the management, operations and maintenance of the SWRO modules, taking into account the associated costs and risks of different contractual arrangements.

14. Initial topographical surveys have been conducted for each site, with the preparation of process plans, preliminary site and engineering plans, profiles, cross-sections, details and an implementation schedule for the required works. These inputs have been incorporated into this feasibility study report containing initial bills of quantities and estimates of cost. Preliminary design plans have been prepared and are presented with the feasibility study report. The option of solar power as the energy source for the desalination units has also been investigated.

15. Economic and financial assessments of the proposed investment have been carried out according to ADB's Guidelines for the Economic Analysis of Projects to ensure that an economic internal rate of return of at least 12% can be achieved. The economic and financial analyses have considered the 'with" and "without" project options and have assessed the impact of operations and maintenance arrangements on the sustainability of the proposed investments, and the likely realization of associated benefits and revenues. The analyses have also looked at possible interim financing arrangements to support operations and maintenance while service improvements are being undertaken, tariff reforms are introduced, and improved collection and billing systems are put into place.

16. An environmental screening of proposed investments has been conducted according to the Environmental Assessment and Review Framework prepared for the South Tarawa

Sanitation Improvement Sector Project and ADB's Safeguards Policy Statement 2009. An initial environmental examination and an environmental management plan for the subsequent works have also been prepared.

17. The feasibility study has also assessed options and recommended measures for equitable access to water supplies in South Tarawa among low-income households who cannot afford to pay for water supply connections and/or monthly water bills and for discouraging illegal water supply connections and tampering.

18. An overall strategy for adding SWRO production to the system outlining the sequencing of complementary activities to improve the water supply in South Tarawa (leak detection, installation of meters and other required rehabilitation works), as well as an approach for undertaking water supply system improvements throughout South Tarawa, has been recommended with timing and costs. Adoption of a zonal approach for supply is advocated to the management of supplies allowing efforts to concentrate on the more critical zones that will give greatest benefit from reduced losses, and by ensuring that these zones operate property before moving on to the next zone, until the entire system is functioning.

1.4.2 Organisation and conduct of the study

19. The feasibility study report was prepared over a period of three months between early February and April 2012. Work commenced on 6 February 2012 with a visit to the Melbourne office of Veolia Water, a leading manufacturer and supplier of desalination and SWRO. The EPANET modeling of the transmission and distribution networks started on 9 February and on the same date the Team Leader John Howse and the Water Supply Engineer Geoff Mills mobilized to South Tarawa for local consultations, the identification of the desalination sites, the testing of the seawater feed waters and other tasks associated with the feasibility study design activities.

20. Son Nguyen the project CAD Specialist and Design Engineer mobilized to South Tarawa on 26 February following completion of the initial network modeling to supervise the topographical survey of the desalination plants by MELAD and complete the design for the four desalination plants with the assistance of the national water supply engineer, Taboia Metutera. During these activities the project's national community awareness specialist Dr. Temakei Tebano assisted with the consultation meetings with stakeholders and community groups. Regular meetings were convened with the Secretary of the Ministry of Public Works and Utilities and his staff, the CEO of the Public Utilities Board and Board staff and BTC and TUC to discuss the program for the feasibility study and the process for introducing desalination to South Tarawa. There is wide spread support for the study.

21. The locations of the desalination plants have been established, and the feasibility study design activities have finalized the site plans, plant layout and construction details, and estimates of cost. Financial, economic and environment assessments have also been completed. In response to comments on the Roadmap the study gave consideration to the use of solar power for the energy to power the SWRO units and the impact of such an approach on existing power station capacity and operating costs. A comparison has been made between using seawater for sewer flushing and the installation of larger SWRO units given that the larger desalination capacity, albeit at higher capital and operating costs, would avoid the need for the separate seawater flushing mains and systems.

1.4.3 Work Program

22. The program followed for the feasibility study is illustrated in Figure 1:

Figure 1: Work Program South Tarawa Desalination Feasibility Study

Item	Description Month	February				March				April				May		Desalination Feasibility Study							
	Week Commencing	6	13	20	27	5	12	19	26	2	9	17	24	1	8	JH	GM	SE	CC	SF	SN	TM /TT	FT
1.	**Water Network Modelling**		▨	▨	▨	▨	▨	▨	▨														
i.	Develop, test network model		▬	▬	▬	▬	▬	▬								○	○			●	●	○	●
ii.	Finalise network model with SWRO								▬							○	○			●	●	○	●
2.	**Establish SWRO Details & Sites**	▨	▨	▨	▨	▨																	
i.	Visit SWRO manufacturer (Melbourne)															●	●						
ii.	Establish site locations South Tarawa			▬	▬	▬										●	●						
iii.	Finalise site locations				▬											●	●			●			○
3.	**SWRO Feasibility Study**	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨										
i.	Topographical & land surveys - MELAD			▬	▬	▬										●					●	○	
ii.	Testing of seawater for quality/salinity					▬	▬	▬									●					○	
iii.	Design process and specifics of plants				▬	▬	▬	▬	▬	▬	▬					●	●				●	○	
iii.	Develop preliminary BoQ & estimates							▬															
iv.	Finalise drawings, BoQ and Estimates								▬	▬	▬	▬	▬			●	●				●	●	
v.	IEE for each plant and EMP								▬	▬	▬							●				○	
vi	Economic evaluation									▬	▬	▬	▬						●			○	
vii	Preparation of Feasibility Study Report			▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬		●	●	●	●		●		
viii	Lodgement of Feasibility Study Report													▼		●							

Notes

JH	John Howse	SN	Son Nguyen	●	Primary Involvement
GM	Geoff Mills	TM	Taboia Metutera	○	Support Role
SE	Stephen Eagle	TT	Temakei Tebano		
CC	Chris Cheatham	FT	Fraser Thomas Staff		
SF	Sean Finnigan				

1.5 Purpose of Feasibility Study

23. The methodology for the feasibility study was designed with the following outcomes in mind:

a. Provide confidence in the decisions for SWRO plants in South Tarawa;
b. Review the available technology for suitability;
c. Establish the technical requirements;
d. Establish requirements for equipment robustness and extended operating life;
e. Confirm the desalination costs and again give confidence in their accuracy;
f. Establish the sequence for installation of the desalination units;
g. Recommend the best arrangements for management and maintenance;
h. Reduce the lead time for the introduction of desalination as an additional source to augment water supplies.

2. DESALINATION IN KIRIBATI

2.1 Previous Studies

24. The possibility of desalination for South Tarawa was considered in the Tarawa Water Master Plan “Other Sources” report of 18 February 2011, where mention was made of desalination by distillation or Reverse Osmosis (RO) being long considered as the logical alternate source for freshwater supply for small islands as it is in use throughout the world in small islands where water is scarce. The report observed that reverse osmosis plants have been installed previously to produce fresh water in Tarawa and more recently Banaba, as a result of recent droughts.

25. While the Technical Assistance study preceding the ADB Sanitation, Public Health and Sanitation (SAPHE) project did not consider desalination as an option, the water supply design report for the SAPHE project (OEC, 2000) did include desalination in its assessment of the then current and the future water supply resources needed to meet demand. The report produced during the 1998 to 2001 drought made mention of the fact that three desalination plants were operating in South Tarawa at the Tungaru Central Hospital (50kL/day), at the Otintaai Hotel (50kL/day) and in Betio (100kL/day). The report recommended that a larger desalination plant of 800kL/day capacity be added to the then existing desalination plants in South Tarawa, but did not include the cost of desalination in its capital cost estimates of the water supply component of SAPHE.

26. The Tarawa Master Water Plan also makes mention of an examination of water supply options for the outer islands in Kiribati by A. Falkland in 2003 where Falkland concluded that although reverse osmosis desalination technology is proven, it has often failed in small island countries, as it requires considerable investment, trained operators, a reliable source of energy and a dependable supply of chemicals and spare parts. Falkland saw the greatest potential for reverse osmosis technology in the urban areas of Kiribati where groundwater resources are limited, demand is high and where people are likely to have a greater capacity to pay.

2.2 Kiribati Experience with Reverse Osmosis Technology

27. The previous section confirms that shortages of water throughout the 1998 to 2001 drought, led to the introduction of reverse osmosis technology in several islands including Banaba (10kL/day) and in South Tarawa at the Tungaru Central Hospital in Nawerewere (50kL/day), Otintaai Hotel in Bikenibeu (50 kL/Day) and Betio (110kL/day). The reverse osmosis system at Betio operated for 18 months from 1999 and the two smaller plants on South Tarawa as well as the unit on Banaba failed soon after installation. A private system producing local bottled water is operating at Antenon and a new reverse osmosis unit (17kL/day) has been installed on Banaba (2010).

28. All the reverse osmosis systems on South Tarawa failed through a lack of maintenance and inadequate funds for spare parts and repairs. The new plant on Banaba has also failed as a result of the failure of the membranes. Enquiries about routine and planned maintenance would indicate that the membranes had not been washed or descaled regularly through a lack of funds to purchase the chemicals. Also, while MPWU has technicians trained in the plant operations these skilled people are in South Tarawa remote for the plant and its operations. Work at the plant requires preplanning and two days’ travel either way. The private unit at Antenon has a varied history, often producing water of sub-standard quality through failure of the membranes.

29. In Tarawa the prevailing attitude has been to install the plants and operate them without maintenance or routine and/or special periodic cleaning of the membranes in the belief they will continue to operate. The SWRO units, while not complex, require a rigorous regime for routine cleansing, maintenance and care, with adequate funding for expendable items such as rated micron filters, chemicals and spare parts. These aspects, plus a lack of the full appreciation of the operating and maintenance requirements has contributed to the poor performance of the plants. Poor selection of the plants and technology employed has also been a contributing factor. Alongside this experience by the Government is the desalination plant at the Moroni High School operated and maintained by the I-Kiribati maintenance manager and maintenance staff at the school. This unit has been operating successfully for nine years and is only now approaching the point where membrane replacement has been considered.

2.3 Reverse Osmosis Desalination

30. Prevailing technical assessment confirms that of all the available desalination technologies, reverse osmosis has lower unit water costs due to lower energy demands, making it the most economical of all the desalination methods. Recent advancements in membrane technology have decreased the cost of RO desalination and increased water quality. Clogging membranes, once a major problem when treating seawater, causing reduced flows and increased operational costs and down-time is now no longer a concern. The selection of appropriate pre-treatment options for filtering will be suitable for pre treating the expected South Tarawa seawater quality is a key process design consideration. Filtration using pre-treatment membranes will also remove harmful pathogens such as Giardia, Cryptosporidium and viruses. These technological advances are leading to continued reduction in the unit production costs per kL as are energy recovery systems using the high pressure rejected brine stream.

31. The Tarawa Water Master Plan confirmed the advantages of human pathogen free water from RO desalination, the small land area footprint which minimises land rental costs, and the advantage of being able to locate the units close to areas of highest need. It suggested that two 1,000kL reverse osmosis desalination plants could be located in Betio and Bairiki with the duplication mitigating the risk of failure of a larger plant. The author, Prof Ian White, also rejected the possibility of using solar rather than fossil fuel produced electricity because of significantly increased cost, the area required for the solar array, problems with batteries in tropical islands, and the low (40%) operational time of a battery-less solar powered system.

32. The Tarawa Master Water Plan also drew attention to the main focus for RO plants which has largely been associated with the purification of seawater. Reference was made to the situation in South Tarawa where there is the potential to use brackish or polluted groundwater as the stock water source, employing infiltration galleries to extract the groundwater. Since this stock water is of lower salinity than seawater, energy requirements are less than those for seawater sources but there is still the potential problem of membrane clogging due to higher marine organism concentrations compared to groundwater from deeper sources. The Master Plan however concluded that SWRO systems best suited for Tarawa will have their feedstock drawn from deep vertical wells into the karst limestone underneath the unconfined, unconsolidated aquifer in order to filter the feed water.

33. The Tarawa Master Plan identified and analysed the three factors that have the largest effect on the cost of desalination per unit of freshwater produced. These are the feed water salinity level, energy costs and plant size. While there are clear economies of scale and decreasing unit production costs (UPC) with increased plant capacity these advantages are outweighed by the difficulty of sea freight and handling for larger 40-foot containers (the shipping companies to Tarawa and Port of Kiribati are only equipped to handle 20-foot

containers), difficulties of abstracting feed water in sufficient quantity for the larger plants and the disposal, by dilution of significantly higher volumes of brine.

34. After taking all considerations into account the Tarawa Water Master Plan concluded that SWRO desalination in terms of its capital and operating costs appears to be the most economic means of augmenting South Tarawa water supply provided it can be managed and maintained over a period longer than 10 years. The Water and Sanitation Roadmap 2011-2030 built upon these recommendations and carried the level of analysis further resulting in this more detailed feasibility study to determine the best, financially viable arrangements for the supply and installation of the SWRO desalination plants. The following sections of this report provide technical, financial, economic and environmental assessment of the desalination plants necessary to establish their feasibility. In essence the approach recommended by the Tarawa Water Master Plan, confirmed by the Roadmap, and now fleshed out in this feasibility study are the same with only subtle differences. Whereas the Master Plan recommends two 1,000kL/day desalination plants, the Roadmap and this study plan for four 528kL/day desalination plants (22 hours daily production), with each desalination plant consisting of three SWRO modules producing 176kL/day each. The Master Plan, the Roadmap and this feasibility study all propose an additional daily supply of 2,210kL.

3. DESALINATION

3.1 Introduction to Desalination

35. To meet the 2030 water demand requirements for South Tarawa a further 2,110 kL/day of freshwater from sources other than the enhanced Bonriki/ Bouta water reserve will be required. This is based on population projections and an assumed consumption of 50l/person/day. An analysis of alternatives[2] identified that seawater desalination was the only viable source of 'new freshwater'. The Roadmap clearly indicates that the main freshwater lenses under Bairiki and Betio are under stress. It also provides evidence that extensive use of the existing shallow underground brackish water resource will lead to further deterioration of the freshwater lens that underlie Bairiki and Betio and affect the salinity level of the brackish water that is currently used by significant numbers of people in the community for purposes such as bathing and washing clothes. It is known that at least some members of the community use the brackish and unsafe water drawn from shallow wells for drinking water in times of water shortage or simply because of poverty.

3.2 Desalination Options

36. Desalination is neither an emerging technology nor is it a mature technology as indicated by the fact that a number of yet to be proven modifications designed to improve efficiency are due to come on-stream in the next decade. Some recent developments have reduced operating costs particularly high power consumption. For example in the case of membrane desalination, power consumption has been reduced from 6.6kWh/m^3 (1980's) to about 2.5-3.0kWh/m^3 (2000's).

37. Three main technologies which are viable options for desalination have been considered in the South Tarawa context.

3.2.1 Multiple -Effect Distillation (MED)

38. Seagoing vessels used to rely on MED for producing potable water but have now trended towards membrane based treatment. Essentially, MED plants use heated steam coils immersed in seawater to condense the seawater to steam. Scale formation problems, on-going corrosion and maintenance requirements including the need for regular and expensive mechanical cleaning of the coils have been major problems although these have progressively been solved over an extended time frame.

39. Modern techniques use new materials to produce acceptably robust systems. Technical advances include optimised water spray patterns and systems that inhibit the propensity to form scale on coils. If scale forms, the production rate for an MED system decreases whereas for a multi-stage flash (MSF) distillation process, a more sophisticated form of MED, the consumption of steam increases to maintain production. Still unresolved is the complex thermodynamic relationship between power and water production and the problem is exacerbated when power production varies diurnally. The management skill level required to keep an MED system operational, is high, as is the requirement for monitoring and the number of preventative maintenance actions that must be taken. The skill base and resources required for even relatively simple repairs are beyond the resources of most Pacific Island nations and variable quality and security of power supply is a constant unknown.

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[2] ADB PPTA South Tarawa Water and Sanitation Roadmap 2011-2030

3.2.2 Multi-stage flash (MSF) distillation process

40. The multi-stage flash (MSF) distillation process evolved from the MED system in the 1960's and since that time, huge plants have been and are being constructed in the Middle East. Advances that include developments in scale control technologies, heat transfer improvements and the use and development of corrosion resistant materials including titanium and improved design. These improvements have led to their continued use. The name of the process is derived from the 'flashing effect' from the streams of brine as they move through the system-a fine balance of vapour flashing and heat recovery using a heat source underpins the whole process. The steam needed to operate distillation plants can be provided by extraction or heat recovery from thermal power generating plant so often development is a joint operation with thermal power stations. This technology has similar high technical skill and preventative maintenance requirements to the MED process.

3.2.3 Membrane Processes

41. The development of membranes with controlled pore sizes allows for the separation of water from saline solution without having to undergo a phase change as in the previously outlined distillation processes. A range of membranes is available but the relevant membrane type applicable to desalination is known as a reverse osmosis membrane, or to be specific for the situation in South Tarawa, seawater reverse osmosis (SWRO). In brief, the reverse osmosis process is when the application of a pressure higher than the osmotic pressure of seawater is applied using a high pressure pump (greater than 25bar) to reverse the normal tendency for water to flow to the higher concentrated solution. In simple terms the process forces the water from the concentrated solution to the more dilute solution to produce freshwater (permeate).

Figure 2: Typical Containerized SWRO Unit[3]

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[3] Reference HOFH USA and Carib.

42. Production rate is dependent on water temperature and the driving pressure from the pump. The quality of the permeate improves with increase in pressure. The maximum driving pressure allowable is dependent on the physical strength of the membrane and support structure. As a guideline for seawater reverse osmosis, 42% of the feed rate is typically recovered as permeate (product water) and the other 58% is a brine stream discharged to receiving waters, normally to the ocean.

43. The same pore size that prevents salt from passing through the membrane will also prevent contaminants passing through but it is important to prevent many contaminants reaching the membranes because it will become fouled and the membrane will then need to be chemically cleaned. Likewise, scaling of membranes can be an issue that needs to be resolved for each specific application. It is intended that a continuous low concentrations of scale inhibitor will be dosed at South Tarawa to minimize the risk of scale formation. Needless to say, excellent feed-water quality is a pre-requisite for effective SWRO operation and temperature is a critical operating parameter. Feed water temperature has a significant effect on water flux through the membrane approximating to a 3% increase per C^o rise in temperature. Note that production rates are normally referenced to 25^o C.

44. Membrane technology has developed in leaps and bounds to the extent that membranes (reverse osmosis) are the preferred technology for desalination plants in at least the southern hemisphere. Sheet type polyamide membranes rolled into long pressure vessels are used for SWRO. Technical reasons and performance favour this option but ease of membrane replacement is also another factor.

45. Raw seawater quality has an impact on the life cycle and performance of membranes so sufficient samples need to be taken to confirm the existing quality of the water and to identify any variables that may affect the quality of the raw seawater. For South Tarawa there is a general appreciation of the generic water quality variables that affect membrane performance so risk mitigation measures such as multi-step pre-membrane filtration will be installed, the exact configuration of which will be refined when the results of the source water quality are known with certainty. Some manufacturers provide a sliding scale reimbursable cost guarantee spread over 5 years for membrane replacement i.e. if the membranes fail in year three the redeemable cost is 0.6 of the original capital cost of the membrane. For South Tarawa OPEX costs were based on a conservative 5 year life for the membranes. With good management, membranes can last up to about 10 years.[4]

46. Successful large scale systems have recently been constructed to supply a number of Australian cities and there is a large 10 year old membrane based system in Tauranga New Zealand. Veolia has reported that an almost 10 year old plant in Nauru is working effectively and the system is only now due for membrane replacement.

47. On the negative side a 1999 SWRO (110kL/day) installation by PUB in Betio South Tarawa worked for about 18 months before failing and is now abandoned. The reasons for the failure are not clear but lack of funds for spare parts, a higher than expected salt concentration in the treated water were given as reasons but a major consideration appears to be that the equipment was supplied by a non-traditional supplier that could or would not provide after sales service. A small community installation in the Ocean Islands (Banaba Island) serviced by MPWU is reported to be giving problems. This unit is also believed to be sourced from a non-traditional supplier and after sales service is also weak.

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[4] The 9 year old membranes on the SWRO system at Moroni College South Tarawa have just been replaced.

48. On balance the preferred desalination option is SWRO. A SWRO system has a specialized element (the membranes), a number of readily available although specialized components such as the high pressure pump and valves, are specifically designed to be corrosion proof and incorporates an off-the-shelf high quality control system so in theory at least, a competent vendor can provide immediate back up. In contrast, MED and MSF systems have many components made from specialized metals that may require the services of repair specialists who have unique skills and there may be unacceptable delays in getting replacement parts mainly because parts have to be manufactured to order.

49. When considering the installation of SWRO a number of factors need to be considered and resolved. Desalination is not new to Pacific nations and there is anecdotal evidence that many earlier installations have failed before reaching the end of their economic life. Given that modern membranes from reputable manufacturers are reliable and that overall the systems are designed according to best practice using corrosion proof materials the reasons why systems regularly fail are not immediately obvious. Most desalination references do not deal with system failures and tend to gloss over the key factors linked to failure but interpolation and experience indicates the following:

(a) Using a reputable manufacturer is important. Such a manufacturer has developed systems based on experience and can provide back-up and spare parts at short notice. The reverse osmosis concept is a relatively simple system to put together but the difficulties associated with making the completed system operate efficiently and effectively are usually in the hidden intellectual property of a particular system. For example two suppliers may use the same membrane manufacturer but the machining of surfaces and quality of membrane seals will determine how the system works under high pressure and the quality of water produced.

(b) A comprehensive and proactive monitoring and service recording system is essential. The key word is proactive. For example it is much easier to prevent membrane fouling rather than trying to clean the membranes so work plans and monitoring requirements need to be focussed to achieve this.

(c) Programmed maintenance and corrective actions with associated budget support are essential elements that must be delivered in a timely way. For example failure to order and or replace filter cartridges as required could lead to irreversible fouling or damage to the membranes. Put simply, lack of a $200 investment in cartridges can easily lead to the complete failure of a system or at the least the premature failure of membranes which in turn has a major impact on the unit cost of water.

(d) Changes to the existing institutional framework need to be put in place. Operational responsibility, adequate budget provision and management flexibility must be packaged so that South Tarawa does not end up with another ‘non working machine behind a padlocked door’ It is important that there is a willingness to make institutional changes if the Project is to succeed.

(e) SWRO modules from reputable suppliers are modern systems of good design with comprehensive diagnostic systems that provide performance data and early warning of problems so in effect what is required of an operator is

” the ability to recognise the warning signals, decide what corrective action is required and do it within an enabling institutional framework.”

(f) Lack of attention to this is typically the underlying reason for failure of physical systems such as water supply systems, power plant and the like, so a new model needs to be put in place that recognises the following limitations; (i) required technical skills do not exist in South Tarawa, (ii) budgets are limited, (iii) the Departmental budgeting process is not rigorous and (iv) the enabling institutional framework at PUB and the Ministry of Public Works is weak.

50. A preferred model for successful operation of a membrane plant is to make provision in the supply contract for performance based operation and maintenance or alternatively maintenance of the SWRO systems to remain with the supplier for a 5-10 year period with declining rate of support as local capacity develops. This will give time for the institutional and budget framework to be developed to support the model and enable performance to be measured.

3.3 The SWRO Process

3.3.1 Raw water sources

51. The seawater feed requirement at each of the four sites is 57kL/hour. Two viable source water options exist. Bores drilled down into the limestone to a depth of about 35m or well engineered shallow infiltration galleries in the intertidal area adjacent to each site.

(a) Bores

52. Bores are the preferred source of water because they can be managed and maintained more easily than infiltration galleries and their yield can be reliably proven. Most of the wells on South Tarawa are shallow (about 3m for freshwater or brackish water depending on their location in relation to the Bairiki and Betio freshwater lens) and the only deep bores in South Tarawa are the three observation bores constructed under KAPII (18m deep). There is however a considerable amount of background information available to be able to assess bores as a viable option.

53. Falkland[5] in his literature research states that the unconformity between the tighter Holocene formation and the looser Pleistocene formation is in the range 10-17m so it is a practical proposition to drill to about 30-35m and screen from about 15m to the final depth to get the proposed yield.

54. Falkland[6] advised that on Home Island in the Cocos (Keeling) Islands, water yields varied from 1.4l/sec to as high as 3.3l/sec. On his advice a conservative yield of 1.0 kL/hr/metre of screen based on Home Island drilling results was taken as the basis for the bores. This would mean four bores for each site, three duty bores with a pump in each and one standby bore with no pump. Each borehole will be 200mm in diameter with an internal 150mm PVC casings and screens, and equipped with 100mm down-well bore hole pumps to provide the total 57kL/hour flow. Based on Falkland's experience the bores should be placed approximately 20-30m apart.

55. The location of the bores will be specific for each site and could be located 40-50m from the high tide mark or on the lagoon side of the island. There is no risk at any of the four selected sites of interfering with the freshwater lens under Betio and Bairiki[7] because the freshwater lenses do not extend to the areas selected for SWRO plant location. The bores will be connected via a manifold to feed 2 x 30kL interconnected raw water balance tanks.

56. The final design of the bore field will depend on the test results for bore yield.

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[5] Falkland referred to Marshall and Jacobson, 1985 Holocene Growth of a mid-Pacific atoll: Tarawa, Kiribati, Coral reefs 4; 11-17.

[6] Pers comm. detailed in an email referring to Home Islands in the Cocos Islands (Keeling) Islands.

[7] ADB TA-7359 (KIR).

(b) Infiltration galleries

57. If, in the unlikely event a bore field proves to be unsatisfactory then a shallow infiltration gallery in the intertidal area on the lagoon side of each location will be installed. The design will be based on the seawater extraction galleries proposed for seawater flushing of the sewers. In brief, two galleries (one duty one standby) will be installed, each 25m long comprising an engineered slotted pipe laid under the seabed not less than 1.5m below the lower tide level onto the lagoon flat and overlaid with graded aggregate. The gallery will feed through a buried and weighted collector pipe to an intake chamber for pumping to the raw water storage tanks.

58. Although the infiltration gallery can provide water of a reasonably consistent physical and chemical quality suitable for a SWRO plant the water quality will be more variable (within a narrow range) than the water quality from bores and the engineered top sand layers in the gallery will tend to block over time. Both potential problems can be managed. The water quality from the gallery is expected to be chemically consistent with fluctuating turbidity over a narrow range that can be coped with using the proposed multimedia filtration and cartridge system. Additional water quality risk management strategies may also have to be adopted if coral fragments and or high concentrations of microbes are detected in the raw water.

59. A self cleaning mechanical filter (Arkal type rated at 20 microns) sized to filter the total flow from the bores may be needed to remove particulate coral material if infiltration galleries are usd. If this is the case, the filter will be installed on a concrete pad just prior to the raw water storage tanks.

60. Microbes that pass through the pre- treatment process are one of the main causes of poor SWRO membrane performance and reduced life span of membranes. The pre-treatment system proposed for the SWRO modules will not remove microbes. The high probability of unacceptable counts of infectious microbes in infiltration gallery water means that chlorination and de-chlorination may need to be incorporated into the pre-treatment process.

61. Bore water which will be abstracted from fissured limestone will generally not need to be treated to reduce microbe content.

62. The design of the seawater galleries will include a back-flushing system to remove material that becomes trapped in the upper sand layers.

3.3.2 Water Quality

(a) General

63. The characteristics of typical seawater are displayed in Table 1, as follows :

Table 1: Composition of Typical Seawater[8]

Chloride (Cl^-)	18.980
Sodium (Na^+)	10.556
Sulfate (SO_4^{2-})	2.649
Magnesium (Mg^{2+})	1.262
Calcium (Ca^{2+})	400
Potassium (K^+)	380
Bicarbonate(HCO_3^-)	140
Strontium (Sr^{2+})	13
Bromide (Br^-)	65
Borate (BO_3^{3-})	26
Fluoride (F^-)	1
Silicate (SiO_3^{2-})	1
Iodide (I^-)	<1
Others	-
Total dissolved solids (TDS)	**34.483**

64. A key consideration for the final design of the SWRO units is an assurance of feed water quality. During the feasibility study, samples were taken from the KAP II observation bores (18m depth) in Betio and Bairiki and additionally two sea water samples were taken (Table 2); one from the lagoon, directly in line with the boat underpass on the Betio-Bairiki causeway and the other from the sea also directly in line with the same channel. The approximate locations were 0.6km either side of the causeway.

(b) Sampling program

Table 2: Test Results for the Four Field Locations

No	Location	Date	Temperature °C	Conductivity mS/m	Salinity (calc) g/m^3
1	Bairiki Bore **N** $1^0$24’36.7’’ **E** 173^o 6’ 45.6’’	24.02.12	30.4	3,120	20,280
2	Betio Bore **N** 1^0 19’46.4 **E** 173^0 58’ 35.5’’	24.02.12	30.6	3,770	24,505
3	Lagoon 0.6 km out from Bairiki causeway		28.5	5,270	34,255
4	Ocean 0.6km out from Bairiki causeway		26.5	5,460	35,490

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[8] Journal Water Condition and Purification Jan 2005.

65. Samples taken from all four sites were packed in ice and forwarded to Hill Laboratories Hamilton New Zealand for analyses. Before the bore samples (KAPII bores) were taken each bore was purged at a rate of 1.5l/min for 2 hours using a small pump connected to the in-situ sampling tube. Conductivity measurements stabilized after about 15 minutes. The seawater samples were grab samples.

66. The suite of water quality tests requested was based on prior discussions with Veolia Water at Melbourne Australia and their recommended schedule (Appendix A). The Hill Laboratories data (Lab No 983572) are also included in Appendix A along with general observations from Veolia Water.

(c) Laboratory data interpretation.

67. The water quality data from the two seawater samples falls within the expected water quality envelope for seawater and apart from a very slightly elevated turbidity level and slightly lower total dissolved solids content in the lagoon sample the lagoon and open sea samples are essentially similar. Turbidity is normally removed in the pre-treatment filtration phase of the process and given that use of lagoon water is not being considered as source water investigations into the relationship between tidal patterns and turbidity is not warranted.

68. The samples taken from the deepest bores in South Tarawa (18m) from each of the Bairiki and Betio freshwater lens shows that the water is ‘brackish’ at this depth with a salinity equivalent to about 60% seawater. The safe yield of these bores is unknown and from the limited hydro-geological knowledge we have and an understanding of potential impacts of pumping on the fresh water lens in the vicinity of the bores, stable water quality and yield could not be guaranteed from bores at this depth in the vicinity of the KAP II bores. SWRO plants treating brackish water would have higher efficiency than when treating seawater but the destabilizing influence on the freshwater lens of abstracting up to 57kL/hour from bores in the vicinity of the lenses is a risky venture that may have long term unintended consequences for the freshwater lenses.

69. The bore hole water quality data mirrors the expected 60% equivalence of seawater but there are several parameters that would need to be considered if bore water of this quality was the source water. Turbidity is low suggesting effective in-situ filtration through fractured rock and limestone, iron and manganese may be of potential concern re scaling, and pH control may have to be considered to ensure that iron and manganese are removed either at the pre-treatment phase or through the membranes, likewise phosphorus and silica concentrations are high in comparison to seawater.

70. If bore water of this quality was to be used, fine tuning of the design would be needed to either convert the iron and manganese to particulate phase and remove in pre-treatment or manipulate treatment to keep these minerals in solution. Reactive silica is also present in the bore water in concentrations that exceed the normal levels in seawater (less than about 1g/m^3) and again is of potential concern. Follow on consideration for the Clean-in Place (CIP) cleaning process design and a good selection of an optimized antiscalant would also be required.

71. The water quality results of particularly the two seawater samples are indicative that the local seawater is suitable for treatment by SWRO. The quality of samples taken from a bore hole depth of 35m is expected to be similar but not of completely equivalent to that of the seawater samples taken in this sampling survey rather than being similar to the water quality from the 18m deep samples. Until the bores are drilled and tested, water quality is an unknown. The indicative data for seawater shows no outlier results so the information now

available is normally sufficient to enable core design of the SWRO system to be completed. For representative data, water quality samples need to be taken from the new bores at each site and sent to an external international laboratory for analysis. This representative water quality information is needed to confirm pre-filtration requirements and water quality/membrane compatibility, to develop operational guidelines and standard operating procedures and to enable a system performance guarantee to be prepared.

3.3.3 Treatment System

(a) Pre treatment

72. The purpose of pre treatment is to remove solids from the raw water to prevent fouling of the membranes by fine particles or biological growths, and reduce the risk of damage to high-pressure pump components.

73. The standard system proposed for each module will comprise a low-pressure pump to pump water from the raw water tanks to the multimedia filter for removing particles down to about 20 micron in size. When pressure across the multimedia bed reaches a pre-determined value the media will be automatically backwashed to waste using treated water from the elevated reservoir. The backwash water will be diluted with the waste brine stream in the brine tank prior to discharge to the ocean. The backwash water will not be highly coloured or contain high concentrations of solids. The backwash cycle will take place approximately every 2 days or maybe weekly if the seawater is particularly clean.

74. A single 1.6m diameter multimedia filter tank will be installed before each SWRO module. At a flow rate of 19kL/hr for each filter tank this represents a conservative filtration rate of 9.5m^3/m^2/hr. If water quality is such that it needs further treatment then chemical coagulation using small doses of low molecular weight polymer or poly aluminium chloride can be applied just prior to the filter using a small dosing pump abstracting from a 20 litre container to enhance filtration efficiency but this is considered to be highly unlikely.

(b) Cartridge filtration

75. Second stage treatment for each treatment train will be a single 40 inch (length) housing with a nominally rated 3 micron cartridge. Nominally rated 1 to 5 micron cartridges can be used instead of 3 micron but if the multi-media filter works efficiently, then 3 microns is the preferred rating for the cartridge. These cartridges are replaced on average monthly, and are disposed of to landfill.

(c) Seawater reverse osmosis module

76. Each of the four South Tarawa sites will have three SWRO modules. A SWRO module is made up of membranes rolled (just like a rolled up mat) into fifteen 150-200mm diameter pressure tubes about 5m in length complete with pumps and all ancillary equipment packed into an air conditioned marinised 20ft container connected between the raw seawater tank and the permeate (treated water) tank. An additional container will house the raw water pre-treatment filtration units and the permeate will be chemically stabilized by running the SWRO permeate water through a calcite filter to adjust the pH prior to storage in the low level fresh water tanks. Drawings 50663, sheets 713, 716, 719 and 722 in Volume 2 illustrate the layout at each site.

77. Achieving economies of scale by using larger SWRO modules is not possible in South Tarawa because shipping restrictions limit container size to 20ft. This is not an issue

because the designed system using module units of this size allows for excellent operational efficiencies.

78. Each set of module membranes is fed by a high pressure pump (of the order 25kW creating pressures of the order 65-85bar) rated at 19kL/h and although power requirements are high, a modern design to be selected for South Tarawa will incorporate energy recovery systems that will achieve an energy cost reduction of the order 40%. This is achievable because the hydraulic energy is recovered from the reject brine stream. Pelton wheel impulse turbines energy recovery systems have better efficiency than alternatives because they are less sensitive to changes in the reject brine flow.

79. Permeate from each membrane module will be combined and then flow through a calcite contact bed treatment prior to storage in the treated water (permeate) storage tank at a rate of 8kL/hr per module ie 24kL/h per site while a waste stream called the brine stream which concentrates the salt and other major ions separated from the water is discharged at a rate of 11kL/ hr per module or 33kL/h per site - a recovery rate of 42%. Slightly better efficiency may be achievable if the raw water is brackish.

80. The membranes cannot be backwashed in a similar manner to sand or media filters but must be kept clean. This will be achieved by the continuous dosing of a low dose anti-scaling agent (0.2-0.8g/m^3) and regular chemical cleaning of the SWRO membranes to ensure that they continue to perform satisfactorily. Under normal circumstances it is expected that four such regular cleaning cycles per year will be required. The key to successful membrane longevity is to do preventative cleaning i.e. do it before the membranes become irreversibly fouled. The cleaning cycle will typically be optimized after consideration of feed water quality, pre-treatment effectiveness and time taken for the normal flux permeate conductivity to increase by about 10-15% or the normal permeate flux to reduce by 10 – 15% or the differential pressure to increase by 10-15%.

81. Once a program of regular preventive cleaning is set-up during commissioning of the SWRO it will be rigorously monitored and revaluated as necessary. If the feed water quality is stable then cleaning practices will be largely automated. The key to successful operation of SWRO is adherence to preventative maintenance practices. The SWRO will normally be set up with a wide range of automatic monitoring systems through a PLC but the level of automation and remote monitoring required will be reassessed at a later time when the results of the proposed upgrade of the South Tarawa internet service are known.

82. One important consideration in the process needs a brief discussion. When the module is shut down because, for example, the treated water reservoir is full, the SWRO module will normally go into a rinse cycle whereby clean water is pumped to fill the membrane pressure tubes so minimizing the risk of fouling the membranes through static contact of pre-treated water with the membrane. A review of the power supply in South Tarawa has indicated that although peak power loading is only reached occasionally, the system has some unreliable features (leaking transformers, lack of scheduled maintenance for the main diesel generators, some transformers are at peak capacity and an unforeseen agreement to supply both treated water (15kL/day) and power (700-800KW) to a fish processing factory currently under construction at Betio Port) has been made, which will place a significant additional burden on the power and water supply systems and occasional power outages are therefore a strong possibility.

83. The implications for the design of the plant are that the freshwater wash for membranes must be allowed to take place either through an auxiliary power supply backup or through a robust on-site power generator. Onsite back-up power generators will therefore be installed as part of the project to provide back-up power so the final design will need to take this requirement into consideration.

(d) Post-treatment

84. The treated water (permeate) with all the major ions and 99-99.5% of the salt removed is very corrosive to metals and concrete so needs to be stabilsed. The permeate water will be pumped through a single calcite contact bed in a filter vessel about 2m in diameter at a conservative rate of 9-9.5kL/m^2/h to reintroduce ions such as calcium and magnesium and to increase the pH so in terms of the Langelier Stability Index, the final water will be marginally scale forming or marginally corrosive.

85. The calcite contact bed will need to be periodically backwashed to remove fines and again the waste will be mixed with the brine waste stream prior to disposal through the outfall. Typically the calcite level in the contact tank will need to be topped up annually.

(e) Brine waste stream

86. The brine waste stream will be pumped to a 22kL balancing tank and from there disposed of to the ocean at a controlled rate using the head available in the balancing tank. As detailed in the IEE section of the report the normal salt concentration of the brine will be about 1.5 times that of normal seawater and will be rapidly diluted on release into receiving waters.

87. The multimedia filter backwash cycle water will generate about 2kL of dirty water per filter unit which can be diluted up to 9-10 times in the brine tank by manually closing the brine tank outlet until the tank fills and then allowing discharge as per normal through the outfall. The solids content of the backwash water will be low (about 0.1%) and management practices such as a standard operating procedure to only clean one filter per day approximately every week and program the backwash cycle for high tide conditions will reduce any perceived environmental risk to a negligible risk. The approach can also be adopted for the chemical cleaning cycles that are expected to be required about 4 times per year.

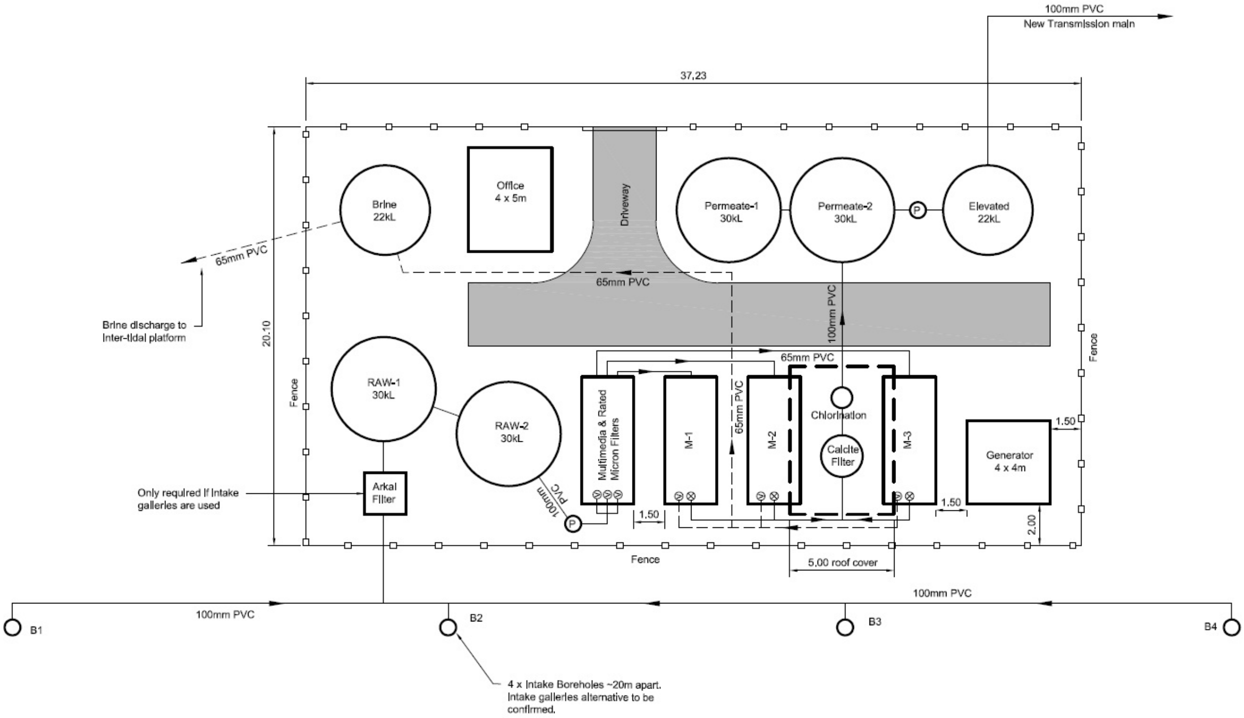
88. The very low continuous dose of anti-scalant will be significantly diluted in the brine tank prior to normal discharge through the brine discharge pipe. The Material Safety Data Sheets for anti-scaling agents records negligible environmental risk from discharge in its concentrated form and the acid based product will have no impact on the pH or chemistry of the brine waste stream or receiving water.

89. Periodic back flushes of the calcite filter may contribute elevated levels of calcium but once again in-brine tank dilution and dilution at the outfall will minimize any potential calcium precipitation problems. Adding calcium solutions to a coral (calcium-rich) environment is not a matter of concern.

(f) In brief

90. Raw seawater will be pumped from three bore holes or one infiltration gallery through the pre-filtration system at 57kL/hr to remove contaminants including solids then into each of three SWRO module where a treated water (permeate) stream of 8kL/hr per module (24kL/h per site) and a waste stream (brine) of 11kL/hr per module (33kL/h per site will be produced. The treated water will be post-SWRO module treated to make it less corrosive before being stored in the treated water storage tanks and the waste brine stream will be directed into a 22kL storage tank to balance the discharge flow from the outfall. The typical site layout and dimensions used for the selection of adequate land in each location is shown in Figure 3.

91. For each site the treated water production based on 22hr/day will be 24kL/hr or 528 kL/day with a brine waste stream of 33kL/ hr or 726kL/day.



Notes:

B1, B2, B3 and B4 = Seawater intake bores
RAW-1 and RAW-2 = Seawater feed tanks
M-1, M-2, M-3 = SWRO units
Permeate 1 and 2 = Treated water tanks
ET = Elevated tank
Office building also contains site amenities and storage

Figure 3: Typical Desalination Plant Layout

4. CONSULTATION WITH SWRO MANUFACTURER

4.1 SWRO Principles and Application

4.1.1 SWRO Process and Suitability

92. The discussions with Veolia Water, Melbourne confirmed that SWRO technology is well established and robust. There is no reason why desalination using SWRO processes cannot be applied successfully in Kiribati with modern technology, well constructed and supported units, and with adequate provision for operations and maintenance to ensure the integrity of the RO membranes, routine procedures to clean and descale the membranes, and provision for the purchase rated micron filter cartridges, multi-media filtration, and stabilization of RO treated water in a calcite bed, and supply of spare parts on an as required basis. Other significant needs will be the training of PUB technicians, the development of capacity to operate the units, and improving community understanding of desalination, its costs and the need to preserve expensive and scare water supplies produced by the process.

93. The experience in Nauru has shown that desalination units can be operated successfully in an environment similar to South Tarawa. The main consideration in this successful experience has been the continuing support of the manufacturer and supplier for the maintenance of the units, with technical backup, spare parts and advice for the programming of maintenance.

4.1.2 Technical Prerequisites for the Protection of the RO Membranes

94. The technical requisites for successful operations and for extending the life of the desalination units start with the fact that the membranes will need to be washed on a regular cycle using washing chemicals and small doses of antiscalants approved for drinking water to be applied on a continuous basis so there are no environmental issues. Washing generally involves the use of proprietary citric acid based compounds. This is all that has been necessary for Narau and while some companies may recommend washing with high pH chemicals this will not be necessary for South Tarawa.

95. The other main requirement is a high standard of pre-filtration to prevent the RO membranes from clogging with sand, marine organisms and biological growths. If galleries are employed, initial coarse filtration will be through an Arkal mechanical filter to remove sand and coral grit and other granular impurities. Pre-filtration will then occur through multimedia filters to 20 micron size, followed by high-flow disposable rated micron filters (3 micron size), with further removal through the RO membranes to 0.001 micron size. Micro-filtration which is another form of membrane filtration with removal capacity down to about 1 micron or less may be better as a pre-treatment step, but more costly and is not appropriate technology nor appropriate for the seawater quality in South Tarawa.

96. The multimedia units will be about 1.6m diameter and only use a small amount of consumables. Back washing of the multimedia filters can be set to operate on pressure or time, but typically on a time basis. The backwash will only contain 0.01% of solids and can be discharged to the ocean through the brine tank and the brine discharge lines. The micron cartridge filters will require replacement on a monthly cycle and will need to be provided for as a consumable expense in the operation of the plants.

4.1.3 Specifications and Performance Requirements for Best Operations

97. Pipes for pre-treatment and RO modules should be specified to 904L grade stainless steel or Zecron 254SMO and PVC and the pumps as super duplex or 904L grade stainless

steel, depending upon the water analysis. Pressure vessel should be of fibre reinforced plastic manufacture. The RO modules must have a clean-in-place system (CIP) and the unit will require a fiberglass fresh water tank with the freshwater being used to automatically backwash the module(s) every time the RO modules shut down, to prevent the scaling of the membranes.

98. Companies being considered for manufacture and supply should be capable of, and required to manufacture their own RO units and to blend their own descalants and cleaning chemicals so allowing the company to custom blend for the specific requirements. For environmental considerations re-blended descalants and washing chemicals from another company should not be allowed because they will not be based on a detailed analysis of the raw water so the risk of unacceptable residuals in the wash water is possible.

99. The containers containing the RO modules and filters should be specified as A-grade (new) containers, or one-use containers. Interior and exterior painting should be marine (exposure) grade paint finishes comprising three coats; etch coat, undercoat and gloss finish coat – all two-pot spray application on a prepared surface. The containers must be air conditioned, and contain the power board/switch board, and have a heavy duty floor finish with coving at the edges to allow for internal seawater spills. Lockable personnel access doors should also be provided in addition to the main container doors.

100. The containers (modules) should be fitted with external weather proof plug-in connections for mains power and generator back-up, internal lighting and exterior security lighting and internal and external (weatherproof and earthed) power points. Each desalination plant should have a PLC with GSM or land line linkage to the secure and fast-speed satellite Internet connection and server presently being installed by MPWU, to allow monitoring, and diagnostic enquiry by the manufacturer/supplier.

101. Secure storage must be provided within the site office for the washing chemicals, descalants and spare part and consumable items. The calcite filter bed will be supplied in a filter shell similar to the multimedia filters and will cost around $55,000 plus the media at between $5,000 and $10,000. A chlorinator and dosing unit would be an extra $15,000.

4.2 Procurement Provisions

4.2.1 Best Technology, Units and Support

102. The RO modules must be fully designed and built in their totality by the company supplying, installing and commissioning the modules. Modules assembled from parts or components from multiple suppliers and manufacturers should not be allowed, nor should the procurement documents allow a contractor to acquire, install and commission modules manufactured with parts from multiple suppliers, or modules manufactured by several sub-contractors or a consortium of suppliers.

103. The company must be world leader in technology and the manufacture and operations of SWRO units, with a proven record of supplying package plants in numbers to others. It must have an established history and track record of manufacturing, installing and operating packaged plants and SWRO units on the scale contemplated for South Tarawa, or larger.

104. The company must have Pacific experience of SWRO units and a track record in maintenance and operations of SWRO units in Pacific environments where the plants have had a proven economic life of ten years or more.

105. The company should have substantial manufacturing and supply operations in the Pacific region with the capacity to provide full and unrestricted technical, management, maintenance and operations support and must be globally linked with in-house or proven R&D capacity.

106. The company must be able to provide plans, drawings, 3D presentations, technical manuals, training to MPWU and PUB and assist with the design and delivery of community education packages. The ability to provided proven off-the-shelf education packages and curriculum support materials for school and community awareness/education programs suitable for customization for Kiribati will be an advantage in selection.

4.2.3 Contract Arrangements

107. The discussions with the SWRO manufacturer covered all options including:

a. Privatized operations where the investor would own and run the plants and PUB would be obligated to purchase an agreed quantity of water at a cost meeting the cost of production (including the capitalisation of the investment) plus profit;
b. Private, Public Partnership between the investor and PUB;
c. A supply and take contract where the company is contracted to supply a specified volume of water and PUB would be obligated to take or pay for the water at the volume and unit rate specified in the contract;
d. Design, Build and Lease (DBL) contracts where the company designs and builds the plant with a guaranteed unit rate per kL for supply, with the company holding the lease of the operation and supply for an agreed period until the original investment is amortised. The agreed rate allows for the operation and maintenance of the plant, the investor's return on the funds employed and profit;
e. A contract for operations and maintenance;
f. A contract for maintenance.

4.2.4 Company Risk Assessment

108. Full privatization, DBL and PPP arrangements would require decisions by the company's Head Office and this could present difficulties given the world economic climate and prior experience with default of contract by Governments, many in Africa following regime changes.

109. Options a to d in sub-section 4.2.3 will therefore require a decision of the company's Head Office in Europe and under the present economic climate this is expected to create insurmountable difficulties. This is due to recent world political unrest where governments have changed, and the incoming jurisdictions have failed to recognise the contracts entered into by the previous administrations. The outcome is wariness on the part of the larger companies to entertain the investments and the risks that run with them.

110. By far the preferred arrangement is for a separate design and construct contract followed by a second contract for operations and maintenance. The operations and maintenance contract would leave PUB responsible for and running the plants and for the management, distribution and recovery of revenue. The company would train and use PUB personnel for maintenance activities. PUB for its part would be required to comply with the maintenance program scheduled by the company.

111. The company would require a minimum of a two year contract, or preferably five years with right of renewal and with a sovereign guarantee for payment, and in the light of

recent international experience in a changing world, the additional guarantee from the donor partners to underwrite payment in default of government payment. Concerns held relate to jurisdiction, breach of contract by the client and the rules of mediation/arbitration.

5. NETWORK MODELLING

5.1 Approach and Parameters

5.1.1 Purpose

112. The objective of the network modelling has been to establish the best positions for the proposed desalination plants to augment the water supplies to the main urban areas of South Tarawa and then to guide the selection of the actual sites based on satisfying both network and technical requirements.

113. With the placement of the desalination plants into the existing supply system it has been necessary to ensure they will provide the design flows and maintain delivery to the existing service reservoirs. The modelling has therefore calculated the discharge pressures required from each of the desalination plants in order to maintain a residual working pressure at the existing service reservoirs along the transmission main. The modelling has considered two situations for the future operation of the supply network:

a. The status quo without the desalination plants with all water being pumped from the Bonriki treatment plant;
b. Two zones comprising an eastern zone between Bonriki and Antemai fed from the enhanced Bonriki and Bouta well fields and a second western zone between Betio and Antemai fed by the desalination plants.

114. The first situation considered the pumping head required to maintain supply along the transmission main to the Betio low level reservoirs, without the desalination plants. The second considered the operation of the two zones, and the ability to cross feed from the desalination plants to service the eastern (Bonriki) end of South Tarawa in the advent of a failure with the Bonriki supplies.

115. The modelling has been developed on the following key assumptions:

a. Existing reservoirs will be fully utilized except for those that are not currently functional;
b. The section of the transmission main between Teaoraereke and Betio will be replaced with new 200mm mPVC pipe under the Kiribati Road Rehabilitation Project in 2012;
c. Leakage and losses will be reduced to 25%;
d. Loses will be reduced further to 20% in 2020.

116. The recharge rate of the reservoirs has been allowed at the average demand of the area they supply, with peak demand being supplied by the existing storage. The design consumption of 50litres/person/day can be satisfied through to 2020 when the Roadmap identifies a requirement for an additional increase in desalination capacity. In the advent of failure in the Buota and Bonriki supplies the desalination units could maintain a lifeline supply of 10litres/person/day at the Bonriki end of the island.

5.1.2 Data Input to Model

117. The existing GIS records of the transmission mains and the core distribution networks for the urban areas and village along South Tarawa were developed to provide node points and their coordinates for entry into the EPANET model. Pipe diameters and pipe coefficients were derived from the GIS data held by PUB along with the levels of the pipe

network node points from topographical plans held electronically by the consultants. Additional information on reservoir capacity and operating head was also entered and all data was reviewed and checked. Plans depicting the exiting water system transmission mains and the primary distribution network are incorporated into this report as drawings 50663 sheets 701 to 710 in Volume 2.

5.1.3 Technical Assumptions and EPANetwork Development

118. The capacity of the existing reservoirs was checked to ensure the availability of adequate storage for water produced by the new SWRO desalination plants over-night on a 22 hour daily production cycle, when draw-off from the systems is low, with the storage providing a buffer for peak morning and day-time use. The reservoir capacities are shown in Table 3.

Table 3: South Tarawa Existing Reservoir Capacities (2012)

Site	**Reservoirs**	
	Elevated (kL)	**Ground Level (kL)**
Tanaea	1 x 17.7 – 4m high	Nil
Bonriki	1 x 22	Nil
Temaiku	1 x 22	Nil
Nawerewere (Tungaru Central Hospital)	1 x 22	Nil
Tabaonga	1 x 22	Nil
Bikenibeu (King George Vth High School	1 x 22	1 x 220 (not in use) 1 x 210 (in use)
Bikenibeu	1 x 22	2 x 220 (one not in use)
Bangantebure	1 x 22	Nil
Eita	1 x 22	3 x 22
Tebunia	1 x 22	Nil
Ambo	1 x 22	Nil
Banraeaba	1 x 22	Nil
Existing Storage Eastern South Tarawa	***259.7***	***616***
Antemai	1 x 22	Nil
Teaoraereke	1 x 22	5 x 22
Existing Storage Teaoraereke and Antebuka	***44***	***110***
Nanikai	1 x 22	Nil
Bairiki	1 x 22	2 x 220
Existing Storage Bairiki and Nanikai	***44***	***440***
Betio	1 x 120 – 12m high	2 x 1,160
Existing Storage Betio	***120***	***2,320***

Source: PUB O & M Manual for Tarawa Water Supply System, Part 1 1987. All elevated 22kL tanks are 6m above GL.

119. Design draw-off at the node points has been calculated on a consumption of 50 litres per person to establish the operating flows, head losses and residual operating pressures. The static and operating pressure heads have been plotted on GIS base maps for future reference. The new zones for Bonriki to Antemai in the east and Betio to Antemai in the west have been established and storage at new permeate (treated water) tanks at the desalination plants and the existing reservoirs has been balanced to allow the equalization of supplies and operating heads throughout both zones.

5.2 Delineation of Zones

120. The populations for the enumeration areas used for the 2010 Census have been analyzed to determine the boundary between the proposed western zone fed by the desalination plants and the eastern zone supplied from the Bonriki and Bouta reserves. This analysis gives the water balance shown in Table 4.

Table 4: Proposed Water Supply Zones - Water balance

Area	**Population**		
	2010	**2015**	**2020**
Western Zone – Betio to Antemai (Desalination)			
Betio	15,646	18,961	22,897
Bairiki	3,281	2,967	4,796
Nanikai	1,035	1,251	1,409
Teaoraereke	4,106	4,964	6,003
Antebuka (less EA's 48, 49 and 50)	1,718	2,079	2,491
Subtotal	25,786	30,222	37,596
Litres/p/ day	***61***	***57***	***45***
Eastern Zone – Antemai to Bonriki (Groundwater, Bonriki and Bouta)			
All remaining eastern areas	23,212	27,779	34,080
Antebuka (including EA's 48, 49 and 50)	1,389	1,675	2,024
Subtotal	24,601	29,454	36,104
Litres/p/ day	***62***	***64***	***56***

Note: EA refers to Enumeration Areas used for 2010 Census count

121. The division occurs naturally at Antemai between existing services reservoirs in Antebuka and Ambo. The integrity of the transmission main at the division between the zones will be maintained with valves inserted to establish the separate zones, yet allow a cross-feed should future circumstance require this. The zones and the division between the proposed zones are illustrated in Figure 4.

5.3 Site Identification

5.3.1 Locations and sites (government land, availability)

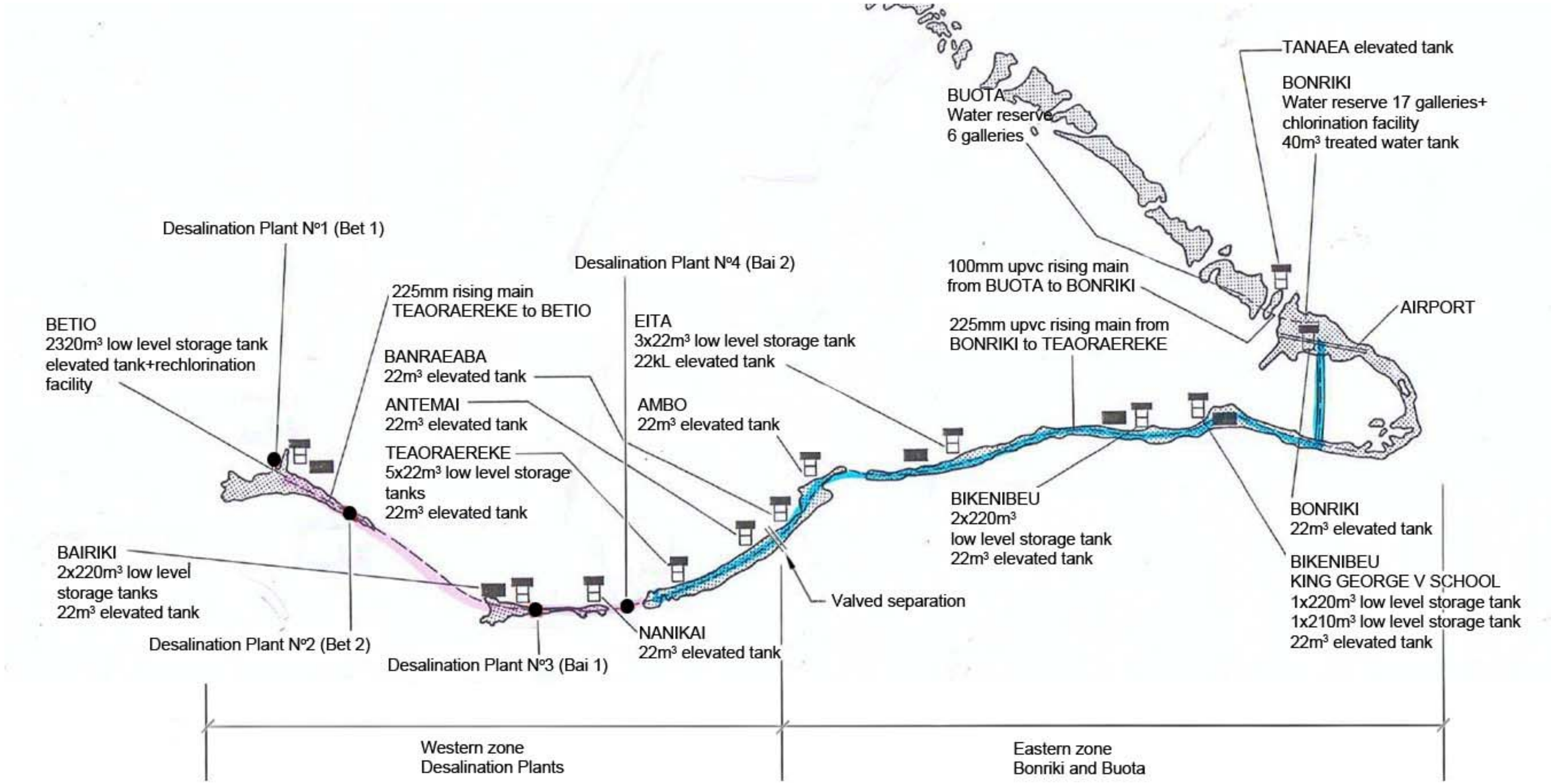
122. The initial modeling using the EPANET identified the best locations for the SWRO plants from the point of view of the equalization of supplies and operating pressures. These locations were then reviewed to locate government or government leased land using the General Land Use Plans (GLUPs) prepared for MELAD by TA-7359 KIR. The ability to connect the new plants to the transmission mains and to discharge the brine waste to the ocean intertidal area were further considerations in the selection of the sites. Outline plans depicting the process and typical layout for the SWRO plants were also prepared to provide an indication of the actual site dimensions, shape and area that would be required to accommodate a typical SWRO plant.

123. On arrival in South Tarawa the plans for the typical site layout and the preferred locations established by the initial desk top modelling were used for discussions with MELAD (refer section 6) to confirm site availability and acceptance by MELAD, government and community. The EPANET model was aligned for the sites selected.

5.3.2 Connection to Transmission lines and Service Reservoirs

124. The SWRO plants are located in positions alongside the existing transmission main, or the case of Betio, close to the alignment of the new transmission main to be laid during the road rehabilitation project. As the topography of South Tarawa is flat with little variation in level the transmission mains have flat gradients throughout their length. Reverse flows induced into the system as a consequence of the proposed zonal arrangement will have little effect on head loss and operating pressure.

Figure 4: Proposed Water Supply Zones - South Tarawa



6. SITE SELECTION

6.1 Consultation

125. The locations for the proposed SWRO desalination plants were discussed extensively with MPWU, PUB, MELAD, TUC, BTC and NZAP which is involved with BTC in planning for the future use of the Betio landfill site. Follow-up meetings occurred as land in different locations was investigated for suitability. At each stage the locations of the potential desalination plants were entered into the network model to confirm the technical suitability of each site.

6.2 Availability of Suitable Land

126. Undeveloped and uncommitted government owned or leased land is scarce on South Tarawa. The site selection therefore involved identifying all possible sites on government land with the Director of Lands, MELAD then inspecting each site for its size and suitability and finally discussing any other potential use with MELAD, TUC and BTC, and NZAP in the case of the Betio landfill.

6.3 Selection of sites

127. All indentified sites where assessed according to the criteria displayed in Table 5. The criteria were chosen to reflect requirements relating to the ease with which the desalination plants can be installed and the impacts they might have. Table 6 shows the application of the criteria to the sites investigated. Ratings from 1 unsuitable to 5 ideal were used.

Table 5: Desalination Plants, Criteria for Site Selection

Criteria	**Rating**		
	1	**3**	**5**
Location – suitability	Poor	Good	Ideal
Brine disposal	Difficult	Over adjacent land	Short discharge
Site availability	Competing uses	Requires decision	Immediate
Site access	Difficult	Secondary road	Main road
Transmission main	Distant	Moderately close	Adjacent
Proximity to electricity	Distant	Moderately close	Adjacent
Sewerage	Difficult	On-site sanitation	Serviced site
Topography	Difficult	Irregular	Level and even
Land area	Compressed	Adequate with design	Adequate
Dimensions and shape	Compressed	Adequate with design	Adequate
Risk of inundation	Moderate to high risk	Low risk	No risk
Separation from houses	Close	Adequate	Well separated
Environmental	Significant impacts	Minor impacts	None apparent
Resettlement	Land acquisition	Easements over adjacent land	Government land

Table 6: Analysis of Sites – Application of Criteria

Ref	Location	Criteria - Rating															Comment
		Location – suitability within network	Location – suitability for brine disposal	Site availability	Site access	Proximity to transmission main	Proximity to electricity	Sewerage	Topography and contours	Land area	Dimensions and shape	Risk of inundation or coastal erosion	Separation from houses	Environmental considerations	Resettlement/Compensation	Overall Rating	
Betio Water Supply Zone																	
Bet1	Betio – Landfill site, completed reclamation adjacent to Betio Shipyards	3	5	3	3	3	5	5	5	5	5	5	5	5	5	62	• Betio Town Council has plans to develop container storage and handling facilities on the land to enable it to control random storage on roads edges and open land throughout the town area; • BTC has agreed to allocation of suitable area of land on north eastern section of land • NZAP has agreed with the proposed location for the desalination unit; • Brine intake can be through boreholes sunk on a narrow reclamation constructed out from the retained areas; • Brine disposal will be into the Port anchorage area.
Bet2	Betio – Location of previous	5	5	5	5	5	5	5	5	5	5	5	5	5	5	70	• Ideal site which meets all criteria;

	desalination plant opposite maneaba at Tokoronga																• Old desalination plant will need to be dismantled; • New plant will need to be located sensitively to preserve historic values of wartime relics; • Brine disposal to ocean lagoon.
Bet3	Betio – meteorological station site at western end of islet.	1	1	5	5	1	5	5	5	5	5	5	5	1	5	54	• Good site which will comfortably accommodate the desalination plant; • Brine disposal can be discharged to the ocean platform with a pipe line along public access way to the foreshore immediately to the east of the cemetery, on the southern side of the Betio loop road; • May be some environmental issues with brine discharge at foreshore; • Long connection to water supply transmission main.
Bairiki/Nanikai/Teaoraereke/Antemai																	
Bai1	Bairiki - On causeway reclamation, lagoon side (north) immediately to the east of the existing urban development	5	5	3	5	5	5	5	5	5	5	3	3	5	5	64	• MELAD indicates some interest by others in this site and a decision to protect it for the desalination plant will be required; • Actual location of plant has been moved eastwards to allow for possible development of first section past existing development. • Brine disposal could be to the Ocean side, or lagoon; • The land area and shape is adequate but will require site specific design; • Site will need filling to increase freeboard above possible inundation; • Protection will be required along road edge with open channel to turn road storm water runoff and wave spray past site;

																• Foreshore sea wall protection will be necessary on lagoon side of development.
Bai2	Nanikai – North side of causeway to immediate east of TSKL storage area at approach to Teaoraereke.	5	5	5	5	5	5	3	5	5	5	3	5	5	5	62	• Brine disposal could be to the Ocean side, or lagoon; • The land area and shape is adequate but will require site specific design; • Site will need filling to increase freeboard above possible inundation; • Protection will be required along road edge with open channel to turn road storm water runoff past site; • Foreshore sea wall protection will be necessary on lagoon side of development.
Bai3	Teaoraereke – South side of main road between present reservoir site and TUC.	5	1	1	5	5	5	3	5	5	5	5	5	5	5	60	• Ideal size and dimensions; • Brine disposal could be to ocean side by a pipe along a public road at the rear of the TUC building and running parallel to the eastern boundary of the Animwarao Junior TUC 2 Secondary School; • TUC is negotiating for the acquisition of the land for municipal purposes for workshops and related uses; • There is no other suitable land for municipal use; • TUC has an urgent need for the land and is pressing hard for the allocation of the land. Their need is as great as the desalination requirement and it was decided to look at other sites for the water supply needs.
Bai4	Bairiki – Reserve area on lagoon foreshore at rear of MISA.	1	1	3	3	1	5	3	5	5	5	3	5	3	5	48	• MELAD indicates there have been plans mooted to establish a fisherman's cooperative on part of the site with associated parking on the balance;

																	• The land area would appear to be sufficient for this purpose plus the desalination plant; • Requires moderately long connection to transmission main; • Brine disposal would need to be piped into the lagoon; • May bring a negative response from fishermen and the fishermen’s collective.

6.4 Determination of Final Sites for Desalination Plants

128. The sites indentified for the four desalination plants are therefore:

1. Desalination plant No. 1 (Betio 1) – on the northeastern corner of the Betio landfill site near the Betio Shipyards;
2. Desalination plant No. 2 (Betio 2) – at the site of the former desalination plant on the south side of the main road opposite the road to the Captain's bar;
3. Desalination plant No. 3 (Bairiki 1) – on the northern side of the main road just beyond the present urban development at the start of the causeway to Nanikai;
4. Desalination plant No. 4 (Bairiki 2) – on the northern side of the main road immediately east of the TSKL site on the causeway at the approach to Teaoraereke.

129. The locations are illustrated on the following Figures 5, 6, 7 and 8. Details of each site are provided in Appendix B.

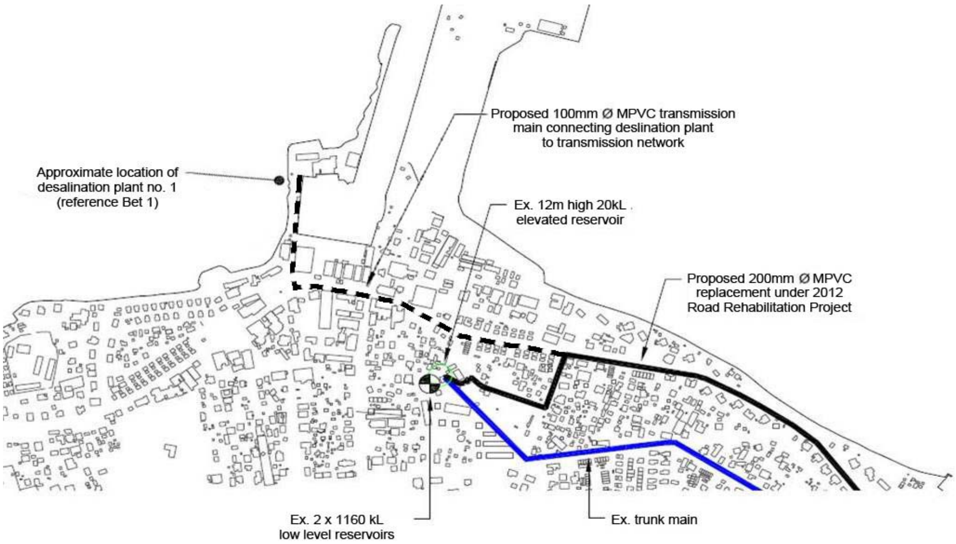


Figure 5: Location of Desalination Plant No. 1 (Betio 1)

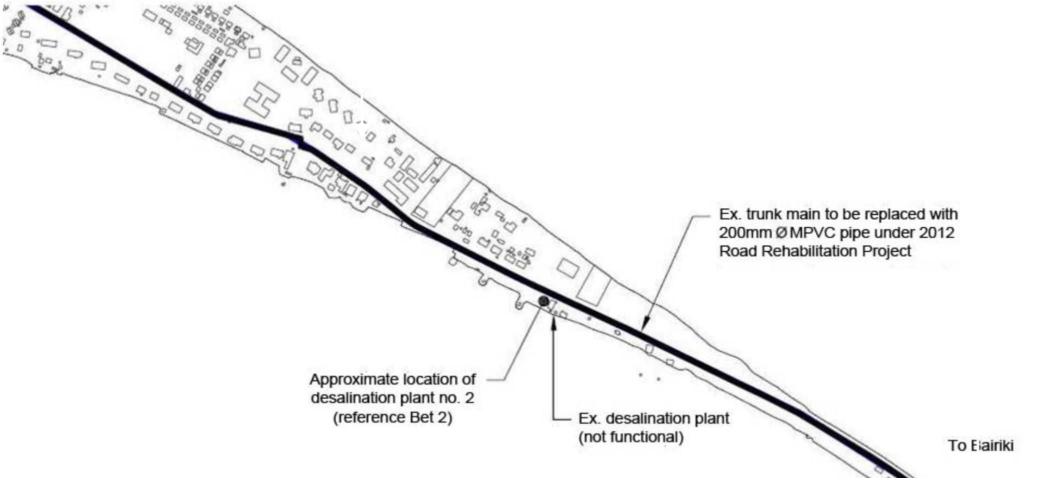


Figure 6: Location of Desalination Plant No.2 (Betio 2)

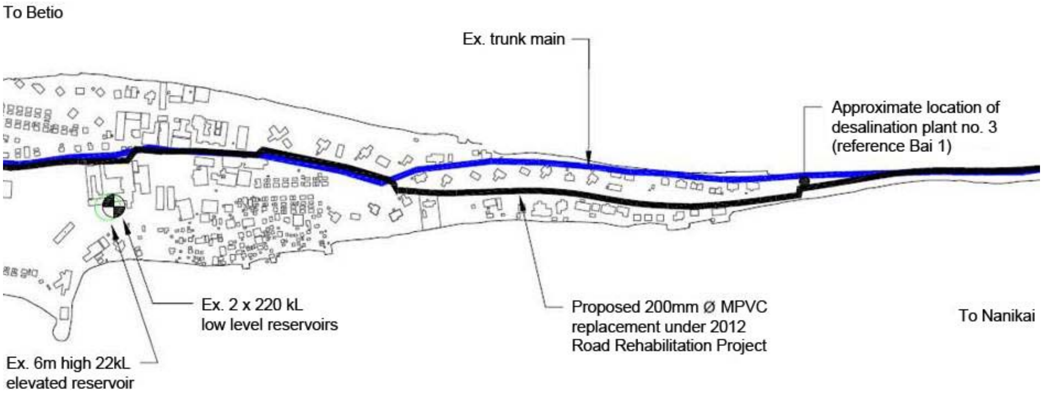


Figure 7: Location of Desalination Plant No.3 (Bairiki 1)

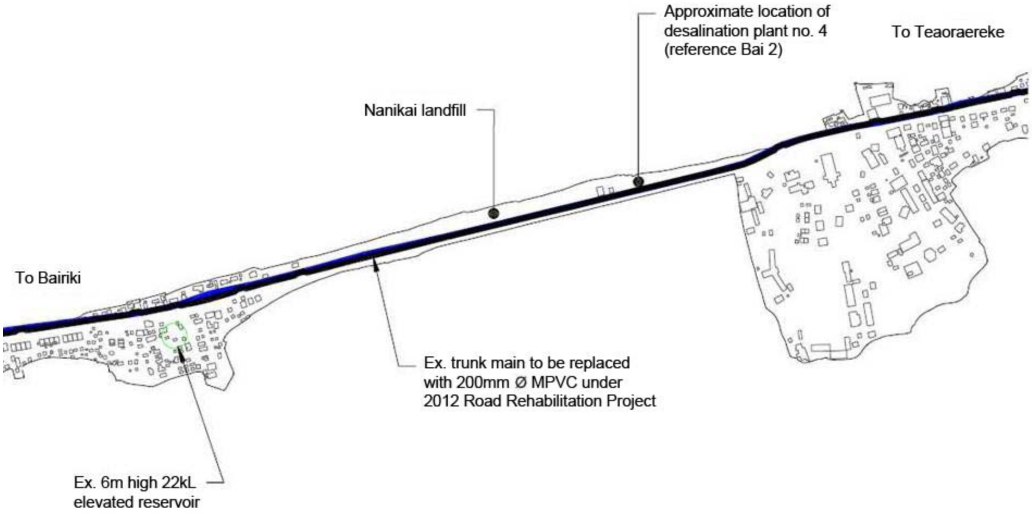


Figure 8: Location of Desalination Plant No. 4 (Bairiki 2)

6.5 Confirmation and Protection of Sites

130. The availability of the four selected sites was reviewed with the Director Lands, MELAD, MPWU and PUB. Agreement to the use of the sites for the desalination units was confirmed and letters were prepared and forwarded to the Secretary MPWU requesting the placement of an embargo on other uses of the land pending the completion of desalination feasibility study and a decision on the funding and implementation of the desalination plants.

131. A letter was also drafted for the secretary MPWU to forward to MELAD as a formal request for the protection of the sites. This letter was submitted on 28 February 2012. Copies of both letters are attached in Appendix C.

7. TOPOGRAPHICAL SURVEYS

7.1 Sites and General Configuration

132. All four sites have dimensions and a shape factor that will accommodate the desalination plants and associated buildings, equipment and storage tanks. The sites are level with flat contours, and with access to the main South Tarawa road, or in the case of the Desalination Plant No. 1 (Betio 1) site, access to the secondary road to the Betio Shipyards and Betio Landfill.

133. The sites are well located for the development of the boreholes and down well pumps for seawater abstraction and for the disposal and dilution of brine in the immediately adjacent ocean side intertidal platform or the port anchorage area in the case of Desalination Plant No. 1.. All sites lie in close proximity to the main 11,000kVA electricity cable with relatively short and convenient connection.

134. For the Desalination Plant No. 1 site the former landfill area within the site will require excavation, reworking and re-compaction with the placement of a minimum 300mm compacted depth of graded coral and sand hard fill to provide a stable and durable surface for the placement of the containerised modules. For Desalination plants No. 3 and 4 engineered hard fill will also be required to lift the levels of the sites to 3.7m on the SEAFRAME datum so the development is placed above assessed sea level rise and wave surge. The lagoon foreshore along the both sites will need protection in the form of constructed sea walls. Open channels with low nib walls to protect the hard fill will also be required along the road frontage (ocean side) of each site to divert storm water and water from wave surges overtopping the sea wall to vacant land past the sites.

7.2 Site Descriptions and Details

135. Information on each site is presented in the site descriptions contained in Appendix B.

7.3 Briefing of surveyors and Survey Activities

136. The Land Survey Office of MELAD was contracted to undertake a topographical survey of each of the four sites. The survey instructions called for the topographical survey of the area in the vicinity of the proposed desalination plants aligned to dimensions delineated on drawings made available to the surveyors. The specific terms of reference called for:

137. Coordinates and Projection:
   a. Grid: Tarawa Local Grid
   b. Projection: Transverse Mecator with Explicit Bound (0, 130000) to (70000, 200000)
   c. Datum: World Geodetic System 1984 (WGS 84)
   d. Spheroid: International
   e. Unit: Metre
   f. Meridian: 173°02' East of Greenwich
   g. Lat of Origin: Equator
   h. Scale Factor: 1,000
   i. False Coords of Origin: 40,000 mE, Nil mN

138. Vertical Datum:
   a. Vertical Datum: SEAFRAME

139. Scope of Works:

a. Survey ground levels (spot height) in a 3m x 3m grid;
b. Survey all topographical features e.g. buildings, structures, fences, Trees/vegetation, power, telecom etc.;
c. Survey road frontage, edge of seal and fix centreline, also site access points and roads;
d. Locate abutting property boundary and beach foreshore embankment. Also carry ground levels down to beach platform and high water springs for sites on both the ocean and lagoon foreshores.

140. Data Format:

a. Topographical features to be provided in AutoCAD DWG or DXF format
b. Ground levels to be provided in either point file, landXML file or excel table with x, y and z coordinates
c. MapInfo data would be useful

7.4 Topographical and site survey plans

141. The topographical survey activities were organized in the week commencing 27 February 2012 with the survey data and CAD drawing of each site becoming available in the following week of 5 March 2012. The survey data was checked by the team’s design engineer and CAD specialist and has formed the base of the feasibility study design drawings. The topographical plans are incorporated into the set of feasibility study design plans in Volume 2.

8. ENGINEERING DESIGN, DRAWINGS AND COSTS

8.1 Summary Description of Desalination Plants and SWRO Units

8.1.1 Outline of Process and Components

142. The details of the SWRO process have been described in section 3 of this report. The process is illustrated in summary form in Figure 9. This shows each stage of the process as a diagrammatic flow chart. The Arkal filter shown would only be installed if a shallow intake gallery is employed rather than the deep boreholes preferred for seawater abstraction. The subsequent statements confirm the nature of the key components allowed for in the design and estimation of costs. Figure 10 shows the process in profile.

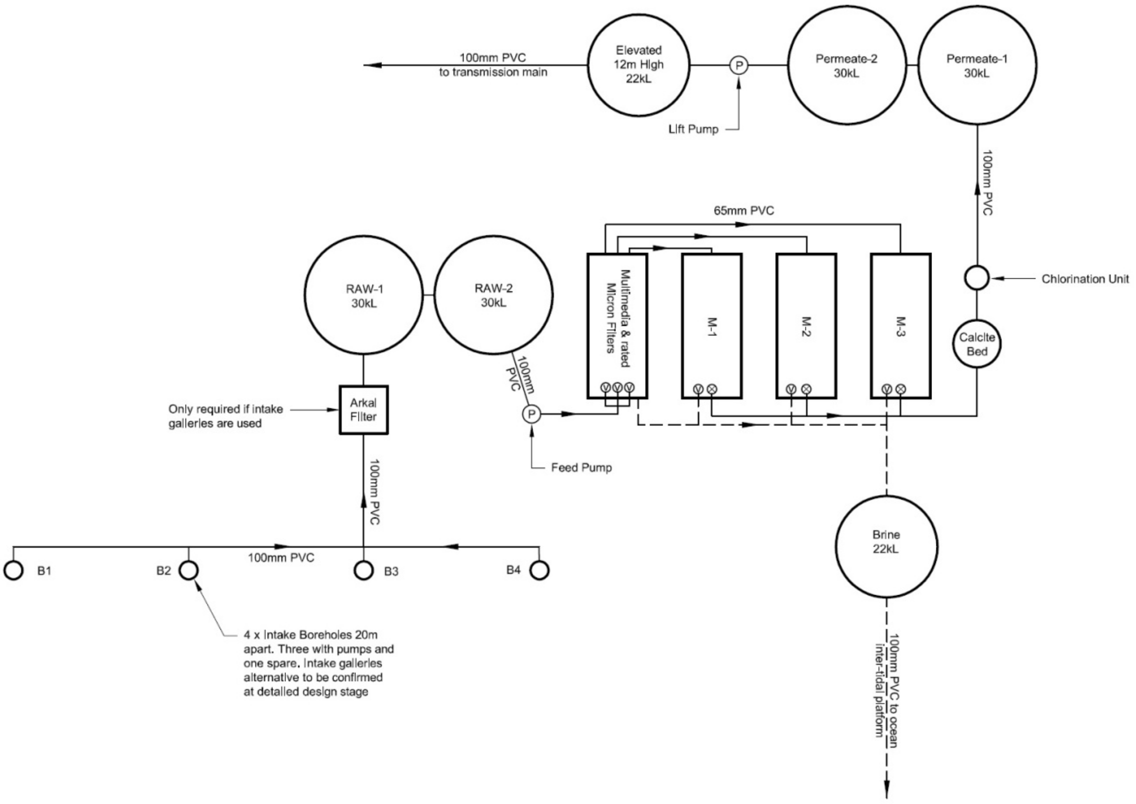


Figure 9: Plan Illustrating Desalination and SWRO Process

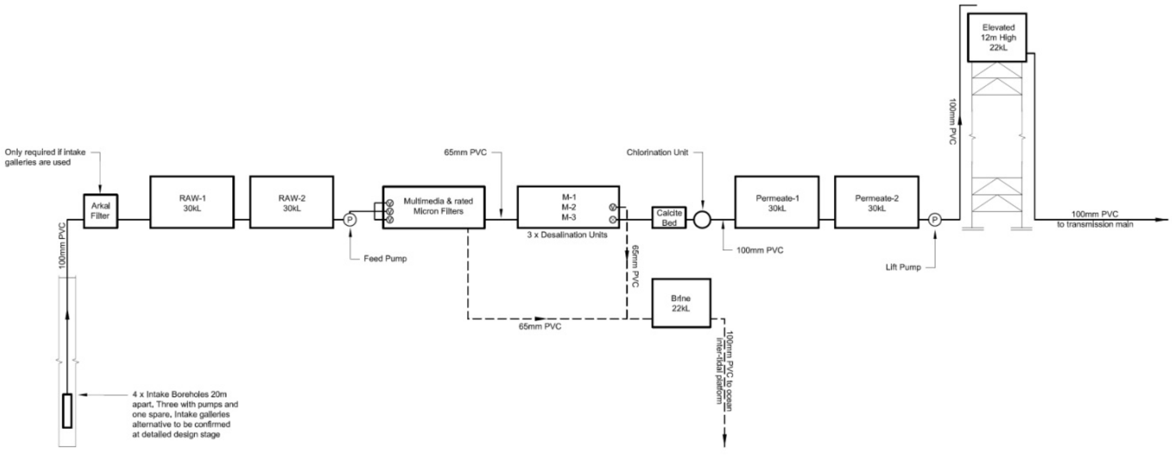


Figure 10: Profile of Desalination/SWRPO Process

8.1.2 Water Quality and Treatment

143. Each desalination plant of 3 SWRO units will produce 24kL of permeate (treated water) hourly and 528kL in a daily production cycle of 22 hours. The water will be pathogen free and of high quality. As indicated in section 3, before discharge to the transmission mains the treated water will pass through a calcite filter to reintroduce ions such as calcium and magnesium and to increase the pH level. At this stage the supply will be chlorinated to provide residual disinfection in the mains and service reservoirs.

8.1.3 Chemicals, Handling, Transport, Storage and Use (approach and risks)

144. The bid document for procurement will require the supply of a total system, with performance proven RO membranes as the core element together with compatible/ tailored chemicals that will have no proven environmental effects, are certified for use for potable water production systems and which are also capable of optimizing membrane performance. For Veolia Water SWRO units the membranes would be continuously dosed with the Veolia proprietary antiscalant chemical (Hydrex 4101) at a rate of 0.4g/m^3. Information provided by Veolia suggests 150 litres for annual dosage which is conservative and probably higher than the actual quantity likely to be used. The chemical is basically a commercial in-house developed product based on phosphoric acid but the concentration will have no impact on the characteristics of the water, particularly pH or the reject brine stream. The toxicological data and exo-toxicological data indicate no environmental issues.

145. Again for a Veolia Water SWRO plant two other chemical products, Hydrex 4701 and 4704 would need to be used intermittently. These two proprietary chemicals are generically similar to chemicals prepared by other membrane suppliers but have the essential requirement that they been fine tuned to match the Veolia developed membranes and will be used perhaps 4 to 5 times a year. Around 60 litres of each chemical is used per cleaning operation under clean-in-place (CIP) arrangements where the chemical will be circulated for a time in diluted form then discharged to the brine tank where they are diluted prior to discharge to the ocean. Scheduling of cleaning operations will be at high tide with high and rapid dilution so the chemical will have no measurable impact on the brine discharge or receiving waters.

8.2 Electricity Demand, Solar Versus Diesel Generation

8.2.1 Electricity Demand

146. The total electricity demand for each desalination plant and the four plants combined is summarised in Table 7 below. The operating costs of power consumption allow for a 42 percent energy saving in the RO modules through the energy recovery devices installed in the SWRO modules.

Table 7: Electricity Demand and Estimated Annual Cost

Each site 3 x SWRO modules
Feed rate : 57m^3/ hr Treated water producti roduction 24m^3/hr Daily production 528m^3/hr
Assume 22 hrs per day 48weeks per year.

No	Item	KW	Number	KW	Running hours	KWH	Unit cost	Daily power cost	Annual No of days	Annual power cost cost $
1	Bore pumps	5	3	15	22	330	0.7	231	336	77,616
2	Arkal filter (mechanical) r	0	0	0		-		-	336	-
2	Low lift to filters	2	3	6	22	132	0.7	92	336	31,046
3	Module HP filter	16	3	48	22	1,056	0.7	739	336	248,371
4	Air conditioning	5	3	15	24	360	0.7	252	365	91,980
5	Misc on site	0.5	1	0.5	24	12	0.7	8	336	2,822
6	High lift pump to reservoir (size) 6.7l/sec	7.5	1	7.5	20	150	0.7	105	336	35,280
				92	134	2,040		1,428	2381	487,116

Standby Generator: allow for generator start up 120

Assumptions:

a 3 bores each 20m^3/hr 5.6l/sec
b High lift pump size is provisional

Total Energy Consumption for 4 sites (rounded):	480
Hours per year:	319,872
Annual cost per site:	$487116,
Annual cost for 4 plants:	$1,948,464
Annual production per site:	528m^3 x 336 = 177,408m^3/yr

8.2.2 Electricity Demand and Capacity

147. PUB reports on power demand and peak loadings prepared for presentation to the Board indicate capacity to handle the four desalination plants. The situation however is constantly changing. For example, when the Water and Sanitation Roadmap 2011 – 2030 was being prepared the consultants confirmed that adequate capacity existed. This took account of the new fish processing plant being planned at the time for the Betio port area.

148. The EIA submitted for approval and consenting of the fish processing venture indicated that the plant would require 500kW for which the company would be installing its own generator to meet the demand. For water supply the EIA stated the company would install a dedicated desalination plant and operate without placing a demand on the PUB water supplies. The EIA was accepted as the basis for an operation that placed no demand on the PUB systems.

149. The reality however is different and the investigations for this feasibility study have confirmed that the company will be taking all its power from PUB. Water will also be purchased from PUB with the desalination unit being held in reserve for “drought” conditions. For power demand the EIA for the establishment of the processing plant indicates a demand of 500kW, whereas PUB reports sighted subsequently place the demand at 700-800kW. This demand absorbs a significant part of the previously available surplus capacity in the system.

150. Presently with the spectre of increased project activities in South Tarawa, additional hotels and guest houses are under construction. With continuing water shortages international organizations and local guest houses are considering the installation of packaged desalination units. Proposed port expansion and other developments will also increase the demand for electricity.

8.2.3 Standby Generation Capacity

151. In summary, while there is present capacity in the system to accommodate the four desalination plants, decisions regarding supplies to other activities and new electricity dependent ventures suggest that power shortages will undoubtedly arise in the near future

and, of more certainty, power outages will occur as a result of either inadequate maintenance, or the shutdown of generators for planned/ emergency repairs and maintenance.

152. Standby generators will therefore be required for each plant and have been included within the estimates of cost. The generators will be 120kVA capacity and be fitted with acoustic packages, with switchboards and controls providing for automatic switchover and manual over-ride.

8.2.4 Solar Power versus Diesel Generation

153. The terms of reference require consideration of solar power for the energy to run the desalination plants. While this is common for smaller packaged plants, for the reasons summarized below, solar power becomes questionable for plants of the size proposed for South Tarawa.

154. The use of solar power is attractive as a clean, free source of power, unaffected by periodical spikes in global oil prices. Solar power is already used for various forms of water purification, including desalination, although invariably on a smaller scale. SolarSpring in Germany, for example, produce stand-alone units that produce 4–6 kilolitres of potable water per day, from seawater sources[9]. Producing potable water by desalination on a municipal scale, however, involves several challenges relating to the extent of the field of capture of solar energy, difficulties in meeting demand at night and during cloudy and inclement weather, difficulties in storing energy and, where solar energy may be a partial source, practical difficulties in hybridising more than one energy source. When using existing, well-established technologies, such as PV cells for collection of solar energy, and efficient desalination plant, a large capture area is vital.

155. The efficiency with which PV panels can transform solar power incident on them into electrical power depends on a number of factors including level of absorption and temperature of operation. Third generation PV cells may have an efficiency of up to 20 percent[10] (although to date, efficiencies of 12 percent are more common). With consumption of around 360,000kWh a year for the RO modules alone and a total of 685,400kWh for the full plant including all pumps, equipment and miscellaneous power needs will require a battery of PV cells of around 4,200 m^2 in extent. This is no small matter given the land availability and acquisition issues on South Tarawa and would undoubtedly present considerable difficulties.

156. Large banks of batteries will be required to store energy for operations during poor and cloudy weather, and during night hours. In the tropics experience has shown a need to house batteries in stable conditions with air conditioning to maintain temperatures for peak operating efficiency. The failure of batteries under high temperatures and humid conditions has been one of the more significant lessons learned, plus the high cost of replacement which adds the costs of producing water by solar powered SWRO. These considerations coupled with problems associated with the regular disposal of batteries raise environmental issues which beg practical solutions in locations such as South Tarawa.

157. In reality, providing a continuous water supply over the a 24 hour period and at times of low insolation would mean that power for desalination would have to be sourced from an

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[9] http://www.solarspring.de/fileadmin/templates/solarspring/Downloads/MMD_DesalinationSystems_SolarSpring2011.pdf

[10] www.climatelab.org

alternative, back-up source as well as sunlight, if satisfactory levels of service are to be met. The use of a backup power source would entail considerable sophistication in terms of the complexity of control systems and operator competence. The technology to do this is not well developed at present.

158. Further afield, solar powered desalination on a municipal scale is in its infancy. A scheme is planned in Port Augusta, South Australia with several high technology features to overcome inherent constraints. These include the use of parabolic troughs to concentrate solar power and therefore allow a slightly smaller area on which to situate photovoltaic cells, a complex energy storage system, and the use of gas as a backup power source.

159. The only practicable way for considering solar generation would be to use funding for the SWRO to establish solar generation to enter the grid and to offset, in part, the energy consumed from the PUB grid. This would mean using roofs of government buildings, schools, churches etc. For a full trade off for the power requirements for the SWRO plants 1.68 ha (16,800m^2) of roof space in total would be needed. Each roof would have to have an inverter for integration into the grid. The servicing of inverters would be basically impractical, but sourcing and maintaining a stock of spare units would cover the maintenance/repair needs.

160. Should a trade-off solar power generation initiative be embarked on, the integration of solar derived power into the grid would be all the more easier by the fact that peak generation tends to coincide with peak usage, as the main surges in use are air conditioning when solar radiation is at its highest.

161. In conclusion solar power cannot be used conveniently to power the desalination units, but could be used to partially substitute for the power the desalination units draw from the grid. This will add considerably to the capital costs of the desalination plants.

8.2.5 Transformer and Cabling Requirements

162. All sites are either adjacent to or in close proximity to the main 11KV high voltage cables. The desalination plants can be connected to the main cables with individual ground mounted transformers. The requirements for connection have been discussed with PUB and the following statements summarize the need for each of the desalination plants.

163. Desalination Plant No.1 (Betio 1) will require; (i) 95mm^2, 4core and earth cable to maintain voltage drop within 5%, 140m length; and, (ii) costs of trenching, cable laying, jointing and connection. The present PUB transformer is adequate for the connection of the desalination plant.

164. Desalination Plant No. 2 (Betio 2) at Takoronga will require; (i) a 200kVA 11kV/433V ONAN ground mount transformer. Outdoor type, 3phase, oil immersed and naturally cooled. Vector group Dyn11; (ii) 11kV cable for connection. Cable specification of 70mm^2, 3Core, PCW - 6.35/11kV XLPE with wire armour, 35m length; and, (iii) costs of trenching, cable laying, jointing and connection.

165. Desalination Plant No. 3 (Bairiki 1) will require; (i) a 200kVA 11kV/433V ONAN ground mount transformer. Outdoor type, 3phase, oil immersed and naturally cooled. Vector group is Dyn11; (ii) 11 kV cable for connection. Cable specification of 95mm^2, 3Core, PCW 6.35/11kV XLPE with wire armour, 35m length; and, (iii) costs of trenching, cable laying, jointing and connection.

166. Desalination Plant No. 4 (Bairiki 2) will require; (i) a 200kVA 11kV/433V ONAN ground mount transformer. Outdoor type, 3phase, oil immersed and naturally cooled. Vector group Dyn11; (ii) 11kV cable for connection. Cable specification of 95mm^2, 3Core, PCW 6.35/11kV XLPE with wire armour, 35m length; and, (iii) costs of trenching, cable laying, jointing and connection.

167. These items have been included in the Bill of Quantities and allowed for in the estimates of cost. The 200kVA transformers have a base cost of around $20,750 each, ex manufacturer in Australia. The 95mm^2 cable costs $50.21/m and the 70mm^2 cable $37.32/m landed in South Tarawa.

8.3 Description and Specification of Required Works by Component

168. The statements in this section summarise the general specifications for each item and the specific requirements relating to their design and estimated costs. In keeping with the harsh operating environment of South Tarawa provision has been made for highest quality items and standards.

8.3.1 Raw (Sea) Water Bores, Pumps, Controls and Raw Water Tanks (including pipes, fittings, valves and electrical)

169. The raw water boreholes will be drilled to a diameter of 200mm and sunk to an average depth of 35m. All boreholes will have an internal casing of 150mm PVC lining which will be left with a 1m up stand. Slotted PVC screens of approximately of 18m depth will be installed in all boreholes with a surround filter of packed and graded aggregate. One borehole will be sunk initially as a test borehole at each site and will be tested to confirm the sustainable abstraction rate that can be expected. The other boreholes will only be constructed if the tests indicate satisfactory flows. If flows are inadequate the design will revert to the use of the shallow seawater galleries indicated as an alternative in the feasibility design drawings.

170. Provision is allowed for the supply and installation of 100mm 409L grade stainless steel down well pumps complete with 100mm PVC discharge pipes, discharge manifold, valves, pumps and controls in the three operating bores, with a spares pump. A control board will be provided for at each site, with low-level in-bore cables for the operating bores.

171. There will be advantage in constructing the boreholes at the same time as the proposed sewer outfall pipelines at Betio, Bairiki and Bikenibeu while the specialised drilling equipment and drill crews are in South Tarawa, thereby reducing mobilisation/ demobilisation and related costs, with associated economies of scale. The boreholes would be constructed, tested and developed with the placement of screens, casing and surround filter material and annulus seals, and capped for the future placement of the down well pumps when the contract for the construction of the desalination plants proceeds. Water samples could be gathered and tested, and reflected in the specification for the design of the SWRO units, to allow for the final design of the SWRO modules.

172. Provision has been made to install an Arkal mechanical filter on the raw water feed line prior to the raw water storage tanks to remove sand and coral grit from the supply, but only if the alternate infiltration gallery source water system is required. Dual interlinked 30kL roofed water tanks will be installed and commissioned. The tanks will be mounted on a 600mm high concrete block and concrete plinth and will be fitted with a bottom discharge and valve for purging and flushing to the brine disposal system. Non-corrosive and high uv resistant materials will be specified for the tank construction.

8.3.2 Package SWRO Units (including pre-filtering and backwash, and RO membrane flushing and cleaning)

173. The SWRO modules (three per site) will be modularized in 20-foot skid mounted containers with the costs allowing for factory testing prior to dispatch. The price includes the low pressure feed pump(s), the multi-media filter(s), rated micron filter(s), the high pressure pump(s) to the RO membranes; the RO module(s and all containers, as specified). The estimate also includes the switch/control board(s), all valves and fittings, filter backwashing provisions, air conditioning and all general electrical requirements all complete and ready for site placement and connection. The containers will be prepared and painted to with a three coat, two-pot marine grade standard with etched, undercoat and finish coats.

174. Four containers (three RO modules and one filter module) will be placed on site at the Desalination 1, 2, 3 and 4 sites. For the Desalination 2 site the prevous desalination building will be stripped and converted to a filter house, parts/ material store and office.

175. Pipes within the RO modules will be 904L SS or Zecron 254SMO and PVC; Pumps will be super duplex or 904L SS (depending upon the water analysis); the pressure vessel will be FRP; the RO will have a clean-in-place (CIP) system; and, as shown above each unit will have a fibreglass tank where fresh water is diverted and when the plant shuts down this supply will be used to flush the system to prevent scaling.

8.3.3 Civil Works and Structures

176. Provision has been allowed for site preparation and formation, for plant offices, amenities, safety equipment and the provision of site services, security including fences, lockable gates and lighting, and landscaping within the site security fences. All sites will be formed with a compacted and stable coral aggregate surface. As indicated previously, and where required the formation levels will be lifted to provide free board from inundation and protection in the form of sea walls will be constructed along site foreshores where these abut onto the lagoon. Site drainage, and open channels for the diversion of storm water and wave surge have also been provided for in the feasibility design and carried into the cost estimates.

8.3.4 Permeate (Treated) Water Storage and Connection to Transmission Mains

177. The connection to the transmission network will consist of a 2 x 30kL roofed ground level reservoirs, a high volume lift pump, an elevated 22kL roofed reservoir with all pipes, valves and fittings. The tanks will be constructed of non-corrosive, high uv resistant material. As for the raw water tanks. The ground level treated water tanks will be mounted on a concrete block and concrete plinths with a bottom discharge and valve and with a connection to the brine disposal system to allow for purging and cleaning. Chlorine dosing will be introduced after the calcite bed. The high level reservoir will be mounted on a prefabricated steel tower with a 12m head with all pipes, valves and fittings. A float valve will be installed to close off the intake when the reservoir is full and float switches will control filling via the lift pump and there will be control interlocks with the bore pumps and the RO system. The high level reservoir will be connected to the transmission main.

178. The elevated towers will be designed, fabricated, galvanized, packed and shipped to South Tarawa complete with access ladders, platforms, gratings and railings. The towers will be erected on foundations constructed for their support and shall be spray painted on site, following their erection with a three-coat, two-pot marine grade finish consisting of etch, undercoat and top coat.

8.3.5 Brine Tanks and Disposal

179. A 22 kL brine tank shall be provided at each site with the tank again being roofed and manufactured from non-corrosive and high uv resistant material. The brine tank will be plinth mounted for purging and cleaning and will discharge to the brine disposal system at the site, as illustrated in the feasibility design drawings. There is the option also of pumping the brine into the seawater flushing systems at Betio and Bairiki as a backup to the seawater intake filters provided for the sewerage flushing systems.

8.3.6 Pipes, Valves and Fittings

180. Al pipes, valves and fittings used to plumb in the installation will be PVC and non-corrosive. All pipes will be adequately protected and buried or covered to prevent uv deterioration. Where exposed the pipes will either be inserted into outer conduits or appropriately painted with water based latex paints to avoid becoming brittle.

8.4 Drawings and Estimates of Cost

8.4.1 Drawings

181. Feasibility design drawings have been prepared and are incorporated as Volume 2: Desalination Feasibility Study Plans and Drawings. These are produced in A3 size for clarity and include site cross-sections and preliminary construction details. The drawings are numbered 50663 sheets 701 to sheet 736 respectively. An index of drawings is provided as the front page of volume 2.

8.4.5 Bills of Quantities

182. A comprehensive set of Bills of Quantities for the four desalination plants have been developed and are incorporated in Appendix D. These schedule the anticipated items of work and form the estimates of cost.

8.5 Estimates of Cost

183. The estimates of cost have been developed from prices and indicative quotations sought from suppliers of the respective items in Australasia, New Zealand and Fiji. Provision is made for sea freighting, transport and handling from source location in the country of origin, to the work site in South Tarawa including port handling and clearance charges, plus internal transport and handling/ installation on site. The Bills of Quantities summarise the specifications for each item and the standards for manufacture and installation. Local costs and unit rates, where these apply, have been extracted from the MPWU schedule of prices and unit rates used for the checking and verification of tenders received for local supplies, and civil works.

184. As a further cross check the unit rates and costs for comparable NZAP and KAP II project activities, for example the construction of protective sea walls have been used to define the costs for similar work associated with the desalination plants. Contingency and other allowances have been provided comparative to project risk and detailed design and supervision have been provided.

185. Tables 8 and 9 summarise the component costs for each desalination plant and the combined plants with either the boreholes or the shallow intake galleries for the abstraction of sea water as the feed source for the plants.

Table 8: Summary of Costs with Borehole Intakes

SOUTH TARAWA DESALINATION WITH BORE HOLE INTAKES					
REF	**ITEM**	**ESTIMATE A$**			
		DESAL 1	**DESAL 2**	**DESAL 3**	**DESAL 4**
100	PRELIMINARY AND GENERAL	43,875.00	43,875.00	43,875.00	43,875.00
200	DESALINATION SWRO MODULES AND PRE-TREATMENT	1,362,290.00	1,362,290.00	1,362,290.00	1,370,690.00
300	CIVIL AND ANCILLIARY WORKS	90,680.00	82,780.00	87,000.00	97,200.00
400	GENERATOR	52,500.00	52,500.00	52,500.00	52,500.00
500	INTAKE BOREHOLES AND PUMPS	176,625.00	176,625.00	176,625.00	176,625.00
600	PIPES AND FITTINGS	93,940.00	24,340.00	21,940.00	18,595.00
700	STORAGE TANKS AND PUMPS	248,400.00	248,400.00	248,400.00	248,400.00
800	ELECTRICAL	46,679.00	64,007.00	63,606.00	63,606.00
	SUBTOTAL SEPARATE DESALINATION PLANTS	2,114,989.00	2,054,817.00	2,056,236.00	2,071,491.00
	TOTAL				**8,297,533.00**
	CONTINGENCY 12%				995,703.96
	ENGINEERING - FINAL DESIGN AND SUPERVISION 3%				248,925.99
	GRAND TOTAL				**9,542,162.95**

Table 9: Summary of Costs with Gallery Intakes

SOUTH TARAWA DESALINATION WITH GALLERY INTAKES					
REF	**ITEM**	**ESTIMATE A$**			
		DESAL 1	**DESAL 2**	**DESAL 3**	**DESAL 4**
100	PRELIMINARY AND GENERAL	43,875.00	43,875.00	43,875.00	43,875.00
200	DESALINATION SWRO MODULES AND PRE-TREATMENT	1,362,290.00	1,362,290.00	1,362,290.00	1,370,690.00
300	CIVIL AND ANCILLIARY WORKS	90,680.00	82,780.00	87,000.00	97,200.00
400	GENERATOR	52,500.00	52,500.00	52,500.00	52,500.00
500	INTAKE GALLERIES	201,670.00	201,670.00	201,670.00	201,670.00
600	PIPES AND FITTINGS	93,940.00	24,340.00	21,940.00	18,595.00
700	STORAGE TANKS AND PUMPS	248,400.00	248,400.00	248,400.00	248,400.00
800	ELECTRICAL	46,679.00	64,007.00	63,606.00	63,606.00
	SUBTOTAL SEPARATE DESALINATION PLANTS	2,140,034.00	2,079,862.00	2,081,281.00	2,096,536.00
	TOTAL				**8,397,713.00**
	CONTINGENCY 12%				1,007,725.56
	ENGINEERING - FINAL DESIGN AND SUPERVISION 3%				251,931.39
	GRAND TOTAL				**9,657,369.95**

8.6 Impact of Planned Road Improvements

186. The location and design requirements for all the sites have been discussed with the Team Leader for the Kiribati Road Rehabilitation Project to assess the likely impact on the road if the desalination plants are constructed following the road improvements. The situation for each site is described in the following paragraphs.

187. Desalination plant No.1 (Betio 1) is at the edge of the Betio landfill site near the port. It is well clear of any road improvements. In Betio the work on the main road will be confined to very limited carriageway repairs to correct localised drainage problems, e.g. the flooding outside the Moels supermarket. Other improvements will be relatively minor. The desalination work provides for a new 100 mm diameter pipe to be installed as part of the transmission system from the desalination plant to connect with the replacement 200mm transmission main being installed by the road project in the vicinity of the PUB works depot. It is anticipated the pipe will be laid behind the kerb line but there will be the need for some road crossings, e.g. the main road to the Port. From the explanation received this seems to

be outside the road upgrading works however if this intersection is to be upgraded then either conduits to be left, or the length of main across the intersection to be laid in advance.

188. Desalination plant No. 2 is in the same location as the former desalination plant in Betio, opposite the road to the Captain’s bar. At the moment there are no plans to lay pipes across the main road, but as the design develops there may be a need for a pipe line for a water intake from a gallery in the lagoon (near the Captain's bar) if the tests for the initial exploratory bore holes show the inability to abstract sufficient quantities through the bore holes. This is unlikely, but could be an eventuality that needs to be considered. The road rehabilitation project has no plans for road works on the main road in this vicinity. While the secondary road to the Captains bar may be a candidate for sealing - this won't be full width and there will be scope to lay the pipe clear of any improvement works.

189. Desalination Plants No.3 and No. 4 are in areas where improvements to the main road are scheduled. There will be the need for several road crossings in both locations, one for a brine disposal pipe line and one to bring the connecting cables from the PUB 11,000 kVA cables to the site. The present feasibility study design will locate these accurately and there should be no problem for the road project to locate conduits allowed for in the design in appropriate alignments to suit.

190. There are possible synergies between the projects. The sites for desalination plants No.3 and No. 4 will need to be raised slightly to a finished level at 3.7m SEAFRAME datum to lift the developments above the future sea level rise and wave surge identified under KAPII. This will require placement of fill, the construction of protective sea walls along the lagoon foreshore of each site, and a low nib wall to retain the fill on the main road side of the sites with an open surface drain to divert storm water and wave over break over the outer sea wall past the site and into adjacent vacant land. There are possible advantages in having these works handled by the road project, so that the sites are ready for the subsequent placement of the desalination plants.

8.7 Other Water System Improvements

191. The Roadmap has identified the immediate water supply improvement required alongside the provision of source of additional fresh water. The requirements and the justification for the improvement are comprehensively covered in section 41 “Water Supply Upgrading and Maintenance, sub-sections 41.1 to 41.8. The recommended improvements are summarised in Table 10.

Table 10: Water System - Summary Other Improvements and Costs

No	Description	Cost ($)
1	**Bonriki Gallery Management**	
a	New 150 mm electromagnetic meter on raw-water line with remote indicator for accumulated and instantaneous flow.	5,000
b	Provide replacements for all 22 mono -pumps and motors plus 5 spares.	60,000
c	Replace 22 water meters plus 5 spares, install Y strainers on meter line, and fit sampling point on raw water line.	20,000
d	Provide and install electricity consumption meters for 22 gallery pumps. 1 Betio WTP and 10 reservoirs and miscellaneous other pumps.	4,000
e	Down rate Bonriki pumps to safe yield - to be done during refit of pumps.	500
2	**Bonriki Treatment System**	
a	Upgrade aerator to cater for Bonriki and Buota combined, plus increased supply from Bonriki. Install sampling point post-aerator replace support framework for pipe between aerator and reservoir.	100.000

b	Purchase new chlorine cylinder changeover valve and associated equipment for second chlorine cylinder or convert to flow proportional calcium hypochlorite tablet feeders. Change the chlorine dosing point from post-reservoir to pre-reservoir.	5,000
c	If converting to calcium hypochlorite tablets convert the existing chlorine cylinder room to dry secure storage.	10,000
d	Supply two Palin brand 7100 photometers and chemicals for chlorine testing at (i) Bonriki and (ii) Betio.	8,000
e	Replace the existing 150mm treated water meter with an electromagnetic meter with remote reading of accumulated and instantaneous flow.	5,000
3	**Transmission main**	
a.	Install 3 electromagnetic/ district type water meters at pre-determined locations on the transmission main and fit pressure gauges at strategic locations.	18,000
b.	Supply and install and retain spare meters for replacement 10 x 100mm water meters to elevated reservoirs and 22x 50mm water meters from the elevated reservoirs.	35,000
4.	**Service reservoirs**	
a.	Repairs and replacement works as prescribed in Roadmap for each reservoir.	50,000
b.	Confined space safety equipment and formal training plus cleaning equipment for reservoir and manhole work.	25,000
c	Develop a methodology and implement a reservoir cleaning program over 24 months.	-
4	**Chlorine residual monitoring**	
a.	Implement a monitoring plan for chlorine residuals in the network.	-
b.	Implement contingency plans for non compliance.	-
5	**Institutional change**	
a.	Implement the recommendations in the TA-7359-KIR institutional Report and carry out the required 'change' program.	-
.	**Subtotal**	**$345,500**
	Contingency 10%	34,500
	TOTAL)	**$380,000**

192. Provision will also need to be included for water meters which have been included in the Roadmap as a four year program at an estimated cost of $1,086,000. Present provisions in the road map anticipate that the program will commence early in 2014. An earlier start in 2013/2014 would see the program rolling out over a longer period, but at the same cost.

9. ENVIRONMENTAL ASSESSMENT

9.1 Provision for Environmental Assessment and Management under STSISP

193. An Environmental Assessment and Review Framework (EARF) has been prepared for the STSISP, setting out the requirements for environmental assessment and management planning, in accordance with the requirements of the ADB and of the Government of Kiribati. The EARF has been officially approved by both the ADB and the Government of Kiribati. An initial environmental examination for the supply, installation and operation of SWRO plants has been prepared and is included as Appendix E. As required in the EARF, the IEE includes a description of the project, a description of the environment, prediction and analysis of environmental impacts, identification of suitable mitigation, provision of an environmental management plan, plans for environmental monitoring, an analysis of alternatives and provision for grievance redress. Assessment work has included consultations with the relevant stakeholder groups.

9.2 Summary of Impacts

194. The principal impact from the SWRO plants is the avoidance of the severe public health situation that would result as a consequence of population growth and perpetuation of the existing situation, where a significant number of households have to resort to the use of unsafe sources for their drinking water. The IEE examines several potential impacts relating to operation that are found to be not significant. These are (i) the effects of brine discharge on marine ecosystems (ii) effects of release of periodically produced backwash water, (iii) the impact on landfills of the use of disposable filter cartridges, (iv) noise from the plants and (v) fumes from the plants. Impacts relating to operation that require mitigation are (i) the use of disinfection and anti-scaling agents, and (ii) risks associated with plant failure. Mitigation is mainly achieved by training in operation and the use of maintenance contracts.

195. Impacts relating to construction are found to be (i) construction noise, which will be mitigated by imposing high standards on plant to be brought to Tarawa for construction, (ii) dust and fumes from construction operations, again limited by the use of good quality plant, (iii) safety hazards, mitigated by good safety practice which will be a contractual requirement for the plants' installers. Risks of damage to property and utilities are very low, but good standards of work supervision will remain a requirement to make certain that any such impacts are avoided.

196. The use of fill material to raise the level of each site beyond vulnerability from flooding will potentially result in secondary impacts at the site of materials extraction. However licensed and materials extraction, planned for the imminent Temaiku subdivision project and the Kiribati Road Rehabilitation project will generate an adequate surplus of materials. The requirement material will be sourced from these projects. Other secondary impacts and cumulative concern the knock-on effects of improved public health and of improved plant operation capacities and are positive.

9.3 Findings of the IEE

197. The IEE, which included site visits undertaken during the feasibility study, consultations with a range of project stakeholders, consultations with SWRO manufacturers, computer modelling of water flows and a review of documentation finds no significant residual negative environmental impacts, following the implementation of specified mitigation measures. The analysis of alternatives confirms that the use of SWRO is the only practicable means of augmenting existing freshwater supplies. The overall finding of the IEE is that the subproject will not cause significant environmental problems and that potential adverse

impacts are manageable through the implementation of the EMP. No further environmental assessment is therefore required.

9.4 EMP

198. The EMP provides for mitigation measures to be implemented during the construction. Monitoring of output water at quarterly intervals is recommended and of the brine discharge and less frequent, half yearly intervals.

10. ECONOMIC ASSESSMENT

10.1 General

199. The economic assessment has assumed that refurbishment of the network and rehabilitation of the Bonriki/Buota reserves and the water treatment plant at Bonriki will proceed over the three year period 2013-2015. In accordance with the approach outlined in this feasibility study, the South Tarawa water supply system is divided into two districts: (i) east – Antemai to Bonriki/Buota and (ii) west – Betio to Antemai (see the map referenced Figure 4 on page 38). Each district contains approximately half of the network and half of the connected consumers[11]. The piped network in each district must be suspended while remedial work is carried out on the network in that district. It is assumed that piped water delivery in each district is sequentially suspended for a period of 18 months beginning with the west district, i.e., the west district will be suspended from the beginning of 2013 to mid-2014, followed by suspension of the eastern district from mid 2014 to the end of 2015. This allows time for (i) leak repair and loss reduction in the piped network in each district, (ii) refurbishment of all customer connections (and detection and elimination of illegal connections) and installation of volume meters for all connections, (iii) establishment of supply kiosks to service customers during the suspension period, and (iv) installation or rehabilitation of water-source works (i.e., the SWRO plants in the west district and rehabilitation of Bonriki/Buota in the east district). At the end of the suspension period in each district, the piped network will be of high integrity with low losses, all connections will be metered, and sources of fresh water supply will be reliable.

200. A 'With project' scenario is compared directly to a 'Without project' scenario in order to make explicit the benefits of the project and its incremental costs over the project lifetime. To be conservative, the analysis is based on the assumption that the full potential of existing groundwater resources is exploited whether or not the SWRO plants are introduced[12,] i.e., that the urgent network maintenance outlined above (loss reduction and rehabilitation of Bonriki/Buota) are undertaken by PUB under both the with project and without project scenarios.

201. It is assumed that the bulk of this work is undertaken in the period 2012-2014, as summarised in Table 11 below. There is little doubt that these expenditures, totalling approximately $5 million over four years, will need to be externally funded. However, for economic analysis purposes, they are not included in the total economic costs associated with the with project scenario.

Table 11: Estimated Costs and Schedule of Remedial Works

Description	2012	2013	2014	2015
Leak repairs	$260,000	$200,000	$200,000	$200,000
Demand management (bulk meters)	58,000			
Reservoir repairs		82,500		
Supply connections (incl consumer meters)			398,084	413,103
Reconnect Buota supply	37,000			

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[11] In 2012, there are approximately 7,200 household connections and 500 business connections.

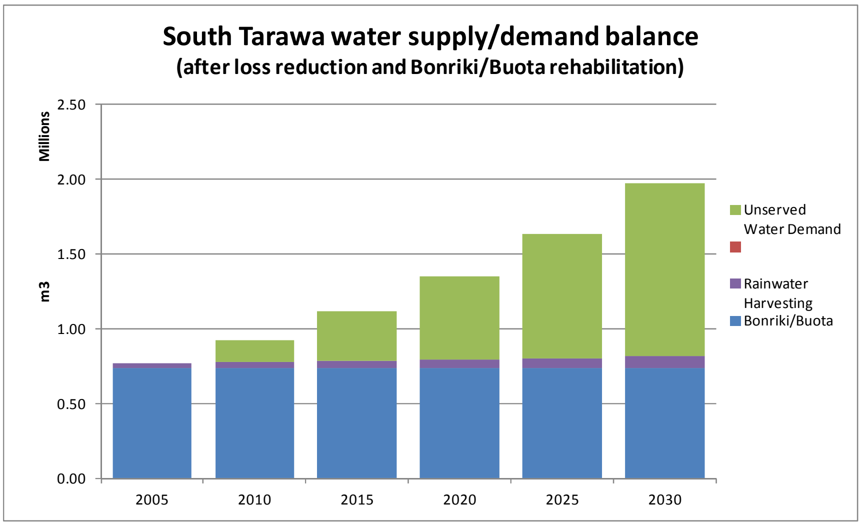
[12] It is emphasised that without this assumption, the 'without project' scenario becomes untenable, as approximately 2/3 of the water supply cannot be delivered to consumers. As tank trucks have limited capacity; a viable piped network is required for effective delivery of water to consumers for survival under either scenario.

Supply protection (Bonriki/Buota)	80,000	60,000	60,000	
Bonriki improvements:				
Clearing of palms	272,000			
Infilling old borrow pits		2,500,000		
Gallery management	98,500			
Water treatment plant improvements	141,000			
Totals	**$946,500**	**$2,842,500**	**$658,084**	**$613,103**

10.2 Without project scenario

202. The current water supply system in South Tarawa is in such straits that Kiribati faces an existential choice: either address the looming water supply deficit or face the prospect of South Tarawa becoming progressively uninhabitable. A "basic water requirement standard for human needs" has been defined as 50 litres per capita per day (l/c/d)[13]. For this analysis, a standard for South Tarawa of 50 l/c/d (domestic and industrial/commercial) has been adopted to define a "needs based" water demand subject to expected population growth. Under this definition of minimal water needs, the prospect for South Tarawa without the project (but with the network and Bonriki/Buota maintenance completed as described above) is illustrated in the figures 11 and 12 below, showing a progressive increase in "unserved water demand" and a declining ability of the system to deliver water to consumers, expressed in litres per capita per day.

Figure 11: Water Supply Balance after Leak Detection and Bonriki and Bouta Improvements



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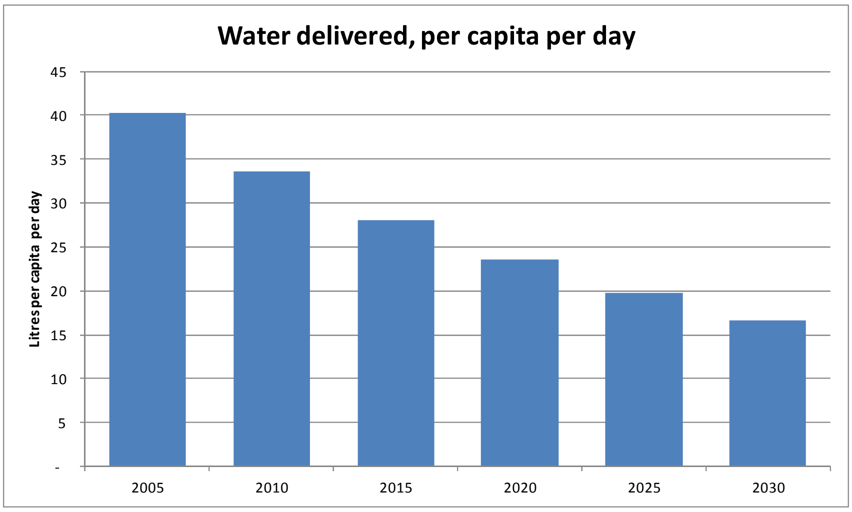
[13] Gleik, Peter H., "Basic Water Requirements for Human Activities: Meeting Basic Needs", Pacific Institute for Studies in Development, Environment, and Security, California, USA, *Water International*, Vol 21, No 2 (1996)

Figure 12: Water Delivered per Capita per Day



203. The increasing incapacity of the current water supply system to provide for the minimal water needs of the population of South Tarawa will have number of possible consequences. The without project scenario outlined below is an attempt to select the most likely (and least cost) of these and thus present a conservative analysis. Because the existential issue for South Tarawa is so stark, plausible consequences of the without project scenario include a steady deterioration of the quality of life, mounting disease, rapidly increasing rates of death of the most vulnerable (the old and the young), and forced migration. However, as a practical matter, it is prudent to expect a series of ad hoc emergency responses to water shortages, mounted as needed by the government with assistance from outside agencies (e.g., bilateral aid donors). It is assumed that the emergency response would be to bring in water from overseas to alleviate immediate shortages, as has been done in response to past droughts in other Pacific island countries (in recent years in FSM, Palau, Tuvalu, and Tokelau). In a typical instance, temporary arrangements are set up onshore to handle storage and distribution needs which, once the short term crisis has passed, are dismantled. In the without project scenario in South Tarawa, the extent of water shortages through time can be predicted, leading to (in the myopic nature of short term emergency responses) an increasingly-frequent series of repetitive costs. To facilitate analysis (and, again, to be conservative in characterising the costs associated with the without project scenario), the PPTA consultants have estimated the costs of setting up a permanently available bulk water supply import mechanism for South Tarawa to offset anticipated water shortages over the next 30 years. Such costs will not exceed, and are very likely to be less than, the sum of costs of mounting an actual series of ad hoc emergency responses. The avoided costs of the without project scenario, based on the estimated bulk-import costs and briefly summarised in Table 12 below, are the basis for quantifying the benefits of the with project scenario.

Table 12: Estimated Monthly Costs of Shipping and Distribution of Bulk Water Supplies

Item	Unit	Rate	Quantity	Amount	Rationale and Comment
Purchase of water - say Fiji	kL	$1.50	60,000	$90,000	
Shipping of Bulk Supplies	per load	$350,000	1	$350,000	Volume to meet water deficit
Port handling & clearance costs	per load	$15,000	1	$15,000	Based on cost of pumping to tanks at 2% of freight costs

Drivers for tankers	Per month	$600	10	$6,000	Based on $9,000 annual salary/wages per driver, taxes removed, 10 tankers
Vehicle maintenance	unit	$250	10	$2,500	Estimated at 5% of capital cost annually
Monthly fuel cost for tankers	litres	$1.20	3,000	$3,600	Based on average mileage of 100 km a day (5 loads and 10 litres per 100 km
Tanker leasing costs for ‘floating storage’	Per month	$450,000	1	$450,000	Based on leasing costs of 1 tanker of 60,000 kL (tonne) capacity, at $15,000/day
Subtotal, Monthly				$917,100	

Consultant estimates.

204. Shipping and tank truck costs are subject to expected real increases in the price of fuel, in the ‘basecase’ assumed to be 1.9% per annum.

205. A ‘permanent’ bulk-import scenario for South Tarawa is constrained mainly by the lack of available land for water storage of sufficient capacity to allow adequate-capacity tankers (most economical for shipping) to unload on arrival. As an alternative to onshore storage, therefore, the without project scenario assumes that tankers would be leased and retained in port as ‘floating storage’ until their cargoes could be offloaded and distributed. (It is noted that approaches made to one of the main shipping company serving South Tarawa, Reef Shipping, have returned cost estimates for shipping and floating storage that greatly exceed the estimates used in this analysis, because the company’s can only carry relatively small water cargoes. This may well be the case for any real emergency response that may be needed in South Tarawa in the future, indicating that actual without project scenario costs are likely to be substantially higher than those estimated.)

10.3 With Project Scenario

206. The SWRO project operating period is 30 years following full commissioning of the desalination investments in 2014. All benefits and costs are expressed in constant 2012 prices on an incremental basis. The domestic price level is adopted for tradable inputs, from which applicable taxes and duties have been removed[14]. A shadow wage rate for labour of 90 percent of the market wage rate has been applied to the unskilled labour component of the operations and maintenance costs. Kiribati uses the Australian dollar (A$) as its domestic currency, and Australia is the country’s main trading partner. A shadow exchange rate factor of 1.0 (indicating no adjustment to the official domestic currency exchange rate with respect to the US dollar or other foreign currencies) is adopted for the analysis.

207. Project economic costs include (i) the initial costs of the SWRO works and equipment, including piping, electrical and other ancillary equipment, costs for which are incurred from late 2012 to mid 2014; (ii) annual and periodic O&M expenditures on the SWRO system through its useful life; and (iii) consulting services for project supervision. The project physical contingency (12%) is included in the total economic costs. Initial investment costs (financial basis) of the four plants, are taken as the estimated costs with borehole intakes scheduled previously in the report

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[14] Import duty on SWRO and ancillary equipment is zero. Labour income is taxed at 20%. Fuel taxes in Kiribati are zero.

208. In addition to SWRO plant investment, the with project scenario includes investment in 27 'kiosks' to provide for the delivery of water services during the 3-year period when portions of the piped network are suspended, as discussed above. The kiosks are intended as the water lifeline in South Tarawa while the system is being upgraded, and will also play a role in demonstrating to the public that the system upgrading is indeed resulting in an appreciable increase in water quality (reliable supply of potable water at affordable cost), thus 'priming' the public to be willing to pay cost-recovery tariffs (subject to subsidisation as discussed in the next section) once the upgrading is completed and the network is re-pressurised. At that time, all connected customers will have volumetric meters. The kiosks will operate as collection points for households and businesses to obtain water with their own transport, but will also operate a tank-truck delivery service, for which customers will be charged full cartage costs. The kiosks will, to the extent feasible (yet to be determined), offer showers and toilets, the latter using a salt-water flush system where these systems exist, further supporting the delivery of high quality water sector services while also helping to reduce urgent sanitation problems. For present purposes, it is assumed that all 27 kiosks are equipped with shower blocks, and of these, 10 are also equipped with toilet blocks.

209. Financial operating costs of the SWRO plants are extracted from the Operating Cost Appendix to the feasibility study report, and have been adjusted to economic value by removing taxes and applying a shadow wage rate for local labour, as discussed above. Routine operating costs include electricity valued at $0.70/kWh, labour costs for operators, replenishment of chemicals, filters, and membranes (inclusive of shipping costs for these), a services contract for SWRO maintenance of estimated $200,000 per year, an inventory of spares, and a contingency allowance (10%). Kiosk operating costs (including tank truck operations) as discussed above are included in the with project routine operating costs.

210. The largest single item in operating costs is the electricity requirement, estimated at 2,742 MWh per year, implying an expense in the first year of operations of $1.92 million. (In subsequent years, electricity costs are assumed to increase at the rate of 1.9% per annum in real terms.)

211. In addition to routine operating costs, it is estimated that certain pumps, valves, filters, and the calcite bed in each plant will need to be replaced every 15 years at a cost of $2 million per replacement, and the chlorination unit in each plant will need to be replaced every 10 years, at a cost of $60 thousand per replacement.

10.4 EIRR and ENPV

212. Given the very high (albeit conservatively estimated) costs of the without project scenario (and hence the avoided costs ascribed as benefits in the with project scenario), it is to be expected that the EIRR of the project will be correspondingly high. The EIRR is calculated under the above assumptions at 68.8%, with an economic NPV of $49.2 million.

10.5 Sensitivity Analysis

213. Sensitivity analysis has been carried out on reasonable (20%) adverse changes in (i) SWRO capital costs (including the kiosk and tank truck components); (ii) O&M and asset replacement costs; (iii) the fuel price escalation rate, and (iv) avoided costs (equivalent to a decrease in benefits).

214. Given the high economic returns to the project, it is not surprising that none of these parameters is notably sensitive in terms of affecting the viability of the project. The EIRR remains above 50% for each of the variations individually, and above 38% when all variations are invoked simultaneously. The most 'sensitive' parameter is the aggregate

avoided costs, showing a sensitivity indicator (SI) of 1.7. The SIs of all other parameters are less than unity. The sensitivity analysis results are summarised in Table 13 below.

Table 13: Sensitivity Analysis

Test Case	Test Variation (+/- %)	ENPV	EIRR	SI	Basecase Parameter	SV	SV (+/-%)
Base (reference case)		46,146,487	70.0%				
Increases in Costs							
Capital Cost	20%	44,184,604	57.1%	0.21	9,542,163	54,431,402	470.4%
O&M and Asset Replacement Costs	20%	41,082,316	63.2%	0.55	2,319,248	6,546,006	182.2%
Decrease in Benefits							
Fuel Price Escalation Rate	-20%	45,502,897	69.8%	0.07	1.9%	N/A	No SV
Decrease in Avoided Costs	-20%	29,891,135	48.3%	1.76	7,300,132	3,155,338	-56.8%
Initial Costs Increased (+) and Benefits Decreased (-)	20%	22,562,876	34.9%				

EIRR=economic internal rate of return, ENPV=economic net present value, SI= Sensitivity Indicator, SV=Switching Value

215. The full economic evaluation is contained in Appendix F.

11. RESETTLEMENT AND COMPENSATION

216. The four proposed sites are located on government owned and controlled land. No resettlement or land and crop compensation issues are anticipated. The feasibility study design has determined the exact dimensions and area of land required for each desalination plant. Procedures for the retention of the sites and their availability for the desalination plants have been initiated.

217. The drawings delineating the sites are enclosed as drawing 50663 sheets 709, 710, 713, 716, 719 and 722 in volume 2 and can be used to for the development of leases over the land in favour of PUB for the construction and operation of the desalination plants.

12. STRATEGY FOR ADDING SWRO PRODUCTION

12.1 General

218. This section of the report highlights the measures necessary (and previously discussed in the financial assessment) to ensure the required investments in desalination are sustainable. Foremost amongst these considerations will be steps to minimize leakage and wastage and to recover actual costs. The proposed measure may not have popular support at first glance but the information provided will serve to highlight that desalination is not a painless quick-fix technological solution to be funded completely by the development partners, which would allow the relaxed attitude towards the management of water and other infrastructure to continue. Hard and somewhat contentious decisions will be necessary to avert the crisis of supply facing South Tarawa.

12.2 Tarawa Water Master Plan

219. The Tarawa Water Master Plan recommends that before any options for augmenting water supplies are considered, leak reduction and the cause of leakage must be addressed as a matter of the highest priority. It continues by stating that with the replacement of the pipeline the SAPHE project reduced leakage in the main transmission pipeline from the Bonriki water treatment plant to Teaoraereke to about 22%. Mention is made of the leakage from the distribution networks and household reticulation of at least 50% and probably higher (Pipe Network Analysis KAP II, 2010). The Master Plan concluded that this leakage rate is unacceptable in a water-scarce island, representing an enormous waste and imposing unnecessary costs on the Government and hardship on households. For these reasons it recommended that every effort should be made to reduce the leakage rate in a systematic fashion to 20% by 2020 and now emphasised as a crucial requirement in the Roadmap.

220. As an interim step the Master Plan recommended that consideration should be given to isolating and shutting off the excessively leaking parts of the reticulation system with water being supplied from fixed points such as existing village head tanks, or installed standpipes and temporary tanks throughout villages, or by tanker from main storage points. It was estimated that ten working water tankers would be required for the whole of South Tarawa.

221. While the Water Master Plan saw the shutting down of parts of the reticulation system as a backward step for South Tarawa’s urban water supply, it nevertheless promoted it as an approach that would dramatically cut waste and the cost of supplying water and a method of ensuring that all water produced was consumed, and not wasted. It was also seen as a step in the direction towards charging for water and recovering costs as the water supplies provided from the fixed distribution points or by tanker would be charged for and this would send a clear message that the tampering with domestic water supply pipelines has consequences for all. The concepts for the temporary supply arrangements are outlined in some detail in the separate Financial and Economic Assessment report incorporated as Appendix F.

222. The Water Master Plan saw no point in increasing the amount of freshwater into the existing water reticulation of South Tarawa if leakage and wastage continued at the present unsustainable level. The Roadmap has endorsed this approach with the added recommendation that new supplies, especially desalination which uses considerable electrical energy should be contemplated until the losses in the system are under control, or the steps being taken give confidence that this is occurring.

12.2 Sequential Installation of SWRO Units

12.2.1 Financial Considerations

223. The production of potable water by SWRO, while more practicable and cheaper than the other future options available, has a relatively high cost. It will therefore be important for all water produced to be distributed and used with minimal loss and wastage. This calls for drastic steps to reverse the current levels of unaccounted for water. At the same time if PUB is to succeed as a utilities company the cost of supplying water needs to be recovered. This should ideally include a fair return on the investment, plus operating margins. Anything less than this will mean that the economic model for PUB's water supply operations will be certain to fail. Government and development partner contributions towards operating and maintenance must also be transparent, and be targeted towards reducing costs for those who have greatest difficulty in meeting full water charges. Subsidies towards general operations also need to be based on justified requirements with monitoring and reporting to ensure application towards the declared need.

12.2.3 Unaccounted for Losses in Zone fed by Desalination

A new (replacement) transmission line is to be laid between Teaoraereke and the PUB reservoirs in central Betio in the course of the Kiribati Road Rehabilitation Project. A addition length of new transmission main is proposed to connect Desalination Plant No. 1 (Betio 1) plant to the transmission network in the vicinity of the Betio reservoirs. The remaining three desalination plants will be directly connected to the new 200mm transmission main to be constructed by the road project. The transmission mains between Betio and Antemai (the western zone) will therefore be newly constructed, well laid, and water tight with negligible leaks. Losses in the zone fed by the desalination plants should be well below the average 20% loss for the remainder of the transmission system, possibly in the order of 5-10%.

224. Given this situation the approach outlined in the Water Master Plan has much to offer as an interim measure until unaccounted for losses are brought back to the initial target figure of 25% and to 20% by 2020.

12.2 Sequencing of Desalination Plants

225. The proposed desalination plants are modularized and can be installed sequentially or in order to bring some efficiencies in the implementation, with two desalination plants being constructed at a time over a period of sixteen months commencing with the proving and development of the intake boreholes then the construction of the Betio 1 and 2 plants, to be followed in a coordinated manner with the installation of the Bairiki 1 and 2 plants. Initially under this approach the Betio area would be isolated from the rest of South Tarawa and fed solely by the first two plants. Following the subsequent installation of the Bairiki plants the final zonal arrangement comprising the western zone fed by the four desalination plants and the eastern zone fed from the Bonriki and Bouta water reserves could be implemented.

12.3 Efficient Use of Limited Water Resources

226. The Tarawa Water and Sanitation Roadmap 2011-2030 recommended the installation of the desalination plants in 2014-2015, but only after sufficient progress could be shown in the reduction of leakage and wastage. If earlier installation of the desalination plants is contemplated steps will need to be taken to ensure that water produced at a relatively high cost and with the consumption of significant levels of electrical energy generated from fossil fuels is not lost to wastage. It should be an imperative that all water produced, or near to all water produced, is either consumed for domestic potable

consumption or for economically viable activities where these are dependent upon water supply.

227. Given these requirements and the considerations governing the installation of the plants, there is only one short-term option if the installation of the desalination plants is to precede the leak detection program. This will mean initiating the steps outlined in the Tarawa Water Master Plan and refined in the Economic Assessment in Appendix F and will involve:

a. Disconnecting or valving off the distribution networks from the transmission mains and service reservoirs;
b. Connecting the desalination plants to the transmission mains and pressurizing the transmission mains and service reservoirs;
c. Installing temporary roadside reservoirs and/or metered water distribution points fed directly off the transmission mains and service reservoirs. These reservoirs and distribution points will effectively be kiosks or water selling points;
d. Selling water by volume into approved containers brought to the selling point by members of the community, or by tanker load to customers bringing their own truck mounted tanks, or by tanker drops from PUB operated tankers. The sale price should cover the cost of production and the operation and management of the system, plus delivery costs where this occurs using the PUB tankers

228. The leak detection program should commence as soon as practical and work outwards in the distribution networks from the transmission mains. As the program proceeds and the networks are repaired and house connections are isolated to control wastage, the individual sections of the network can be reconnected and pressurised. Households should only be reconnected when the private pipes have been repaired, tested and approved. Pre-pay meters should be installed on all connections at the time of reconnection with payment on a volumetric basis. Pre-paid meters would offer cash flow advantage to PUB and would allow low-income households to control the purchase of small amounts within their capacity to fund. Leak detection should commence in Betio where the highest concentration of households exist, then spread progressively to the remaining sections of the western zone, and thereafter into the eastern zone.

229. Legislation should be drafted and introduced making theft of water or tampering with the water mains, meters and pipes and fixtures comprising part, of or connections to the water supply system and reticulation a criminal offence warranting severe penalty. The situation with water and its scarcity in South Tarawa means that its theft and any actions that might deny supplies to the community at large is more than an antisocial offence. It has potential, on a broader scale, to contribute to the failure of the supply system as a whole, to contribute to deaths in the community through an inadequate and poor quality supply and the breakdown of society as it stands in South Tarawa through the complete failure of the water supply.

230. In short, tampering with the system shouldn't be condoned as being smart and shouldn't be excused any longer as the "Kiribati way". It is a crime which affects the whole of society. It is not an overstatement to compare actions which damage the essential infrastructure and affect its ability to perform as a criminal action rather than excusing the actions loosely as vandalism. Kiribati can hardly expect the international community to continually assist with scarce development funds to rebuild infrastructure that fails for these anti-social actions well before its economic life, if the government, its agencies and communities are unwilling to protect the infrastructure and control the excesses in the behaviour of its citizens. I-Kiribati must therefore show a capacity to manage the solution.

12.3 Tanker Delivery and Kiosks for Direct Purchase

231. It is estimated that approximately 27 water points will be required for the distribution and sale by container. These will be a mix of direct connections from the transmission mains with metered standpipes, existing service reservoirs, and new temporary reservoirs as water kiosks connected to the transmission mains. The new temporary reservoirs can be reused later as rainwater tanks on government and community buildings once the need for the temporary supply measures is past.

232. The Tarawa Water Master Plan estimated that 10 water tankers would be required for a similar supply arrangement for the whole of South Tarawa. On this basis 5 water tankers will be required for the temporary supply measures in the proposed western zone until the leak detection program clears the network in this zone for pressurization. Following completion of the leak detection program in the western zone the vehicles could be diverted for use in the eastern zone. NZAP is presently supplying two water tankers leaving three further units to be acquired.

233. One consideration of supplying water by tanker will be the fact that high quality and pathogen free water has the risk of being contaminated in the PUB tankers and, if present PUB practices are followed, the water on delivery is likely to be emptied into contaminated household rainwater tanks. During the temporary measures the PUB tankers can be flushed, cleaned and disinfected on a programmed basis. Drivers and staff can be instructed on the need to clean and disinfect connection hoses and to observe good personal hygiene practice, and these aspects can be monitored. The household rainwater tanks raise an additional dimension which calls for the roll out the guidelines prepared under KAPII for the safe management and maintenance of rainwater tanks. Delivery by tanker should be conditional upon the household observing good management and maintenance and having rainwater tank installations that meet the guidelines. Similar requirements could apply to the filling of private tankers, where the tanker operator/owner would be licensed by PUB with requirements for the cleaning an disinfection of the unit, and where delivery again is going to households that observe safe rain water management. The approach would hasten improved management of rainwater systems.

12.4 Costs

234. The economic assessment allows for the provision of water kiosks, shower blocks and where appropriate communal toilet blocks with salt water flushed operations for locations in Betio, Bairiki and Bikenibeu. Preliminary estimates in the economic appraisal allow $735,000 for the establishment of the kiosks and facilities and $163,500 for the three second-hand tankers.

12,5 Low Income and Disadvantaged Consumers

235. The cost for the water should be set at a volumetric rate related to the cost of production and distribution, including operations and maintenance, less any subsidies from the Government and support through sustainable maintenance funds by the development partners.

236. Based on these costs and the above estimates of produced water from each source, the Table 14 schedules the average costs ($/kL) that have been derived for water supplied by PUB from Bonriki/Buota, the SWRO plants, and distribution activities with the proposed kiosks.

Table 14: Schedule of Average Costs ($/kL)

	Historical	Period of Operation of Kiosks		
	2012	**2013**	**2014**	**2015**
Average cost of PUB water delivered ($/kL)	2.12	5.82	8.29	8.35
Cost of water produced ($/kL)	2.12	4.61	7.01	7.17
From Bonriki/Buota	2.12	2.35	4.99	5.14
From SWROs	-	5.97	5.92	6.00
Cost of kiosk operations ($/kL)	-	1.67	1.76	1.62
Cost of tank truck delivery ($/kL)	-	1.94	1.95	1.96
Total average cost of kiosks + tank truck delivery	-	3.28	3.01	2.90
	Period of Upgraded Network Operation			
	2016	**2017**	**2018**	**2019**
Average cost of PUB water delivered ($/kL)	4.00	4.11	4.23	4.34
Cost of water produced ($/kL)	4.00	4.11	4.23	4.34
From Bonriki/Buota	1.40	1.44	1.48	1.53
From SWROs	5.64	5.59	5.55	5.53

12.6 Proposed Tariffs

237. For discussion purposes, a schedule of tariffs has been prepared against projected revenues based on the tariffs (and required subsidies to cover bottom-line deficits). The recommended tariffs are displayed in Table 17 later in this report.

238. It is assumed that, during the 3-year period of network suspension, poor households obtain their water supply chiefly from kiosks using their own transport (own vehicle, public transport, or on foot). Better-off households and businesses also obtain water from the kiosks during this period, but use their own transport or purchase PUB's cartage service. To use the kiosk service, each household (and only households) will be entitled to purchase a ticket from PUB at distributed vending points for $10, which will entitle the household to take up to a total of 5,000 litres of water in the household's own containers from any kiosk. Only one ticket per household will be issued at any one time, and water taken on a single ticket will be recorded by some means (perhaps a hole punch) on the ticket. Alternative methods of obtaining water at a kiosk will be (i) to have a measured amount of water dispensed to a container in exchange for payment of a per-litre charge, with transport arranged independently by the customer, or (ii) the customer may hire PUB to deliver a requested amount of water, in which case the customer will pay the per-litre charge at the kiosk plus a cartage charge. Businesses and government consumers will not be eligible to buy the household $10 tickets, but will be required to purchase water from kiosks by one of the two alternative methods.

239. When the suspension period is fully lifted beginning in 2016, all consumers will be connected with meters to the upgraded network and it is assumed that the kiosks will be phased out, since water transport by road is a high cost which all consumers will wish to avoid. In particular, all households will be connected to the network, but will pay a lower 'lifeline' rate for consumption up to 5,000 litres/month (thus covering the needs of poor households), and will pay a full cost recovery rate for consumption exceeding that amount. Businesses and government consumers will pay a full cost recovery tariff for all consumption.

240. The suspension period, when the kiosks are in operation, will see consumption constrained below what it would normally be (i.e., there will be unserved water demand), because of limited capacity to transport water to consumers by road. Full water demand will be met by the upgraded piped network (supplied by fully operational SWRO plants and the refurbished Bonriki/Buota reserves) during the period 2016-2019. From 2020 onwards, demand will begin to exceed supply, highlighting the need for possible additional SWRO capacity at that time[15].

241. A payment modality along the above lines will allow low-income households to pay for water in smaller volumes by container as it is purchased as a lifeline supply in line with their needs and ability to pay, whereas those with incomes and greater financial resilience can purchase supply volumes according to the household's consumption and willingness to pay. PUB could own and lease the water meters to avoid the constraint of the installation costs. The question of fees, charges and affordability is covered in section 14.0.

12.6 Implementation Plan

242. The provisional Implementation Plan for the supply and construction of the proposed four desalination plants is incorporated as Figure 13 on the following page.

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[15] Additional desalination capacity for 2020 and beyond is provided for in the financial forecasts incorporated in the Tarawa Water and Sanitation Roadmap 2011-2030, Fraser Thomas Partners TA7359-(KIR), 2011.

Figure 13: Desalination Implementation Plan

	Month	1				2				3				4				5				6				7				8				9				10				11				12				13				14				15				16			
	Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
Task	**Description**																																																																
	ALL PLANTS																																																																
100	**Intake Boreholes**	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥																																																			
	Drilling and Test	🟩	🟩	🟩	🟩																																																												
	Drilling & Borehole Development			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩																																																						
	Water Quality Test					🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩																																																				
200	**Procurement**									🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥																																										
	Bid Documents									🟩	🟩	🟩	🟩	🟩	🟩																																																				
	Tender Period															🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩																																										
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12 MANAGEMENT OPTIONS

13.1 Operations and/or Maintenance of Desalination (SWRO) Plants

243. Section 52.5 of the Water and Sanitation Roadmap refers to the importance of a procurement process designed to ensure the provision of the “best” desalination plants and to guarantee at least 10 years or longer operating life. The Roadmap identified four options:

a. Design, Build, Own and Transfer (DBOT);
b. Design, Build, Operate and Maintain (DBOM);
c. Contracted management; and
d. Contracted maintenance.

244. For the DBOT option the PUB would invite proposals from qualified companies to design, build, own and operate the plants under a franchise granted by government. The franchise could be for any period, but is normally for the period for the amortisation of the original investment with appropriate margins to the company for the risks incurred. At the end of this period the plants would be transferred to PUB in full operating and maintained condition. The option of engaging the company for a further period under a management contract could also be considered. There are a number of different variations on the DBOT concept.

245. DBOM provides for circumstances where Government/PUB selects a company from qualified applicant companies to design, supply, operate, manage and maintain the plants with PUB purchasing the desalinated water on a “take or pay” basis. This would remove the operation and maintenance risks and could also provide for increased production capacity under predetermined circumstances with the company investing the capital costs for the extended production. The option has merit and minimises the risks from Government/PUB perspective, while providing for future increases in capacity. However it has obvious implications of a higher cost of water and the obligation to take and pay for the production of the plants.

246. Management contracts are typically short term contracts that place the operational management of the desalination plants in the hands of a qualified private management company.

247. Contracted maintenance contemplates a contract with the manufacturer/supplier for an agreed period and with routine and planned maintenance to a pre-agreed program. This option contemplates PUB operating the plants PUB entering into a renewable medium term contract with the manufacturer/supplier of the plants for regular inspection and for the planning, programming and the conduct and monitoring of all routine and planned maintenance, including provision for chemicals, spare parts and renewal of components and membranes on a scheduled basis. To ensure a lasting arrangement and continuation of the maintenance activities a guaranteed form of payment to the operator will be required.

248. The options are analysed in Table 15 where the advantages, disadvantages and risk of each approach are assessed. The option favoured by the SWRO manufacturer/supplier consulted is a renewable maintenance contract for a period of up to five years.

Table 15: Desalination Plants Management Options

Ref	Management Option	Explanation	Advantages	Disadvantages	Risks	
					PUB/Government	Other Party
1	Sate Owned Enterprise (SOE)	PUB is meant to operate as an SOE and its mandate would include the operation of the desalination plants.	The SOE model is an effective process provided the correct institutional and regulatory framework is in place and the organisation has the management and technical capability and depth of resources. Under normal circumstance this would allow freedom to act and think "commercially" and provide for effective use of assets.	The institutional and regulatory setting is presently weak. PUB has shown uncertainty in its role, has mixed goals and objectives and remains infused with public sector attitudes. PUB's poor financial performance and use of assets, and lack of technical capability means that the present SOE model isn't appropriate for the operation of the more complex desalination plants	No change, extension of poor performance to a new crucial component of the water supply system. Operation of the plants not efficient and will create a continuing conundrum for Govt as shareholder and the PUB's customers. A continuing and frustrating run-down to eventual insolvency of PUB which can only be averted with a continuing injection of finances by Govt. Poor financial performance, inadequate investment in the operation and maintenance of the plants and their rapid failure	No contracted party involved.
2	Privatization (private operation of the desalination plants)	In this type of governance model, ownership and strategic control over the desalination plants would be partially or fully transferred to a private sector company.	Unlikely to occur as The private sector suppliers of desalination plants do not favour this approach. Too many unknowns and gaps in the information on PUB's business for a	Govt will avoid any need for direct funding of the desalination plants but this isn't a significant concern as the plants will most likely be funded from grant of low interest concessionary loan.	The Govt is ill prepared for this option which will not sit well with present political views The main risk will be the impact on tariffs to bring these to a level for recovery	In the first place the decision to make a considerable investment based on poor information, and in the face of the present poor revenue recovery by PUB.

Ref	Management Option	Explanation	Advantages	Disadvantages	Risks	
					PUB/Government	Other Party
		Normally this takes place by public offering, capital markets, trade sale or a combination of these. In Kiribati where the financial sector is still evolving privatisation would occur as part of the procurement process and selection of manufacturer and supplier for the desalination plants.	private investor to assess the associated risks. Main advantage would be that Govt frees itself from the management of the desalination plants The freeing up and reallocation of funds isn't a consideration as the plants are likely to be funded by grant assistance or low interest concessionary loans Operation can run as a self-funded activity with adequate provision for asset renewal and O&M and with more efficient management practices	The agreement will undoubtedly contain a tariff price adjustment mechanism binding the Govt and the purchaser. These requirements invariably create problems over time. The purchaser will be required to preserve the condition of the desalination plants in line with an asset management plan and policies. The Govt presently lacks the capability to assess this. The situation in South Tarawa is not sufficiently developed or mature enough for privatization to be a readily accepted option.	on the private sector investor to obtain a return on the investment. This has political implications The other consideration is the conditions of privatization relating to unsatisfactory performance and Govt's ability to nullify the sale and to transfer this to a third party, or to take back the activities. There are major and complex risks associated with compensation to the private sector operator if this eventuality arises.	The risk of investment in an environment which is not private sector conducive and where Govt and the community may not accept responsibility for "community service obligations" expected of the company operating the desalination plants. Nationalisation of the desalination plants and loss of investment and expected returns. High risk for company and not favoured as an option.
3	Private Public Partnership (PPP)	A partnership between PUB and a private company	Again unlikely to occur as PUB's assets are presently over valued and the return on the investment by a private sector partner won't be commercially viable Too many unknowns and	Forming a private public partnership will require the partners have to be absolutely clear in their intent after open and transparent due diligence. There needs to an	There are shared risks in the relationship which will demand the understanding by both partners to the position and needs of the other The risks of mediation and	The same as the risks scheduled under PUB/Govt. The loss or write-off of any investment made in financial, human resources and intellectual property

Ref	Management Option	Explanation	Advantages	Disadvantages	Risks	
					PUB/Government	Other Party
			gaps in the information on PUB's business for a potential partner to assess the risks If practicable the PPP option would bring strong management, technical and operational capacity for the operation of the desalination plants through the PPP partner company	acceptance that there will be continual tensions in the relationship, between the commercial interests and community service obligations and political considerations. These may not always have an answer and could test the "partnership"	arbitration if the relationship deteriorates to the point where these provisions have to be enacted Compensation and settlement to the private sector partner in the advent of a complete breakdown in the relationship to the point where the "Partnership" is dissolved The above provisions would normally form part of the partnership agreement	terms. Again a high risk for company and not favoured as an option.
4	Design. Build, Operate and Transfer (BOT)	A design, build and operate arrangement for the desalination plants for a predetermined period (usually the period required to amortise the original investment), then the transfer of the plants to PUB. Normally long term franchise agreements to bring modernization and better performing activities and can range for twenty years or more, but possibly	An option for attracting investment when the Govt is unable to fund the growth and development of a sector Brings appropriate design and construction capability and the funding for improved services Allows scarce Govt funds to be reallocated to social policy, for example health and education DBOT and DBOM	Option requires political and community acceptance DBOT agreements normal are longer-term and once in place the PUB/Govt is committed to the arrangement for the period If PUB/Govt wishes to withdraw it will need to buy out the investor at the valuation placed on investments made There will also be the expectation for Govt to	The DBOT contract will need to determine the risk allocation between the Govt and the private firm and agree on the profitability of the activity during the period. The risks for both parties are political, construction operation, financial and legal. Risks for Govt also include community attitudes towards the DBOT option,	The inability to function effectively through PUB/Govt default on payment. The inability to function effectively through Govt induced changes in the sector's regulatory framework A breakdown in contractual relationships and the risk of Govt termination of the DBOT franchise. Inability to recover

Ref	Management Option	Explanation	Advantages	Disadvantages	Risks	
					PUB/Government	Other Party
		ten years for the desalination plants. BOT is a popular methodology for infrastructure projects like the desalination plants where considerable funds are required along with improved management and technical know-how Different variations have been developed such as BOOT (Build-Own-Operate-Transfer), DBOT (Design-Build-Operate-Transfer), DBOM (Design-Build-Operate-Maintain) and BOO (Build-Own-Operate). In the context of the desalinations plants the DBOT and DBOM would be appropriate.	agreements provide for a commitment towards asset renewal and O&M, according to the requirements of an approved Asset Management Plan. Agreements will also have covenants relating to the setting of tariffs.	reimburse the investor for the profits expected during the remainder of the DBOT term.	with higher service costs and tariffs. The long-term nature of the arrangement will require a disciplined approach in the dealings with the BOT franchisee. The cost of buying out the concessionaire and making restitution where Govt reconsiders the BOT franchise.	investments and forecast profits. Govt nationalisation of the DBOT operation. Again a high risk for company and not favoured as an option.
5	Design, Build Lease (DBL)	Similar to the above options but here the franchisee pays a lease to the Govt for the right to operate the service.	Largely the same as above.	Largely the same as above..	As above.	As above.
6	Management Contract	An option where the	Introduction of new attitudes	The management option will	PUB/Govt will have passed	Risk of policy and

Ref	Management Option	Explanation	Advantages	Disadvantages	Risks	
					PUB/Government	Other Party
		management is contracted to a company with a track record in the management of desalination plants. Typically a short term contract that puts the operational management in the hands of a private company. PUB/Govt will retain ownership, control of the desalination plants and over-all long term strategy, but the short term tactical decisions will transfer to the management company.	and approaches with management and technical skills appropriate to the desalination activities. The ability to ensure immediate changes to what otherwise might be unsatisfactory operations. Efficient use of resources. Success will be related to the length of the contracts and the competitiveness with which they are awarded. Management skills obtained will relate the successful operations of the desalination plants for a given period.	impose an additional cost which will be reflected in the tariffs. Special attention will be needed in drafting the management contact to ensure the obligations of the contract are accurately documented and unambiguously expressed, and to be meaningful and enforceable under the contract. There are difficulties in specifying long term performance criteria and longer term contracts can be incomplete and require post-contract negotiation. Following from this anagers can often be short term orientated and therefore have cost minimization incentives.	the management to a second party and is contractually bound to the actions and decisions of that party for the management of the desalination plants. PUB/Govt's rights and ability to impose policy and guidelines on the management company are limited to the rights permitted under the contract. The cost minimization incentives mentioned raise concerns for the quality of the desalination water and the plants. The need to ensure the management contract provides for renewal and O&M requirements and to monitor the fact that this occurs so that the desalination plants at the end of the contract have been maintained to expected standards and condition	regulatory framework changes by Govt that are contrary to the terms of the management contract. Risk of contractual payment by Govt and recovery of costs. Inability of the company to extricate itself from a bad and financially draining contract. Unacceptable risk for company and not favoured as an option.
7	Maintenance Contract	An option where PUB retains ownership and	Improved planning, programming and	No significant	Limited risk with substantial	Payment for services provided under the

Ref	Management Option	Explanation	Advantages	Disadvantages	Risks	
					PUB/Government	Other Party
		management but contracts the maintenance responsibilities to the manufacturer/supplier of the SWRO desalination modules.	implementation of routine and periodic maintenance requirements commensurate with the needs of the SWRO plant. Improved advice for planning and conduct of operational requirements. Improved asset management and funding for O&M. Technology transfer and institutional and individual capacity building with associated training. Extended economic life of SWRO plant to achieve best industry expectations >10 years membrane life. Support for community awareness and education on desalination and need for reduced losses and wastage and best use of scarce, finite and expensive fresh water. Approach favoured by SWRO manufacturer/ supplier.	disadvantages.	gains.	Maintenance and Operations Contract. Acceptable risks and favoured by SWRO manufacturer/ supplier consulted.

13.2 Summary of Contract Requirements

13.2.1 Design, Design and Installation of SWRO Modules

249. The procurement documents and the contract requirements for the design, manufacture, implementation and commissioning of the SWRO desalination plants should stipulate the following requirements:

a. The SWRO modules must be fully designed and built in their totality by the company supplying, installing and commissioning the modules;
b. The modules shall not be assembled from parts or components from multiple suppliers and manufacturers;
c. Contractors shall not be permitted to acquire, install and commission modules manufactured with parts from multiple suppliers, or modules manufactured by several sub-contractors or a consortium of suppliers;
d. The designer/manufacturer/supplier (the company) shall be a world leader in SWRO technology;
e. The company must be preeminent in the manufacture and operations of SWRO units;
f. The company shall have a proven record of supplying package plants in numbers to others;
g. The company shall have an established history and track record of manufacturing, installing and operating packaged plants and SWRO units on the scale contemplated for South Tarawa, or larger;
h. The company must have Pacific experience of installing and operating SWRO units;
i. The company must be able to display a track record in maintenance and operations of SWRO units in Pacific environments where the plants have had a proven economic life of ten years or more;
j. The company should have substantial manufacturing and supply operations in the Australasian and South Pacific regions;
k. The company shall have the capacity to provide full and unrestricted technical, management, maintenance and operations support and must be globally linked with in-house or proven R&D capacity;
l. The company must be able to provide plans, drawings, 3D presentations, technical manuals for the SWRO modules;
m. The company must be capable of providing training to MPWU and PUB and assisting with the design and delivery of community education packages;
n. The company should desirably have the ability to provide proven off-the-shelf education packages and curriculum support materials for school and community awareness/education programs suitable for customization for Kiribati.
o. The contract could make provision in the supply contract for the maintenance of the SWRO systems to remain with the supplier for a 5-10 year period with declining rate of support provided by the international supplier as local capacity develops.

13.2.2 Maintenance Contract

250. The SWRO manufacturer consulted in the course of the study has a strong preference for a maintenance contract as the best balanced approach between PUB and the private sector for achieving the longer-term problem free operation of the SWRO modules. For the maintenance contract to be successful the following provisions need to be incorporated into the selection process and the subsequent maintenance contract.

a. The maintenance contractor (company) should preferably be the manufacturer and supplier of the SWRO modules;

b. The contractor must be company who manufactures and supplies similar plants and can supply key parts and components off the shelf;
c. The company should be Australasian of Pacific based having the advantage of quick access to South Tarawa for continuing and on demand support services;
d. The company must have proven experience in south pacific operations and show previous experience in the successful maintenance of SWRO plants for a period of up to ten years between membrane replacement;
e. The maintenance contract must require use of descalant and cleaning chemicals blended specifically for the SWRO plant and the salt water quality in South Tarawa;
f. The maintenance contract should be for a period of five years with automatic right of renewal for a further period of five years subject to satisfactory performance (or alternatively see section 12.2.1, item o in the preceding list above);
g. The maintenance contract must stipulate requirements for:
    - The contractor to produce an asset management plan for the SWRO units and desalination plants with longer-term and annual programs for routine and periodic maintenance
    - Provision for expendable items such as the monthly replacement of the rated micron filters, the descalant and washing chemicals and the make-up of the multimedia and calcite beds, as required
    - Technical support, overview and review of PUB operations of plants;
    - Routine visits and inspection
    - Regular reports and condition rating of the SWRO modules and the desalination plants
    - Training of PUB operators and personnel
    - Assistance with community awareness programs
h. The maintenance contract will also require an acceptable escalation clause and terms of payment that to guarantee payment to the contracted company.

14 FEES AND CHARGES

14.1 Background

251. The financial analyses conducted under TA 7359-KIR and additional studies of the Political Economy of Water and Sewerage Tariff Reform in South Tarawa have established that the provision of water and sewerage services in South Tarawa has to the present time been heavily dependent on government subsidies. In 2010 water service operating losses were approximately $513,000 and the annual government subsidy for sewerage services amounted to $480,000. To compound the situation poor cost allocation has resulted in water and sewerage budgets being understated with electricity for pumps and other equipment being absorbed within the electricity operating account. This section of the feasibility report borrows heavily from the statements incorporated in the Tarawa Water and Sanitation Roadmap 2011-2030.

14.2 Present Charges and Recovery

252. Only a very small number of non-domestic customer supplies are metered. Domestic water supply is not metered. The tariff for both non-metered domestic and non-domestic customers is set at a fixed charge of $10 per month while water by meter to the few consumers involved is sold at a rate of $2.00 per kL. Revenue collection in 2010 was 84.5%% and 70% for domestic and non-domestic customers respectively, inclusive of arrears. At the present time there are no sewerage service charges.

253. PUB has consistently incurred operating deficits since 2004 with a continuing run down in its cash resources and a steady increase in its overdraft. The operating deficit and overdraft reached crisis levels in 2011. Despite this PUB's water tariffs have not been revised for some time and PUB's weak billing and collection activities has lead to customers treating PUB as a cheap source of finance which has compromised the water supply services.

254. PUB's domestic customers, who are seen to have a good understanding about paying for utility services through regular use of pre-paid telecommunication and transport services, have responded to the decline in service delivery standards by withholding their payments, without incurring any service delivery penalties. Customer payment levels have also been influenced to some degree by a historical belief on the part of some customers that PUB water services should be free in view of the Government's earlier practices of not imposing charges for a range of public services.

14.3 Cultural and Social Impacts

255. The present perception in some sections of the community that water should not be priced is not surprising in view of PUB's lack of transparency. The increasing youthfulness of the Kiribati population, who use pre-paid utility services, may however well lead to a gradual change in perceptions about the pricing of government services and could be built upon for the future.

256. Kiribati is a highly egalitarian society. There is a belief that all individuals should be treated equally. This view poses major challenges for future tariff reform. One stakeholder noted that the incidence of illegal domestic water connections could be viewed in an egalitarian context where those domestic customers without access to a regular water supply should, nevertheless, be able to secure access via an illegal water connection. The non-payment of domestic water charges could also be viewed in a similar manner where some customers know of others who do not pay their water charges and then elect not to make payments to PUB.

257. Reciprocity is an important aspect of Pacific Island culture. This practice, known as "bubuti" in Kiribati, is known to take place in the context of water service delivery through the supply of water on request to neighbors and support to family members who are unable to meet water charges. However many in the community are now aggrieved by the demands others make of their goodwill and the way the expectation of "bubuti" compromises their own access and use of the water supplies.

258. Kiribati people are described as very conservative. Considerable public consultation will be required if changes are proposed to current monthly domestic water tariffs and service delivery arrangements. Proposed changes will have to be supported by demonstrable community benefits to gain public support.

14.4 Community Attitudes to Present Water Services

259. Consultations held under TA 7359-KIR with stakeholders including accommodation providers, business services representatives, church representatives, government and local government agencies, officials and the public revealed an overwhelming dissatisfaction with the quality of the level of the water supply services. Many of the respondents consider PUB has been poorly managed. The intermittent nature of the supply is also the subject of considerable discussion in community forums about PUB's poor performance.

260. Some stakeholders suggested there is poor community understanding of the rationale for making payments to PUB for water. Perceptions about water resources were reported to vary in the community with some people believing there is plenty of water. Domestic customers also expressed some willingness to pay a higher overall tariff for improved water and sewerage services but this support is strongly linked to receiving improved water quality, quantity and service.

14.5 Assessment of Situation

261. The statements in this section leading on from the above comment have been uplifted directly from the Economic Assessment contained in Appendix F, as follows.

262. The Political Economy Analysis of Water and Sewerage Services[16] and the "Fees and Charges – Sustainability" section of the Tarawa Water and Sanitation Roadmap 2011-2030, both prepared in conjunction with this PPTA, provide a firm analytical framework for the determination of tariffs and subsidies, based on the costs outlined above. As outlined in the Roadmap, the following principles and criteria are adopted:

- There is overwhelming public dissatisfaction with the quality of the level of the water supply and sanitation services. Domestic customers have some willingness to pay a higher overall tariff for improved water and sewerage services but this support is strongly linked to receiving improved water quality, quantity and service and improved and reliable sanitation services. People may be expected to make spending decisions linked to the relative level of service.
- The poorest 20%-25% of households will have difficulty in paying utility charges provided on credit and billed in arrears. However, as demonstrated in strong pre-paid services markets in South Tarawa (e.g., cell phone, public transportation), it is expected that households with very limited ability to pay can purchase urgently required pre-paid services as needs arise. Therefore, a lifeline block per household

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[16] Reference, footnote 2.

per month is proposed, to be charged at a lower rate than non-domestic consumers and households consuming more than the lifeline block in litres per month.

- In the short to medium term a water cost recovery target of 60% for domestic customers is recommended.
- Households consuming more than 5,000 litres/month will pay a higher rate than that charged for the household lifeline block, but will nevertheless be subsidised at a rate below cost (consistent with the above cost recovery target).
- The public good component of projected enhanced water and sewerage services justifies the provision of a partial subsidy for these services on economic efficiency grounds. A higher subsidy is appropriate for sewerage services in view of their greater positive externalities in South Tarawa compared with those applicable to water services.
- Generally there is an acceptance that households should spend no more than 5% of household income on combined water and sewerage services. As shown below, this level of expenditure can largely be managed by choice by the majority of households, with exception of the 20% to 25% identified as poor.
- Business owners should not be asked to make any cross-subsidy to water and sewerage services provided to domestic customers, but they should nevertheless pay the full cost of their respective services (i.e., a 100% cost recovery target).
- Bad debts on water services billed in arrears are assumed to be 30% of domestic + non-domestic annual revenues (in line with recent historical experience) from 2012-2015, thereafter reducing to 20%[17]. As shown below, before considering subsidies, total revenues rise from about 50 percent of costs in 2012-2013, to about 60 percent by 2020.
- A sustainable management fund (SMF) (combining government and development partner funds) for the water supply sector, linked to a rigorous asset management plan, is recommended (similar in purpose to the fund recommended for the sanitation sector). The fund would largely cover network and Bonriki/Buota refurbishment as discussed in Section II above, plus ongoing maintenance and leak detection, and could also cover kiosk operation and maintenance costs during the suspension period (2013-2015). During the suspension period, incorporating network and Bonriki/Buota refurbishment and kiosk operations, the SMF would be funded at approximately $2.5 million/year, dropping to approximately $570,000/year in the period 2016-2020. In the tariff and subsidy calculations discussed in this section, the SMF is not included as a tariff-offsetting source of revenue.

263. Currently in South Tarawa, there is no charge for sewerage services. Under the current PPTA, a sanitation project has been developed and sewerage connections have been estimated and flat-rate monthly sewerage tariff charges have been proposed as illustrated in Table 16.

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[17] If prepayment (and tamper-proof) metering is adopted, bad debts will be far less.

Table 16: Proposed Sewerage Charges

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Sewer Connections										
Domestic	1,505	1,505	1,530	1,580	1,680	1,750	1,750	1,750	1,750	1,750
Non Domestic	495	495	500	500	500	500	500	500	500	500
Total	2,000	2,000	2,030	2,080	2,180	2,250	2,250	2,250	2,250	2,250
Sewer Tariffs										
Domestic ($/month)	-	-	-	5.00	5.00	7.50	7.50	7.50	7.50	7.50
Non-domestic ($/month)	-	-	-	20.00	25.00	30.00	35.00	40.00	50.00	60.00

264. For discussion purposes, and on the basis of the above principles and criteria, Table 17 presents a schedule of tariffs with projected revenues based on the tariffs. Since revenues do not recover full costs, the deficit that is required to be covered by a combination of annual subsidy and a possible SMF is also indicated.

265. The network suspension period, 2013-2015, is also a transition period for both the supply and the demand components of the water system. As mentioned, on the supply side, the delivery system will be fully refurbished, and new sources of water (SWROs) will be added. On the demand side, consumers will be disconnected from the dilapidated distribution system, and delivery will be transferred to kiosks. (Only half the network will be down at any one time during the suspension period—since road transport for water delivery by itself could not cope—but all consumers will be affected at one time or another.) During this period, consumers will inevitably suffer inconvenience and some hardship, leading to the expectation that, in combination with a demonstration of reliable potable water supply through the kiosk delivery mechanism, a willingness to pay metered charges for water after the refurbished network is pressurised will be general and high.

266. During the transition, however, it is not intended that households should also suffer financial hardship in procuring a survival-level volume of water. For this reason, the current flat-rate monthly charge for water ($10) is extended through the transition period, and applied to the procurement by each household of 5,000 litres of water per month. The $10 charge for that quantity is equivalent to $2.00/kL. 5.0 kL is calculated as a very basic survival level of water consumption of approximately 22 litres of water per person, per day for an average family of 7.5 members. Better-off households and businesses will consume more than this, as discussed above, and will pay more for it, chiefly through own-transport costs and PUB cartage charges. (In addition, businesses will pay the full cost of water production, much more per kL than households during the transition period: approximately $7/kL, plus cartage. Businesses will pay the full cost recovery rate (exceeding $4.00/kL) once they are connected to the refurbished network. Better-off households will pay the rate $2.00/kL during the transition, but will pay a higher rate, rising to $3.00/kL by 2021, after they are connected to the refurbished network.)

267. PUB cartage service, for all customers who request it during the transition, will be charged at the rate of $2.00/kL. It is assumed that customer meters (perhaps prepayment meters) will cost on the order of $100. Connection charges are thus subsidised for households at $25. Businesses will be charged $100 for a connection to the piped network. Deficit-offsetting subsidies and SMF contributions average about $2.0 million per year to 2021 (to cover below-cost tariffs for households).

Table 17: Schedule of Proposed Tariffs (and Revenue Impact)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Water Supply Tariff Schedule										
Non-domestic connections										
Flat monthly rates ($/mo/connection)	10.00	10.00	10.00	10.00						
Metered Supply, all consumption ($/kL)		4.65	6.72	6.87	4.00	4.11	4.23	4.34	4.43	4.52
Cartage Charges ($/kL)		2.00	2.00	2.00						
Domestic connections										
Flat monthly rates ($/mo/poor household)	10.00	10.00	10.00	10.00						
Metered Supply, 0-5.0 kL/mo ($/kL)		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Metered Supply, >5.0 kL/mo ($/kL)		2.00	2.00	2.00	2.17	2.33	2.50	2.67	2.83	3.00
Cartage Charges ($/kL)		2.00	2.00	2.00						
Water Supply Connection Charges ($/connection)										
Non-domestic connections		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Domestic connections		25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Revenues - Water Sales										
Non-domestic connections	59,400	217,992	365,800	512,948	407,446	435,194	464,477	495,378	524,982	556,507
Domestic connections										
Poor Households	172,658	179,340	186,280	193,490	200,978	208,755	216,834	225,226	233,942	242,996
Non-Poor Households	345,316	1,740,506	1,659,345	1,798,731	1,769,021	1,978,827	2,202,223	2,439,945	2,604,001	2,729,828
Total domestic connections	863,291	1,919,846	1,845,626	1,992,220	1,969,999	2,187,583	2,419,057	2,665,171	2,837,943	2,972,823
Less Bad Debts	(276,807)	(641,351)	(663,428)	(751,550)	(475,489)	(524,555)	(576,707)	(632,110)	(672,585)	(705,866)
Total Tariff income	**645,884**	**1,496,487**	**1,547,998**	**1,753,618**	**1,901,956**	**2,098,221**	**2,306,827**	**2,528,439**	**2,690,340**	**2,823,465**
Water Supply Connections ($)										
Non-domestic connections	-	-	-	50,000	-	-	-	-	-	-
Domestic connections	-	-	-	201,552	7,800	8,102	8,415	8,741	9,079	9,431
Total water supply connections	-	-	-	251,552	7,800	8,102	8,415	8,741	9,079	9,431
Total Income	**645,884**	**1,496,487**	**1,547,998**	**2,005,169**	**1,909,756**	**2,106,323**	**2,315,242**	**2,537,180**	**2,699,419**	**2,832,895**
Total Expenses excluding depreciation	**1,244,837**	**3,005,413**	**3,732,711**	**4,013,800**	**3,723,034**	**4,000,517**	**4,293,343**	**4,602,357**	**4,759,711**	**4,864,769**
Deficit, to be offset by government subsidy	**(598,953)**	**(1,508,926)**	**(2,184,713)**	**(2,008,631)**	**(1,813,278)**	**(1,894,193)**	**(1,978,101)**	**(2,065,176)**	**(2,060,292)**	**(2,031,874)**
Income as % of Expenses excl depreciation	0.52	0.50	0.41	0.50	0.51	0.53	0.54	0.55	0.57	0.58

Deficit offset could be a combination of government subsidy and donor support for SMF

268. Table 18 presents a further analysis of poor and non-poor households' expected expenditures on water supply and on sewerage charges under the proposed tariffs. For poor households, the projected combination of expenditures during the transition are less than or equal to 5% of income for a household earning $2,400 annually or above in 2013-2014, and $4,100 in 2015 (when sewerage charges are proposed to be introduced). As sewerage charges increase, the minimum household income for a poor family to meet sewerage and water supply costs not exceeding 5% of income rises to about $4,220 from 2017 onwards. According to the Household Income and Expenditure Survey (HIES, 2006), the average income of a poor household in South Tarawa at that time was just over $8,000 per annum. For better-off households, the projected combination of expenditures during the transition are less than or equal to 5% of income for a household earning $5,800 annually or above in 2013-2014, and $7,300 in 2015. As sewerage charges increase, the minimum household income for a better-off family to meet sewerage and water supply costs not exceeding 5% of income rises to a maximum of about $8,600 to 2021. According to the HIES, the average income of a non-poor household in South Tarawa in 2006 was over $12,000 per annum. It is therefore concluded that the proposed combination of water supply and sewerage charges to poor and non-poor households is affordable through 2021.

269. A prolonged public consultation program will be required to build awareness about all the relevant issues associated with the proposed upgrading of water and sewerage services in South Tarawa. Constructive changes in community attitudes relating to the provision of and payment for water services cannot be achieved without such a program. The consultation program must be accompanied by significantly increased annual disclosures by PUB about its operations. Innovative measures such as prompt payment discounts and competitions with entry based on payment of water charges may well generate additional marginal improvements in cost recovery levels but are unlikely to have a material impact in generating additional revenue flows.

Table 18: Annual and Monthly Household Expenditures on Water and Sewer based on Proposed Tariffs

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Domestic sector: annual and monthly water supply + sewer costs per household ($)										
***Poor Households**, Water Supply Costs*										
Annual	120	120	120	145	121	121	121	121	121	121
Monthly	10	10	10	12	10	10	10	10	10	10
Poor Households, Sewer Costs										
Annual	-	-	-	60	60	90	90	90	90	90
Monthly	-	-	-	5	5	8	8	8	8	8
Poor Households, Water + Sewer Costs										
Annual	120	120	120	205	181	211	211	211	211	211
Monthly	10	10	10	17	15	18	18	18	18	18
*For affordability (sewer+water costs=5% income), expenditures imply **poor household** income of*										
Annual	2,400	2,400	2,400	4,100	3,619	4,219	4,219	4,219	4,219	4,219
Monthly	200	200	200	342	302	352	352	352	352	352
***Non-Poor Households**, Water Supply Costs*										
Annual	60	291	267	304	265	285	306	326	335	338
Monthly	5	24	22	25	22	24	25	27	28	28
Non-Poor Households, Sewer Costs										
Annual	-	-	-	60	60	90	90	90	90	90
Monthly	-	-	-	5	5	8	8	8	8	8
Non-Poor Households, Water + Sewer Costs										
Annual	60	291	267	364	325	375	396	416	425	428
Monthly	5	24	22	30	27	31	33	35	35	36
*For affordability, water and sewer expenditures imply **non-poor household** income of*										
Annual	1,200	5,823	5,345	7,278	6,500	7,506	7,912	8,319	8,497	8,559
Monthly	100	485	445	606	542	626	659	693	708	713

Appendix A

Water Tests: Recommended Schedule Results of laboratory Testing and Veolia Water Comments

Company:

Location:

Contact:

Phone:

Water source:

Analysis by:

Date:

Cations	**as Ion (mg/l)**	**as $CaCO_3$ (mg/l)**	**Anions**	**as Ion (mg/l)**	**as $CaCO_3$ (mg/l)**	**Other**		
Calcium	🟨		Bicarbonate	🟨		pH	🟨	
Magnesium	🟨		Carbonate	🟨		Conductivity	🟨	mS/m
Sodium	🟨		Chloride	🟨		TDS	🟨	mg/l
Potassium	🟨		Sulfate	🟨		TSS	🟨	mg/l
Aluminium	🟨			🟨		Turbidity	🟨	NTU
Cadmium			Fluoride	🟨				
Barium	🟨		Nitrate	🟨		Free chlorine	🟨	mg/l
Boron	🟨		Phosphate	🟨		TOC	🟨	mg/l
Copper	🟨					Temperature	🟨	ºC
Iron (Total)	🟨		Bromide			Colour	🟨	Pt/Co
Iron (soluble)	🟨					HCC		cfu/mL
Manganese (total)	🟨					E-Coli		cfu/mL
Manganese (soluble)	🟨							
Strontium	🟨		Silica	🟨				
Total			**Total**					

Enter data in cells coloured 🟨

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

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ANALYSIS REPORT

Client:	Watermark Training & Consultancy	**Lab No:**	983572 SPv1
Contact:	Geoff Mills	**Date Registered:**	02-Mar-2012
	C/- Watermark Training & Consultancy	**Date Reported:**	19-Mar-2012
	45 Hawkestone Road	**Quote No:**	47988
	MARTON 4710	**Order No:**	128645
		Client Reference:	Kiribati Desalination Plant
		Submitted By:	Geoff Mills

Sample Type: Aqueous

	Sample Name:	BAL 25-Feb-2012	BAS 25-Feb-2012	BAK 29-Feb-2012	BT 29-Feb-2012	
	Lab Number:	983572.1	983572.2	983572.3	983572.4	
Apparent Hazen Colour*	Hazen units	< 5	< 5	< 5	< 5	-
Turbidity*	NTU	1.03	0.43	0.26	0.13	-
pH*	pH Units	8.3	8.2	7.5	7.6	-
Analysis Temperature for Bicarbonate	°C	21	23	23	23	-
Bicarbonate	g/m^3 at Analysis Temperature	128	135	276	260	-
Electrical Conductivity (EC)*	mS/m	5,370	5,490	3,430	4,000	-
Total Suspended Solids*	g/m^3	9	< 3	< 3	< 3	-
Total Dissolved Solids (TDS)*	g/m^3	38,000	39,000	23,000	26,000	-
Total Aluminium*	g/m^3	< 0.013	< 0.013	< 0.013	< 0.013	-
Total Barium*	g/m^3	0.0046	0.0049	0.0052	0.0100	-
Total Boron*	g/m^3	3.8	3.6	2.4	2.7	-
Total Calcium*	g/m^3	420	410	260	290	-
Total Copper*	g/m^3	< 0.0011	0.0020	< 0.0011	< 0.0011	-
Dissolved Iron*	g/m^3	< 0.004	< 0.004	< 0.004	0.011	-
Total Iron*	g/m^3	< 0.0042	< 0.0042	0.0198	0.022	-
Total Magnesium*	g/m^3	1,160	1,140	720	820	-
Dissolved Manganese*	g/m^3	< 0.0010	< 0.0010	0.036 [#1]	0.0071	-
Total Manganese*	g/m^3	< 0.0011	< 0.0011	0.032 [#1]	0.0074	-
Total Potassium*	g/m^3	410	400	230	270	-
Total Sodium*	g/m^3	11,300	11,100	6,400	7,600	-
Total Strontium*	g/m^3	9.0	8.8	6.1	6.5	-
Bromide*	g/m^3	58	59	37	39	-
Chloride*	g/m^3	20,000	21,000	10,100	12,600	-
Fluoride*	g/m^3	1.2	1.2	1.2	1.2	-
Nitrate-N*	g/m^3	< 5	< 5	< 5	< 5	-
Dissolved Reactive Phosphorus*	g/m^3	< 0.004	0.017	0.090	0.073	-
Phosphate	g/m^3	< 0.02	0.05	0.28	0.22	-
Reactive Silica*	g/m^3 as SiO_2	< 0.10	0.12	2.1	5.6	-
Sulphate*	g/m^3	2,800	3,000	1,690	1,840	-
Non-Purgeable Organic Carbon (NPOC)*	g/m^3	2.0	2.0	1.3	1.3	-

Analyst's Comments

Severe matrix interferences required that a dilution be performed prior to analysis of samples 983572/1 to 4, resulting in a detection limit higher than that normally achieved for the Bromide and Nitrate-N analysis.

[#1] It has been noted that the result for the dissolved fraction was greater than that for the total fraction, but within analytical variation of the methods.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	1-4
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 21st ed. 2005.	-	1-4
Apparent Hazen Colour*	Detemined on orginal sample without filtration or centrifugation, determination by Lovibond colorimeter. APHA 2120 B 21st ed. 2005.	5 Hazen units	1-4
Turbidity*	Saline sample. Analysis using a Hach 2100N, Turbidity meter. APHA 2130 B 21st ed. 2005.	0.10 NTU	1-4
pH*	Saline water, pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	1-4
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	1-4
Bicarbonate	Bicarbonate (HCO3) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m^3 at Analysis	1-4
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.10 mS/m	1-4
Total Suspended Solids*	Saline sample. Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 21st ed. 2005.	3 g/m^3	1-4
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 21st ed. 2005.	50 g/m^3	1-4
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 21st ed. 2005.	-	1-4
Total Aluminium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.013 g/m^3	1-4
Total Barium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.00063 g/m^3	1-4
Total Boron*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.042 g/m^3	1-4
Total Calcium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	1.1 g/m^3	1-4
Total Copper*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.0011 g/m^3	1-4
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.004 g/m^3	1-4
Total Iron*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.0042 g/m^3	1-4
Total Magnesium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.42 g/m^3	1-4
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.0010 g/m^3	1-4
Total Manganese*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21st ed. 2005.	0.0011 g/m^3	1-4
Total Potassium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	1.1 g/m^3	1-4
Total Sodium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.42 g/m^3	1-4
Total Strontium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 21st ed. 2005.	0.00021 g/m^3	1-4
Bromide*	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.05 g/m^3	1-4
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 21st ed. 2005.	0.5 g/m^3	1-4
Fluoride in seawater*	Saline sample. Ion selective electrode. APHA 4500-F^- C (modified from manual analysis) 21st ed. 2005.	0.05 g/m^3	1-4
Nitrate-N*	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.05 g/m^3	1-4
Dissolved Reactive Phosphorus*	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 21st ed. 2005.	0.004 g/m^3	1-4
Phosphate from DRP	Calculation: from Dissolved Reactive Phosphorus * 3.065.	0.02 g/m^3	1-4
Reactive Silica*	Filtered sample. Heteropoly blue colorimetry. Discrete analyser. APHA 4500-SiO_2 F (modified from flow injection analysis) 21st ed. 2005.	0.10 g/m^3 as SiO_2	1-4

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Samples**
Sulphate*	Filtered sample. Ion Chromatography. APHA 4110 B 21st ed. 2005.	0.5 g/m^3	1-4
Non-Purgeable Organic Carbon (NPOC)*	Acidification, purging to remove inorganic C, catalytic oxidation, IR detection. APHA 5310 B (modified) 21st ed. 2005.	0.3 g/m^3	1-4

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This report must not be reproduced, except in full, without the written consent of the signatory.

Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental Division

Comments received from Philip Battey, Manger Business Development, Veolia Water, Melbourne. Will be obtained on letterhead for the final report

Hello Geoff

Am not in the office at present, however I can respond briefly via email with regards to your water analysis.

Firstly one needs to appreciate that this is only a single grab sample, a series of samples over differing tides, weather and seasons would ideally be utilised to provide a sound basis for design. Additionally onsite SDI testing will need to be done at some point.

Having said that with regards to the report received, the only potential issue may be the suspended solids, these may vary widely from an open intake and as such may have an impact on the pre-treatment. A sea water bore (beach well) should alleviate that issue. Other than that there aren’t any surprises that the proposed Veolia Water system could not treat.

Regards

Phil

Appendix B

Desalination Site Details

Desalination Plant Number 1

Site Reference:	Betio 1
Village:	Betio
Location	Betio landfill site

Description of site:

- Level site at water's edge of port anchorage and inner basin;
- Will need excavation of filled refuse and consolidation and placement of engineered fill to make good the surface for the placement of the containers;
- Design will also have to incorporate flexible jointing of pipes to allow for differential settlement;
- Access down secondary road;
- Road to the site will need levelling and some repairs;
- Intake waters can be drawn straight from the sea water by installing a small reclaimed quay out into the inner anchorage and then installing boreholes or a stilling well with submersible pumps;
- Brine discharge can be piped to inner edge of port anchorage.

Adjacent properties:

- No adjacent development on the wide expanse of the reclamation;
- Neighbouring properties on other side are industrial;
- Nearest neighbour is Betio shipyards.

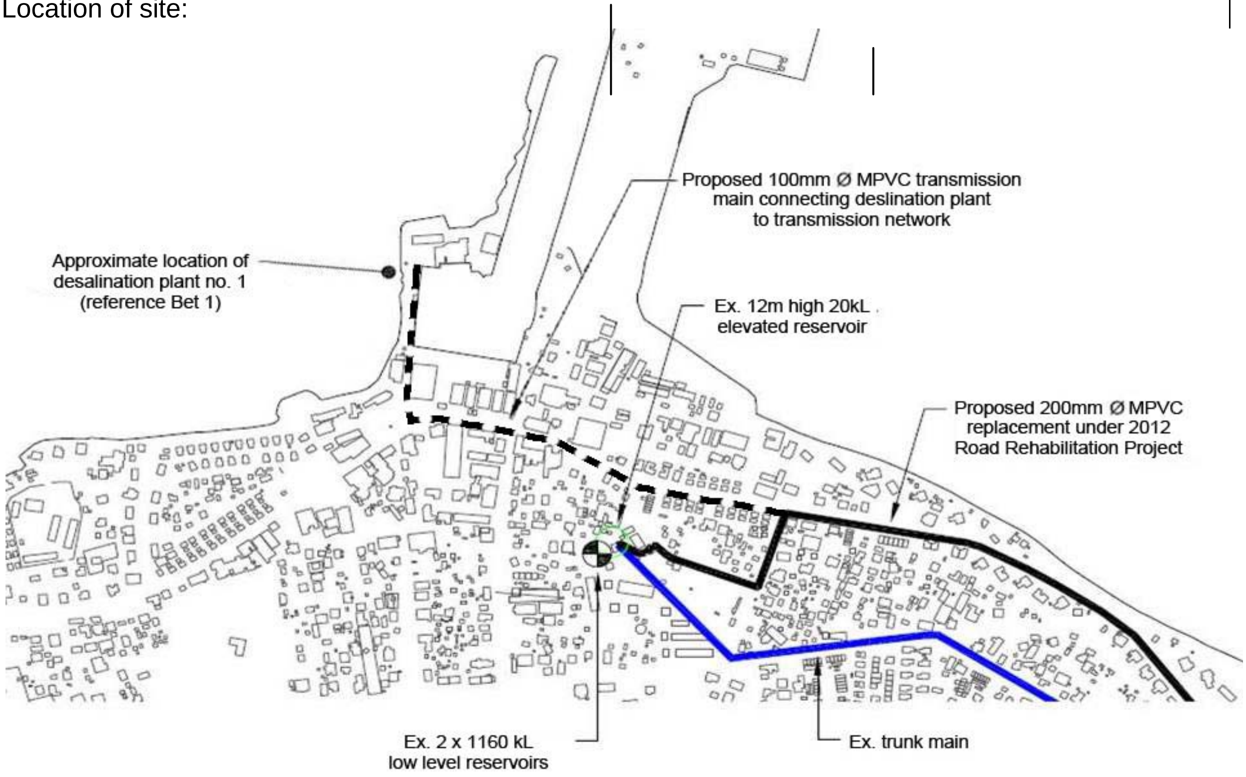
Proximity to transmission main and electricity;

- Transmission main will need to be laid along the secondary road from the desalination plant and along the Betio loop road to link with new transmission main being installed under the road rehabilitation project;
- PUB electrical transformer has adequate capacity but 140m of new cabling is required to control voltage drop;
- Site sanitation to be by on-site means.

Brine disposal:

- Brine disposal directly to the port anchorage or into inner basin.

Location of site:



Photographs:

Landfill from end of access road

Looking down centre of landfill

Looking down centre of landfill

Looking from the north east

Harbour – inner basin

Looking back along secondary access road

Foreshore immediately fo north of landfill

Foreshore looking along sea wall to harbour anchorage

Desalination Plant Number 2

Site Reference:	Betio 2
Village:	Betio
Location	Government land at site of former desalination plant opposite Betio maneaba

escription of site:

- Level and well graded site;
- Good access from main road;
- Could be filled 300mm to improve drainage;
- Old desalination plant has to be written off and sold, or repaired and relocated;
- Existing building could house filters, store and office;
- Small building alongside housing the original intake sump could be secured and the sump could be cleaned out, and used as sump for sanitation disposal;
- Layout and design has to be sensitively handled to leave adjacent war relics untouched and visible;
- No vegetation, land has grass cover with several pandanus palms at the foreshore.

Adjacent properties:

- No immediately adjacent development;
- Maneaba on the opposite side of road is the closest building.

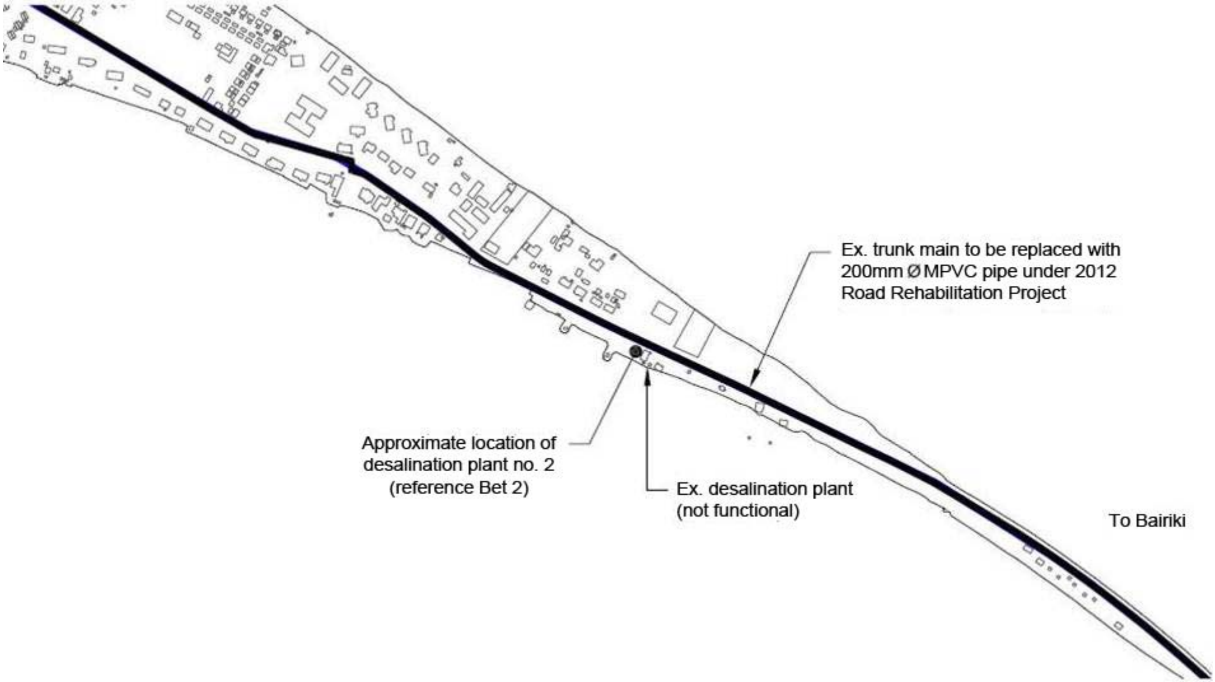
Proximity to transmission main and electricity;

- Transmission main runs past site;
- Electricity cable runs past site;
- Site sanitation can be connected to nearby sewerage.

Brine disposal:

- Brine can be disposed of to the ocean intertidal flat.

Location of site:



Photographs:	
	
Site looking from east	Site looking from west
	
Old desalination plant building	Old desalination plant building from ocean foreshore
	
Site from Ocean foreshore looking towards maneaba	Slab over cistern at rear of the old desalination plant building
	
Cistern, eastern side of old desalination building	Ocean side foreshore

Ocean flat 12:30 pm Wednesday 22 February (Low tide 10:56 am)

Ocean flat 12:30 pm Wednesday 22 February (Low tide 10:56 am)

Ocean flat 12:30 pm Wednesday 22 February (Low tide 10:56 am)

Ocean flat 12:30 pm Wednesday 22 February (Low tide 10:56 am)

Lagoon 12:30 pm Wednesday 22 February (Low tide 10:56 am)

Lagoon 12:30 pm Wednesday 22 February (Low tide 10:56 am)

Desalination Plant Number 3

Site Reference:	Bairiki 1
Village:	Bairiki
Location	North side on causeway on approach to Bairiki from Nanikai. Immediately before urban development

Description of site:

- Level site with wide main road frontage;
- Site will need minor filling of the order of 300mm to 500mm to provide graded site;
- Open area is presently used as a waste dump along lagoon foreshore;
- One 20 foot container on site close to residential boundary;
- Waste material dumped along lagoon foreshore will require removal and placement of engineered fill;
- Foreshore will need protection with a small sea wall;
- MELAD indicates that that there could be other competing interest for the site. Water supply is an essential work and needs to have precedence.

Vegetation:

- One larger tree which can be planned around;
- Otherwise scraggly and nondescript vegetation and weed cover.

Adjacent properties:

- Site abuts end house in Bairiki;
- A landscaped buffer area can be provided between the house and the site of the desalination plant;
- Adjacent land on Nanikai side of the site is open space.

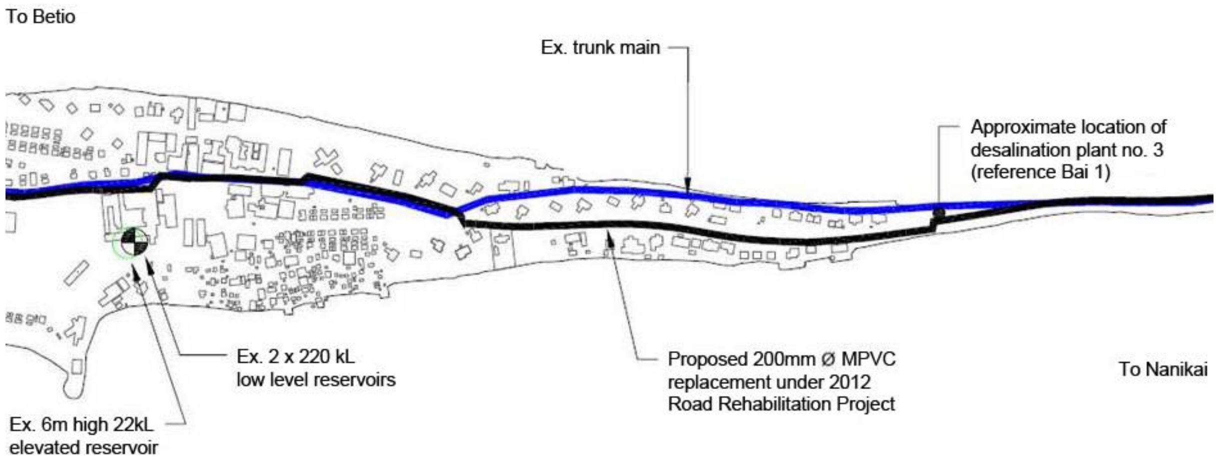
Proximity to transmission main, electricity and sewerage;

- Transmission main runs across the frontage of the site along the main road;
- Electricity cables also pass the site;
- Sewerage can be handled on-site.

Brine disposal:

- Brine can either be discharged to the ocean side.

Location of Site:



Photographs (18 February 2012):

Site looking from the south east

Site looking from the south

Other part of site looking from the south west

Looking towards Bairiki from the east

Container alongside private property

Foreshore looking from east

Foreshore from further to the east

Typical beach drop off

	
Looking directly across main road to ocean lagoon	Foreshore at lagoon side
	
Ocean flat 12:20 pm Wednesday 22 February (Low tide 10:56 am)	Ocean flat 12:20 pm Wednesday 22 February (Low tide 10:56 am)
	
Ocean flat 12:20 pm Wednesday 22 February (Low tide 10:56 am)	Ocean flat 12:20 pm Wednesday 22 February (Low tide 10:56 am)
	
Ocean flat 12:20 pm Wednesday 22 February	Lagoon 12:20 pm Wednesday 22 February

	
Lagoon 12:20 pm Wednesday 22 February (Low tide 10:56 am)	Lagoon 12:20 pm Wednesday 22 February (Low tide 10:56 am)
	
Lagoon 12:20 pm Wednesday 22 February (Low tide 10:56 am)	Lagoon 12:20 pm Wednesday 22 February (Low tide 10:56 am)

Desalination Plant Number 4

Site Reference:	Bairiki 2
Village:	Teaoraereke
Location	North side of reclamation to east of Nanikai Landfill site

Description of site:

- Reasonably level but will require compaction and placement of engineered fill – approximately 0.50 m;
- Main road frontage with secondary road providing access on western end;
- Will require sea wall along lagoon frontage;
- Site has more space and shape factor that can comfortably accommodate the desalination plant;
- Saltwater raw water feed can be piped in across road from ocean side with abstraction of sea water via a stilling well and submersible pumps or bores;
- Design of foundations for the elevated towers and tanks will require geotechnical investigations;
- Open will be required along road frontage to turn storm water and wave over surge past site;
- Brine can be dispoded of to the ocean side.

Vegetation:

- Sparsely vegetated and mainly low grass and weed;
- Some nondescript trees requiring removal;
- Site will be landscaped.

Adjacent properties:

- The abutting property to the immediate west is a storage site for TSKL;
- Land to the east is vacant.

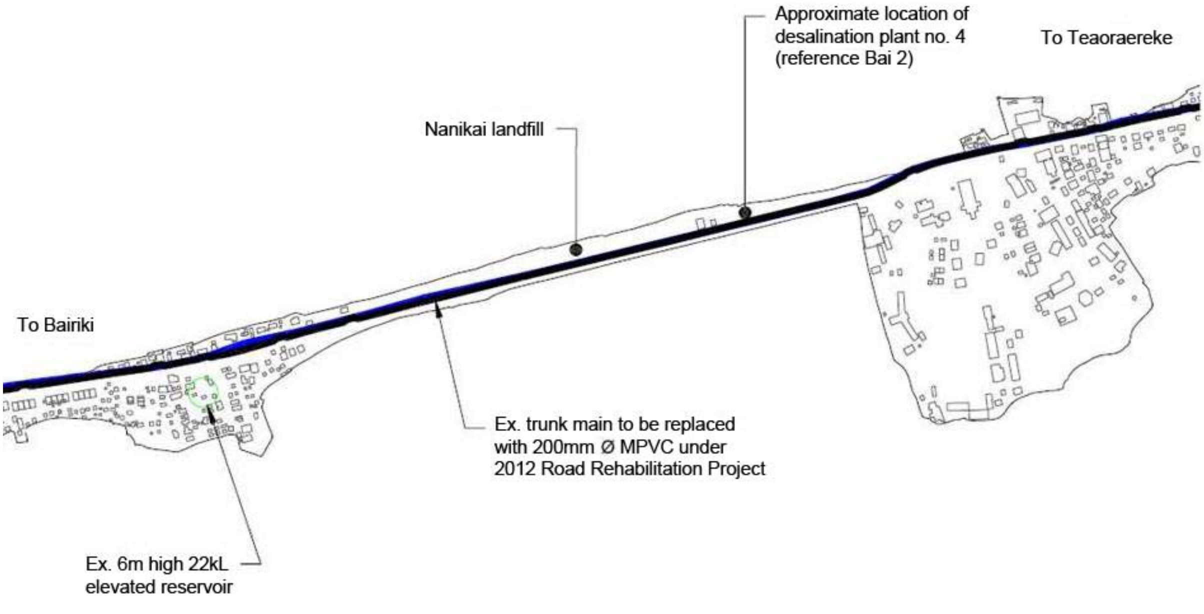
Proximity to transmission main and electricity;

- Transmission main runs across frontage of site;
- Electricity cables run past site;
- Sanitation will need to be on-site with transevaporation bed.

Brine disposal:

- Pipe to ocean lagoon and disperse.

Location of site:



Photographs:	
	
Looking from east along site	Looking from west alongs site
	
TSKL storage site and fence	Road around back of TSKL storage area
	
Road intersection with main road	Main road looking from west or Nanikai end
	
Looking across sea wall at ocean side	Looking along sea wall towards Nanikai

	
Looking over sea wall at ocean reef	Looking along sea wall towards Teaoraereke
	
Lagoon foreshore looking towards Teaoraereke	Lagoon foreshore lokking towards Nanikai landfill
	
Ocean flat 12:15pm Wednesday 22 February (Low tide 10:56 am)	Ocean flat 12:15 pm Wednesday 22 February (Low tide 10:56 am)
	
Ocean flat 12:15 pm Wednesday 22 February (Low tide 10:56 am)	Ocean flat 12:15 pm Wednesday 22 February (Low tide 10:56 am)

	
Lagoon 12:15 pm Wednesday 22 February (Low tide 10:56 am)	Lagoon 12:15 pm Wednesday 22 February (Low tide 10:56 am)
	
Lagoon 12:15 pm Wednesday 22 February (Low tide 10:56 am)	

Appendix C

Letters Initiating Site Protection

Fraser
Thomas
ENGINEERS • RESOURCE MANAGERS • SURVEYORS

23 February 2012 50663

Mr. Eita Metai

Secretary
Ministry of Public Works and Utilities
Betio
South Tarawa, Republic of Kiribati

Dear Mr. Metai

Re: TA 7359 (KIR) Feasibility Study Desalination Plants

You will be aware of the current activities of the project team relating to the study for the provision of salt water reverse osmosis (SWRO) desalination plants in South Tarawa.

The water and sanitation road map 2011 -2030 has recommended the installation of four desalination plants comprising 3 SWRO units capable of producing around 175 kL each daily for a total production from each plant of 528 kL a day. Two desalination plants are planned for Betio, and two for the combined area of Bairiki, Nanikai, Teaoraereke and Antebuka

Our terms of reference require us to identify suitable sites on government or government leased land that can be made available without resettlement or land compensation issues. Since arriving back in South Tarawa on 16 February we have consulted with the Director of Lands, MELAD, the Mayors and administrations of BTC and TUC and NZAP in relation to one of the possible sites on the periphery of the Betio Landfill where BTC is supported by NZAP. These discussions have identified four workable sites and I enclose plans based on Google Earth images identifying each location and the general dimensions of each site

MELAD is being contracted to carry out a topographical survey of each site in order to allow preliminary design and an estimation of costs. We will also be producing CAD plans of the sites, the plant layout, cross sections and construction details. When the preliminary design is completed we will provide site layout drawings with dimensions to identify the actual land and area required for the plants.

This initial advice is provided to enable you and MPWU to communicate with the Director Lands, MELAD and request that his department place an embargo on any other approaches for the allocation of the sites for other uses so that the design process can be completed with certainty so you can then formally request the setting aside of the sites for the future desalination plants and the leasing of the land to PUB when the plants are installed.

We emphasize that there are no other suitable sites and if the land identified is allocated for other use the ability to provide adequate water supplies to South Tarawa will be lost. I have also taken the liberty to draft a letter for you to send to the Director Lands, MELAD which you could use as the basis of your formal letter to him.

Yours sincerely

John Howse
Team Leader TSIP

FRASER THOMAS PARTNERS
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Letter from Secretary MPWU to Director of Lands MELAD

[Date]

Mr. Tebutonga Erata
Director of Lands
Ministry of Lands and Agriculture Development
Bairiki
South Tarawa
Republic of Kiribati

Dear Mr. Erata

Re: TA 7359 (KIR) Feasibility Study Desalination Plants

You will be aware of the current activities of the Asian Development Bank project team relating to the study for the provision of salt water reverse osmosis (SWRO) desalination plants in South Tarawa.

The water and sanitation road map 2011 -2030 has recommended the installation of four desalination plants comprising 3 SWRO units capable of producing around 175 kL each daily for a total production from each plant of 528 kL a day. Two desalination plants are planned for Betio, and two for the combined area of Bairiki, Nanikai, Teaoraereke and Antebuka

The consultant's terms of reference require the identification of suitable sites on government or government leased land that can be made available without resettlement or land compensation issues. Since arriving back in South Tarawa on 16 February I understand the team has met and consulted with you, the Mayors and administrations of BTC and TUC and NZAP in relation to one of the possible sites on the periphery of the Betio Landfill where BTC is supported by NZAP. These discussions have identified four workable sites and I enclose plans based on Google Earth images identifying each location and the general dimensions of each site

The consultants will be producing CAD plans of the sites, the plant layout, cross sections and construction details. When the preliminary design is completed they will provide MPWU with site layout drawings and dimensions to identify the actual land and area required for the plants.

In the meantime and until the preliminary design is completed I would seek your assistance and that of your department in placing an embargo on any other approaches for the allocation of the sites for other uses so that the design process can be completed. Once this is in hand a formal request will be made to set sites aside for the future desalination plants with the leasing of the land to PUB when the plants are installed.

We emphasize that there are no other suitable sites and if the land identified is allocated for other use the ability to provide adequate water supplies to South Tarawa will be lost. Your assistance in this matter would be greatly appreciated.

Yours sincerely

Eita Metai
Secretary
Ministry of Public Works and Utilities

Estimates and Quantities

Summary all Desalination Plants

SOUTH TARAWA DESALINATION WITH BORE HOLE INTAKES

REF	ITEM	ESTIMATE A$			
		DESAL 1	**DESAL 2**	**DESAL 3**	**DESAL 4**
100	PRELIMINARY AND GENERAL	43,875.00	43,875.00	43,875.00	43,875.00
200	DESALINATION SWRO MODULES AND PRE-TREATMENT	1,362,290.00	1,362,290.00	1,362,290.00	1,370,690.00
300	CIVIL AND ANCILLIARY WORKS	90,680.00	82,780.00	87,000.00	97,200.00
400	GENERATOR	52,500.00	52,500.00	52,500.00	52,500.00
500	INTAKE BOREHOLES AND PUMPS	176,625.00	176,625.00	176,625.00	176,625.00
600	PIPES AND FITTINGS	93,940.00	24,340.00	21,940.00	18,595.00
700	STORAGE TANKS AND PUMPS	248,400.00	248,400.00	248,400.00	248,400.00
800	ELECTRICAL	46,679.00	64,007.00	63,606.00	63,606.00
	SUBTOTAL SEPARATE DESALINATION PLANTS	2,114,989.00	2,054,817.00	2,056,236.00	2,071,491.00
	TOTAL				**8,297,533.00**
	CONTINGENCY 12%				995,703.96
	ENGINEERING - FINAL DESIGN AND SUPERVISION 3%				248,925.99
	GRAND TOTAL				**9,542,162.95**

SOUTH TARAWA DESALINATION WITH GALLERY INTAKES

REF	**ITEM**	**ESTIMATE A$**			
		DESAL 1	**DESAL 2**	**DESAL 3**	**DESAL 4**
100	PRELIMINARY AND GENERAL	43,875.00	43,875.00	43,875.00	43,875.00
200	DESALINATION SWRO MODULES AND PRE-TREATMENT	1,362,290.00	1,362,290.00	1,362,290.00	1,370,690.00
300	CIVIL AND ANCILLIARY WORKS	90,680.00	82,780.00	87,000.00	97,200.00
400	GENERATOR	52,500.00	52,500.00	52,500.00	52,500.00
500	INTAKE GALLERIES	201,670.00	201,670.00	201,670.00	201,670.00
600	PIPES AND FITTINGS	93,940.00	24,340.00	21,940.00	18,595.00
700	STORAGE TANKS AND PUMPS	248,400.00	248,400.00	248,400.00	248,400.00
800	ELECTRICAL	46,679.00	64,007.00	63,606.00	63,606.00
	SUBTOTAL SEPARATE DESALINATION PLANTS	2,140,034.00	2,079,862.00	2,081,281.00	2,096,536.00
	TOTAL				**8,397,713.00**
	CONTINGENCY 12%				1,007,725.56
	ENGINEERING - FINAL DESIGN AND SUPERVISION 3%				251,931.39
	GRAND TOTAL				**9,657,369.95**

Estimates and Quantities

Desalination Plant 1 (Betio 1)

	DESALINATION PLANT 1 (BETIO 1) - SUMMARY			
ITEM	**DESCRIPTION**	**COST**	**DUTY**	**AMOUNT (A$)**
100	PRELIMINARY AND GENERAL	$ 43,875	$ -	$ 43,875.00
200	DESALINATION PLANT	$ 1,362,290	$ -	$ 1,362,290.00
300	CIVIL AND ANCILLIARY WORKS	$ 90,680	$ -	$ 90,680.00
400	GENERATORS	$ 52,500	$ -	$ 52,500.00
500	INTAKE BOREHOLES AND PUMPS AT DS PLANT	$ 176,625	$ -	$ 176,625.00
600	PIPES AND FITTINGS	$ 93,940	$ -	$ 93,940.00
700	STORAGE TANKS AND PUMPS	$ 248,400	$ -	$ 248,400.00
800	ELECTRICAL	$ 46,679	$ -	$ 46,679.40
	Subtotal			$ 2,114,989.40
	Contigencies 12%			$ 253,798.73
	Engineering , Design and Supervisions 3%			$ 63,449.68
	TOTAL ESTIMATE IN AUSTRALIAN DOLLARS			**$ 2,432,237.81**
	Note: prices include profit			

	PRELIMINARY AND GENERAL				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
100	**PRELIMINARIES AND GENERAL**				
	The Contract will be based on the FIDIC Conditions of Contract for Works of Civil Engineering Construction				
	The Scope of this Contract is for a Candidate Subproject of the South Tarawa Sanitation Improvement Sector Project - Desalination Plants - and is a lump sum contract in all conditions found				
	This Bill of Quantities has been prepared generally in accordance with NZS 4224 : 1983 and no deviation from same shall form the basis of a claim				
	The site is located in Betio, South Tarawa, Kiribati and is designated Desalination Plant 1 (Betio 1) in the desalination feasibility study report.				
	The following metric abbreviations for units have been used:				
	m^3: Cubic Metres				
	m^2: Square Metres				
	mm : Millimetres				
	no : Number				
	kg :Kilogram				
	kL : Kilolitre				
	MPa: Megapascal				
	Site Visit				
101	Allow to visit the site and ascertain all conditions affecting this Contract (allowance per site)	1	Item	$ 3,525.00	$ 3,525.00
	Site Establishment				
102	Insurances	1	Item	$ 28,700.00	$ 28,700.00
103	Temporary services connection: water, power, phone and internet	1	Item	$ 800.00	$ 800.00
104	Site establishment and mobilisation of personnel and equipment to South Tarawa (allowance per site).		Item	$ 10,000.00	$ 10,000.00
105	Temporary Services		Item	$ 850.00	$ 850.00
106	Miscellaneous Plant and Equipment		Item		$ -
107	Allow to provide care and security of the works outside normal working hours		Item		$ -
108	Allow for any special hours of work as may be required		Item		$ -
109	Day Rates (Unit Rates)				
a	Excavator		Day	$ 850.00	$ -
b	Roller		Day	$ 650.00	$ -
c	Bulldoser		Day	$ 800.00	$ -
d	Welding eqipment		Day	$ 400.00	$ -
e	Misc/ small stools		Day	$ 100.00	$ -
f	Allow for testing of materials		Item	$ 4,000.00	$ -
g	Site clean up and de-establishment		Item	$ 5,000.00	$ -
	Note: This Schedule should not be used as an ordering list of materials.				
	TOTAL ITEM 100 - PRELIMINARY AND GENERAL				$ 43,875.00

	DESALINATION PLANT				
ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT (A$)
200	**DESALINATION PLANT**				
201	Desalination plants each comprising 3 x 190 PX SWRO modules, with each RWSO module in a 20 foot skid mounted container including factory testing before dispatch. Price including low-pressure feed pumps, multi-media fliters and micron filters for the three units in an additional 20-foot container, switch/control boards, and back washing provisions, all complete ready for site placement and for connection to site placed pipes and electrical cabling provided and priced separately. SWRO modules to include pipes/valves, high-pressure pumps, RO units, airconditioning, switchboard and electic fittings and installation, all including containers to specification.	1	no.	$ 1,300,000.00	$ 1,300,000.00
202	Installation and commissioning of desalination plants in South Tarawa. Cost to include air flights, accommodation and living allowance, labour and local land transport. (allowance per plant).	1	LS	$ 37,290.00	$ 37,290.00
	Transport and Freight from manufacturer to South Tarawa including all handling, port charges and insurance				
203	SWRO modules and filters, 20' containers	4	no.	$ 5,000.00	$ 20,000.00
204	Miscellaneous equipment and materials, 20 foot container	1	no.	$ 5,000.00	$ 5,000.00
	TOTAL ITEM 200 - DESALINATION PLANT			**A$**	$ 1,362,290.00

	CIVIL AND ANCILLIARY WORKS				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
300	**CIVIL AND ANCILLIARY WORKS**				
301	Site clearance - remove vegetation, trim topsoil and prepare site for engineered fill	740	m^2	$ 2.00	$ 1,480.00
302	Engineered filled - supply and place engineered fill with coral mud to levels shown in drawings	152	m^3	$ 40.00	$ 6,080.00
303	Concrete blocks retaining wall - supply and install concrete block to height and location shown in drawings.	30	m^2	$ 80.00	$ 2,400.00
304	Seawall - supply and install sand cemment bags seawall with 0.5m high nib to height and location shown in drawings	0	m^2	$ 380.00	$ -
305	Access to site - Construct 3m wide 200mm thick compacted coral aggregate site accessway to dimensions and location shown in drawings incl. parking area in front of the office and generators	30	m^3	$ 35.00	$ 1,050.00
306	Fence - Supply and install galvanized post and galvanized chain link mesh security fence. 1.5 m high with 0.3 m topping of razor wire to details and location shown in drawings.	110	m	$ 200.00	$ 22,000.00
307	Entrance gate - Supply of materials and construction of 4m wide entrance gate to desalination plant compound. Secure with galvanized chain and padlock with key matched to all sites.	1	no.	$ 400.00	$ 400.00
308	Drainage V-channel - Supply and consctruct 2m wide x 100mm thick unreinforced concrete drainage V-channel at the perimeter of the site to location as shown on drawings	0	m^3	$ 300.00	$ -
309	Vehicle crossing - supply and construct 3m wide x 4m long x 150mm thick reinforced concrete crossing (V shape) at site entrance.	2	m^3	$ 340.00	$ 680.00
310	Concrete pad - supply and construct 4.3x4.6m 100mm thick reinforced concrete pad forplacement of standby generator.	2.4	m^3	$ 340.00	$ 816.00
311	Concrete containment bund - 200 mm thick reinforced concrete with 300mm upstand.	1.1	m^3	$ 340.00	$ 374.00
312	Office - Supply and construct prefabricated 4x4m site office. Office to include desk and chairs (3), layout table, opening winndows with security bars, lights, adequate power points and air conditioning. *Note: Office to have a central control switchboard covered under item 800 -Electrical.*	1	LS	$ 36,000.00	$ 36,000.00
313	Calcite bed and Chlorination unit shed - supply and construct 4.0x6.0m open, carport like shed between container units with corrugated iron sheeting incl. galvinised steel post and foundation.	24	m^2	$ 350.00	$ 8,400.00
314	Landscaping - to the layout and details illustrated on the site drawing and layout plan.	1	LS	$ 5,000.00	$ 5,000.00
315	Supply and install concrete filled mattress to protect brine discharge pipes	1	LS	$ 5,000.00	$ 5,000.00
316	Supply and install precast diffuser units fore brine discharge	2	No.	$ 500.00	$ 1,000.00
	TOTAL ITEM 300 - CIVIL AND ANCILLIARY WORKS			**A$**	$ 90,680.00

	GENERATORS				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
400	**GENERATOR**				
402	Shed - Supply and construct 4.3x4.6m open, carport like shed with corrugated iron sheeting including galvinised steel post and foundation to house the generator	20	m^2	$ 350.00	$ 7,000.00
403	Generator - supply and install and comission 120kVA diesel generator. Include control switch installed inside the main office. Note: external cabling is covered under item 800 electrical.	1	no.	$ 35,000.00	$ 35,000.00
404	Generator - transport, sea freight, port charges and placement, commissioning on site including insurances	1	no.	$ 5,000.00	$ 5,000.00
405	Fuel tank - supply and install 1.6kL stainless steel fuel tank including support and pipeworks connected to the generator.	1	no.	$ 5,000.00	$ 5,000.00
406	Fuel tank - transport, sea freight, port charges and placement, commissioning on site including insurances	1	no.	$ 500.00	$ 500.00
	TOTAL ITEM 400 - GENERATOR			**A$**	$ 52,500.00

	INTAKE BOREHOLES AND PUMPS AT DS PLANT				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
500	**INTAKE BORHOLES AND PUMPS**				
	Well Construction (4 boreholes)				
501	Mobilise drill rig and establishment including shipping (allowance per site)	1	LS	$ 5,000.00	$ 5,000.00
502	Drill 250mm dia into sand, coral and fractured limestone	140	m	$ 450.00	$ 63,000.00
503	Supply and install 150mm dia PVC casing, finish 1m proud of ground level	72	m	$ 280.00	$ 20,160.00
504	Supply and install 150mm dia PVC screen	68	m	$ 280.00	$ 19,040.00
505	Well development	4	LS	$ 1,000.00	$ 4,000.00
506	Water Quality test	4	LS	$ 1,000.00	$ 4,000.00
	Pumps and Pump Controls				
507	Supply and install 100mm dia 20m^3/hr @ 25 m head 904L stainless steel submersible pumps (with 1 spare)	4	no.	$ 10,500.00	$ 42,000.00
508	Supply and install 63ODPE riser pipe	105	m	$ 45.00	$ 4,725.00
509	Supply and install power supply cable from ground level to pump single 60A phase	105	m	$ 20.00	$ 2,100.00
510	Supply and install control cable from ground level to pump	105	m	$ 20.00	$ 2,100.00
511	Supply, intall and commission control panel in office	1	LS	$ 500.00	$ 500.00
512	Supply materials and construct reinforced concrete box ground well unit with inner dimensions of 1.2m x 1.2m by 1 m height, complete with hinged and lockable galvanised steel lid, 316 SS pump support cable hook. All as indicated on drawings.	4	no.	$ 1,000.00	$ 4,000.00
513	Manifold pipeworks and valves	4	LS	$ 1,500.00	$ 6,000.00
	All electrical and control cables to switch/control board mounted in site office provided for under 600 and 800				
	TOTAL ITEM 500 - BOREHOLES AND PUMPS			**A$**	$ 176,625.00

	INTAKE GALLERIES AND SUMPS AT DS PLANT (ALTERNATIVE)				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
500.1	**INTAKE GALLERIES AND SUMPS**				
501.1	Seawater Galleries and Intake - Install new seawater galleries and intake to pump. Supply and install slotted saltwater gallery pipes with poly weave fabric and gravel pack around the pipe, end caps and backwash arrangments, all as specified and detailed on drawings.	1	no.	$ 125,000.00	$ 125,000.00
502.1	Supply , install and commission marinized 409L grade stainless steel 5 kW standby and duty pumps discharging to Arkal filter. include 316 stainless impellor, anodes, tungsten carbide mechanical seals, thermal switches for protection, pump controller and corrosion resistant pressure tank, all as specified and detailed on drawings. Including shipping, freight, cost to site and installation.	2	no.	$ 7,500.00	$ 15,000.00
503.1	Supply and install 1050mm dia. fibre glass intake cylinder incl all interconnection pipes and fittings	2	no.	$ 7,000.00	$ 14,000.00
504.1	Arkal Mechanical Filter - Arkal filter - Spin Klin SeaWater 20 micron filtration system utilizing online backwash, pre plumbed and wired including installation into raw water supply and backwash controller and connection of backwash to brine discharge pipe line. Including shipping, freight, cost to site and installation.	1	no.	$ 47,500.00	$ 47,500.00
505.1	Concrete pad - supply materials and construct 2 x 2m 100mm thick reinforced concrete pad for Arkal mechanical pre-filter on intake pipe line prior to raw water storage	0.5	m^3	$ 340.00	$ 170.00
	TOTAL ITEM 500.1 -SEAWATER INTAKE GALLERIES			**A$**	$ 201,670.00

	PIPES AND FITTINGS				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
600	**PIPES AND FITTINGS**				
	Pipeworks				
601	63mm ODPE at 0 - 1.5m deep	15	m	$ 45.00	$ 675.00
601	65mm uPVC SN16 at 0 - 1.5m deep	60	m	$ 60.00	$ 3,600.00
602	100mm uPVC SN16 at 0 - 1.5m deep	180	m	$ 75.00	$ 13,500.00
604	100mm uPVC SN16 at 0 - 1.5m deep extension from DS plant in the Betio landfill area to the Betio ground level storage tanks. This section is in the vincinity of/ or under the main road	800	m	$ 90.00	$ 72,000.00
	90 degree bends				
606	65mm	14	No	$ 30.00	$ 420.00
607	100mm	8	No	$ 50.00	$ 400.00
	Tees				
611	100/65mm	4	No	$ 150.00	$ 600.00
611	100/100mm	2	No	$ 65.00	$ 130.00
612	100/200mm	1	No	$ 350.00	$ 350.00
	Valves				
616	50mm	5	No	$ 60.00	$ 300.00
616	65mm	9	No	$ 85.00	$ 765.00
617	100mm	2	No	$ 600.00	$ 1,200.00
	Note: Price include shipping of materials from AUS				
	TOTAL ITEM 600 - PIPES AND FITTINGS			**A$**	$ 93,940.00

	STORAGE TANKS AND PUMPS				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
700	**STORAGE TANKS AND PUMPS**				
701	Raw water tanks - Supply, ship, install and commission 22 kL interlinked covered tanks of non-corrosive and high uv resistant material. Including 63mm OD PE drain down pipes and valves connected to brine discharge system. Connection to intake from borehole pumps and to backwashing units for muli-media filters. Connection to low pressure line pumps for intake to filters. All as indicated on drawings, including freight, handling, port charges and insurances.	2	no.	$ 12,000.00	$ 24,000.00
702	Permeate tanks - Supply, ship, install and commission 30 kL interlinked covered tanks of non-corrosive and high uv resistant material. Including 63mm OD PE drain down pipes and valves connected to brine discharge system. Connection to intake from RWO units. Connection to lift pumps for intake to elevated tank. All as indicated on drawings, including freight, handling, port charges and insurances.	2	no.	$ 15,000.00	$ 30,000.00
703	Brine tank - Supply, ship, install and commission 22 kL covered tank of non-corrosive and high uv resistant material. Including 63mm OD PE drain down pipe and valve connected to brine discharge system. Connection to intake from RWO units. Connection to discharge pipe into water body. All as indicated on drawings, including freight, handling, port charges and insurances.	1	no.	$ 12,000.00	$ 12,000.00
704	Elevated tank - Supply, ship, install and commission 22 kL covered tank of non-corrosive and high uv resistant material. Including 63mm OD PE drain down pipes and valve. Connection to intake from lift pump from permeate tanks. Connection to discharge pipe into trunk main. All as indicated on drawings, including freight, handling, port charges and insurances.	1	no.	$ 15,000.00	$ 15,000.00
705	Concrete pad for low level tanks - 400mm high concrete pad constructed from blocks filled with compacted sand and covered with 150mm reinforced concrete slab	200	m^2	$ 70.00	$ 14,000.00
706	Tower for elevated tank - design, supply, ship and install 12m high galvinised steel tower, double coating paint suitable for marine environment. Completed with steps, safety bars and working platform. Assume 120kg/m length of trusses. All as indicated on drawings, including freight, handling, port charges and insurances.	1	no.	$ 80,400.00	$ 80,400.00
707	Lift pump - supply, install and commission 50 mm 316 grade stainless steel pump 10 l/s at 14m head discharging from ground level treated water tanks to elevated reaervoir at each Desalination plant 316 stainless impellor, anodes, tungsten carbide mechanical seals, thermal switches for protection, pump controller and corrosion resistant pressure tank, all as specified and depicted on drawings.	1	no.	$ 3,000.00	$ 3,000.00
	Calcite Beds and Chlorination				
708	Supply, freight and install calcite bed within 2m diameter shell for final water adjustment including media and all shipping, freight, handling costs and insurances. All as indicated in drawings.	1	no.	$ 55,000.00	$ 55,000.00
709	Supply, freight and install chorination unit complete with automatic monitoring and controls, including shipping, freight, handling costs and insurances.	1	no.	$ 15,000.00	$ 15,000.00
	TOTAL ITEM 700 - STORAGE TANKS AND PUMPS			**A$**	$ 248,400.00

	ELECTRICAL				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
800	**ELECTRICAL**				
801	100mm uPVC duct at 0 - 1.5m deep	75	m	$ 60.00	$ 4,500.00
802	Control cable: 2 sets of 4 x single core copper cable 6.2mm	150	m	$ 70.00	$ 10,500.00
803	200kVA 11kV/433V ONAN ground mount transformer. Outdoor type, 3phase, oil immersed and naturally cooled. Vector group Dyn11. Cost ex manufacturuer	0	no.	$ 20,750.00	$ -
804	Transport and delivery of transformer to site and contractors mark-up	0	no.	$ 5,000.00	$ -
805	Power cable 95mm^2, 3Core, PCW 6.35/11kV XLPE with wire armour - cable only	140	m	$ 50.21	$ 7,029.40
806	Trenching for cable and reinstatement	140	m	$ 30.00	$ 4,200.00
807	Connection and jointing to 11kVA main cable and placement of transformer and connection	1	no.	$ 2,500.00	$ 2,500.00
808	Power aluminium cable: 3 phase light 60A/phase.	75	m	$ 50.00	$ 3,750.00
809	Central control switch board in the office (light industrial)	1	no.	$ 12,000.00	$ 12,000.00
810	Install and commission all control switches	1	LS	$ 1,000.00	$ 1,000.00
811	Security 500W flood light open type	4	no.	$ 300.00	$ 1,200.00
	TOTAL ITEM 700 - ELECTRICAL			**A$**	$ 46,679.40

COST BREAKDOWN

Based on construction duration of 16 weeks as per attached programme

Item	Description	Qty	Unit	Rate	Amount
101	Site visit say 7 days				
	Air fare	1	Item	$ 1,500.00	$ 1,500.00
	Per diem	7	day	$ 150.00	$ 1,050.00
	Wages	7	day	$ 1,600.00	$ 11,200.00
	Vehicle rent	7	day	$ 50.00	$ 350.00
	Total 101				**$ 14,100.00**
	Allow 25% per plant				**$ 3,525.00**
102	Insurance, contract value approx. $2.2 million per DS plant				
	Contractor all risk - 0.8% of contract value	1	Item	$ 17,600.00	$ 17,600.00
	Public liability - 0.3% premium of contract value	1	Item	$ 6,600.00	$ 6,600.00
	Vehicle x 3	1	Item	$ 1,500.00	$ 1,500.00
	Plant and equipment	1	Item	$ 3,000.00	$ 3,000.00
	Total 102				**$ 28,700.00**
312	Site office, storage and amenities				
	Construct 4x5m office	20	m^2	$ 1,250.00	$ 25,000.00
	Toilet including water connection and irrigation or evapotransporation bed	1	no.	$ 4,000.00	$ 4,000.00
	first aid	1	Item	$ 500.00	$ 500.00
	Safety equipment and handwashing facilities	1	Item	$ 5,500.00	$ 5,500.00
	security	1	Item	$ 1,000.00	$ 1,000.00
	Total 103				**$ 36,000.00**
	DESALINATION PLANT				
202	Installation and commisioning say 2 weeks for 2 technicians, labour provided by main contractor				
	Air fare x 2	2	Item	$ 1,500.00	$ 3,000.00
	Per diem x 2	28	day	$ 200.00	$ 5,600.00
	Wages x 2	28	day	$ 1,000.00	$ 28,000.00
	Vehicle cost	12	day	$ 50.00	$ 600.00
	Vehicle running cost	1.5	Week	$ 60.00	$ 90.00
	Total 202				**$ 37,290.00**
	BOREHOLES				
502	Drilling rig on-site plus crew	16	week	$ 8,200.00	$ 131,200.00
	Mobilization and demobilization	4	Container	$ 5,000.00	$ 20,000.00
	International flights	4	RT	$ 1,750.00	$ 7,000.00
	Accommodation and per diem	448	day	$ 120.00	$ 53,760.00
	Miscellaneous Items	1	LS	$ 5,000.00	$ 5,000.00
	In-country transport	16	week	$ 450.00	$ 7,200.00
	Contractor's mark-up and risk allowance	1	LS	$ 40,000.00	$ 40,000.00
					$ 264,160.00
	Estimated cost per metre				$ 471.71
				say	**$ 450.00**
	STORAGE TANKS				
705	Concrete pad 10x10mx 0.4H				
	Blockwork	16	m2	$ 80.00	$ 1,280.00

	150mm reinforced slab	15	m3	$	300.00	$	4,500.00
	Compacted fill	25	m3	$	40.00	$	1,000.00
	Total 705					**$**	**6,780.00**
						per 100m2	
				i.e. ~		$70 per m2	
706	Tower for elevated tank						
	Foundation 3x3x2m deep	18	m3	$	300.00	$	5,400.00
	Design, fabricate, pack and freight galvanised tower complete with platforms, ladders and guardrails	1	no.	$	42,000.00	$	42,000.00
	Erect and paint tower to marine grade three-cost finish	1	no.	$	25,500.00	$	25,500.00
	Miscellaneous items	1	no.	$	7,500.00	$	7,500.00
	Total 706					**$**	**80,400.00**

Estimates and Quantities

Desalination Plant 2 (Betio 2)

	DESALINATION PLANT 2 (BETIO 2) - SUMMARY			
ITEM	**DESCRIPTION**	**COST**	**DUTY**	**AMOUNT (A$)**
100	PRELIMINARY AND GENERAL	$ 43,875	$ -	$ 43,875.00
200	DESALINATION PLANT	$ 1,362,290	$ -	$ 1,362,290.00
300	CIVIL AND ANCILLIARY WORKS	$ 82,780	$ -	$ 82,780.00
400	GENERATORS	$ 52,500	$ -	$ 52,500.00
500	INTAKE BOREHOLES AND PUMPS AT EACH DS PLANT	$ 176,625	$ -	$ 176,625.00
600	PIPES AND FITTINGS	$ 24,340	$ -	$ 24,340.00
700	STORAGE TANKS AND PUMPS	$ 248,400	$ -	$ 248,400.00
800	ELECTRICAL	$ 64,007	$ -	$ 64,007.35
	Subtotal			$ 2,054,817.35
	Contigencies 12%			$ 246,578.08
	Engineering , Design and Supervisions 3%			$ 61,644.52
	TOTAL ESTIMATE IN AUSTRALIAN DOLLARS			**$ 2,363,039.95**
	Note: prices include profit			

	PRELIMINARY AND GENERAL				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
100	**PRELIMINARIES AND GENERAL**				
	The Contract will be based on the FIDIC Conditions of Contract for Works of Civil Engineering Construction				
	The Scope of this Contract is for a Candidate Subproject of the South Tarawa Sanitation Improvement Sector Project - Desalination Plants - and is a lump sum contract in all conditions found				
	This Bill of Quantities has been prepared generally in accordance with NZS 4224 : 1983 and no deviation from same shall form the basis of a claim				
	The site is located in Betio, South Tarawa, Kiribati and is designated Desalination Plant 2 (Betio 2) in the desalination feasibility study report.				
	The following metric abbreviations for units have been used:				
	m^3: Cubic Metres				
	m^2: Square Metres				
	mm : Millimetres				
	no : Number				
	kg :Kilogram				
	kL : Kilolitre				
	MPa: Megapascal				
	Site Visit				
101	Allow to visit the site and ascertain all conditions affecting this Contract (allowance per site)	1	Item	$ 3,525.00	$ 3,525.00
	Site Establishment				
102	Insurances	1	Item	$ 28,700.00	$ 28,700.00
103	Temporary services connection: water, power, phone and internet	1	Item	$ 800.00	$ 800.00
104	Site establishment and mobilisation of personnel and equipment to South Tarawa (per site).		Item	$ 10,000.00	$ 10,000.00
105	Temporary Services		Item	$ 850.00	$ 850.00
106	Miscellaneous Plant and Equipment		Item		$ -
107	Allow to provide care and security of the works outside normal working hours		Item		$ -
108	Allow for any special hours of work as may be required		Item		$ -
109	Day Rates (Unit Rates)				
a	Excavator		Day	$ 850.00	$ -
b	Roller		Day	$ 650.00	$ -
c	Bulldozer		Day	$ 800.00	$ -
d	Welding eqipment		Day	$ 400.00	$ -
e	Misc/ small stools		Day	$ 100.00	$ -
f	Allow for testing of materials		Item	$ 4,000.00	$ -
g	Site clean up and de-establishment		Item	$ 5,000.00	$ -
	Note: This Schedule should not be used as an ordering list of materials. Shipping expenses covered item 900				
	TOTAL ITEM 100 - PRELIMINARY AND GENERAL				$ 43,875.00

	DESALINATION PLANT				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
200	**DESALINATION PLANT**				
201	Desalination plants each comprising 3 x 190 PX SWRO modules, with each RWSO module in a 20 foot skid mounted container including factory testing before dispatch. Price including low-pressure feed pumps, multi-media fliters and micron filters for the three units in an additional 20-foot container, switch/control boards, and back washing provisions, all complete ready for site placement and for connection to site placed pipes and electrical cabling provided and priced separately. SWRO modules to include pipes/valves, high-pressure pumps, RO units, airconditioning, switchboard and electic fittings and installation, all including containers to specification.	1	no.	$ 1,300,000.00	$ 1,300,000.00
202	Installation and commissioning of desalination plants in South Tarawa. Cost to include air flights, accommodation and living allowance, labour and local land transport. (allowance per plant).	1	LS	$ 37,290.00	$ 37,290.00
	Transport and Freight from manufacturer to South Tarawa including all handling, port charges and insurance				
203	SWRO modules and filters, 20' containers	4	no.	$ 5,000.00	$ 20,000.00
204	Miscellaneous equipment and materials, 20 foot container	1	no.	$ 5,000.00	$ 5,000.00
	TOTAL ITEM 200 - DESALINATION PLANT			**A$**	$ 1,362,290.00

	CIVIL AND ANCILLIARY WORKS				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
300	**CIVIL AND ANCILLIARY WORKS**				
301	Site clearance - remove vegetation, trim topsoil and prepare site for engineered fill	910	m^2	$ 2.00	$ 1,820.00
302	Engineered filled - supply and place engineered fill with coral mud to levels shown in drawings	140	m^3	$ 40.00	$ 5,600.00
303	Concrete blocks retaining wall - supply and install concrete block to height and location shown in drawings.	30	m^2	$ 80.00	$ 2,400.00
304	Seawall - supply and install sand cemment bags seawall with 0.5m high nib to height and location shown in drawings	0	m^2	$ 380.00	$ -
305	Access to site - Construct 3m wide 200mm thick compacted coral aggregate site accessway to dimensions and location shown in drawings incl. parking area in front of the office and generators	46	m^3	$ 35.00	$ 1,610.00
306	Fence - Supply and install galvanized post and galvanized chain link mesh security fence. 1.5 m high with 0.3 m topping of razor wire to details and location shown in drawings.	118	m	$ 200.00	$ 23,600.00
307	Entrance gate - Supply of materials and construction of 4m wide entrance gate to desalination plant compound. Secure with galvanized chain and padlock with key matched to all sites.	2	no.	$ 400.00	$ 800.00
308	Drainage V-channel - Supply and consctruct 2m wide x 100mm thick unreinforced concrete drainage V-channel at the perimeter of the site to location as shown on drawings	0	m^3	$ 300.00	$ -
309	Vehicle crossing - supply and construct 3m wide x 4m long x 150mm thick reinforced concrete crossing (V shape) at site entrance.	4	m^3	$ 340.00	$ 1,360.00
310	Concrete pad - supply and construct 4.3 x 4.6 x 120mm thick reinforced concrete pad forplacement of standby generator.	2.4	m^3	$ 340.00	$ 816.00
311	Concrete containment bund - 200x300H upstand.	1.1	m^3	$ 340.00	$ 374.00
312	Office - Strip and convert old desalination plant building and reconfigure as filter house, store and site office Office to include desk and chairs (3), layout table, opening winndows with security bars, lights, adequate power points and air conditioning. Incorporate toilet and handwashing facilities,	1	LS	$ 25,000.00	$ 25,000.00
313	Landscaping - to the layout and details illustrated on the site drawing and layout plan.	1	LS	$ 5,000.00	$ 5,000.00
314	Calcite bed and Chlorination unit shed - supply and construct 4.0x6.0m open, carport like shed between container units with corrugated iron sheeting incl. galvinised steel post and foundation.	24	m^2	$ 350.00	$ 8,400.00
315	Supply and install concrete filled mattress to protect brine discharge pipes	1	LS	$ 5,000.00	$ 5,000.00
316	Supply and install precast diffuser units fore brine discharge	2	No.	$ 500.00	$ 1,000.00
	TOTAL ITEM 300 - CIVIL AND ANCILLIARY WORKS			**A$**	$ 82,780.00

	GENERATORS				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
400	**GENERATOR**				
401	Shed - Supply and construct 4.3 x 4.6m open, carport like shed with corrugated iron sheeting including timeber post and foundation to house the generator	20	m^2	$ 350.00	$ 7,000.00
402	Generator - supply and install and comission 120kVA diesel generator. Include control switch installed inside the main office. Note: external cabling is covered under item 800 electrical.	1	No.	$ 35,000.00	$ 35,000.00
403	Generator - transport, sea freight, port charges and placement, commissioning on site including insurances	1	no.	$ 5,000.00	$ 5,000.00
404	Fuel tank - supply and install 1.6kL stainless steel fuel tank including support and pipeworks connected to the generator.	1	no.	$ 5,000.00	$ 5,000.00
405	Fuel tank - transport, sea freight, port charges and placement, commissioning on site including insurances	1	no.	$ 500.00	$ 500.00
	TOTAL ITEM 400 - GENERATORS			**A$**	$ 52,500.00

	INTAKE BOREHOLES AND PUMPS AT EACH DS PLANT				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
500	**INTAKE BORHOLES AND PUMPS**				
	Well Construction (4 boreholes)				
501	Mobilise drill rig and establishment including shipping (allowar	1	LS	$ 5,000.00	$ 5,000.00
502	Drill 250mm dia into sand, coral and fractured limestone	140	m	$ 450.00	$ 63,000.00
503	Supply and install 150mm dia PVC casing, finish 1m proud of ground level	72	m	$ 280.00	$ 20,160.00
504	Supply and install 150mm dia PVC screen	68	m	$ 280.00	$ 19,040.00
505	Well development	4	LS	$ 1,000.00	$ 4,000.00
506	Water Quality test	4	LS	$ 1,000.00	$ 4,000.00
	Pumps and Pump Controls				
507	Supply and install 100mm dia 20m^3/hr @ 25 m head 904L stainless steel submersible pumps (1 spare)	4	no.	$ 10,500.00	$ 42,000.00
508	Supply and install 63OD PE riser pipe	105	m	$ 45.00	$ 4,725.00
509	Supply and install power supply cable from ground level to pump single 60A phase	105	m	$ 20.00	$ 2,100.00
510	Supply and install control cable from ground level to pump	105	m	$ 20.00	$ 2,100.00
511	Supply, intall and commission control panel in office	1	LS	$ 500.00	$ 500.00
512	Supply materials and construct reinforced concrete box ground well unit with inner dimensions of 1.2m x 1.2m by 1 m height, complete with hinged and lockable galvanised steel lid, 316 SS pump support cable hook. All as indicated on drawings.	4	ea	$ 1,000.00	$ 4,000.00
513	Supply, intall and commission manifold pipeworks and valves	4	LS	$ 1,500.00	$ 6,000.00
	All electrical and control cables to switch/control board mounted in site office provided for under 600 and 800				
	TOTAL ITEM 500 - BOREHOLES AND PUMPS			**A$**	$ 176,625.00

	INTAKE GALLERIES AND SUMPS AT DS PLANT (ALTERNATIVE)				
ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT (A$)
500.1	**INTAKE GALLERIES AND SUMPS**				
501.1	Seawater Galleries and Intake - Install new seawater galleries and intake to pump. Supply and install slotted saltwater gallery pipes with poly weave fabric and gravel pack around the pipe, end caps and backwash arrangments, all as specified and detailed on drawings.	1	no.	$ 125,000.00	$ 125,000.00
502.1	Supply , install and commission marinized 409L grade stainless steel 5 kW standby and duty pumps discharging to Arkal filter. include 316 stainless impellor, anodes, tungsten carbide mechanical seals, thermal switches for protection, pump controller and corrosion resistant pressure tank, all as specified and detailed on drawings. Including shipping, freight, cost to site and installation.	2	no.	$ 7,500.00	$ 15,000.00
503.1	Supply and install 1050mm dia. fibre glass intake cylinders including interconnection pipes and fittings	2	no.	$ 7,000.00	$ 14,000.00
504.1	Arkal Mechanical Filter - Arkal filter - Spin Klin SeaWater 20 micron filtration system utilizing online backwash, pre plumbed and wired including installation into raw water supply and backwash controller and connection of backwash to brine discharge pipe line. Including shipping, freight, cost to site and installation.	1	no.	$ 47,500.00	$ 47,500.00
505.1	Concrete pad - supply materials and construct 2 x 2m 100mm thick reinforced concrete pad for Arkal mechanical pre-filter on intake pipe line prior to raw water storage tanks.	0.5	m^3	$ 340.00	$ 170.00
	TOTAL ITEM 500.1 -SEAWATER INTAKE GALLERIES			**A$**	$ 201,670.00

	PIPES AND FITTINGS				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
600	**PIPES AND FITTINGS**				
	Pipeworks				
601	63mm ODPE at 0 - 1.5m deep	15	m	$ 45.00	$ 675.00
602	65mm uPVC SN16 at 0 - 1.5m deep	100	m	$ 60.00	$ 6,000.00
603	100mm uPVC SN16 at 0 - 1.5m deep	180	m	$ 75.00	$ 13,500.00
	90 degree bends				
604	65mm	14	No	$ 30.00	$ 420.00
605	100mm	8	No	$ 50.00	$ 400.00
	Tees				
606	100/65mm	4	No	$ 150.00	$ 600.00
607	100/100mm	2	No	$ 65.00	$ 130.00
608	100/200mm	1	No	$ 350.00	$ 350.00
	Valves				
609	50mm	5	No	$ 60.00	$ 300.00
610	65mm	9	No	$ 85.00	$ 765.00
611	100mm	2	No	$ 600.00	$ 1,200.00
	Note: Price include shipping of materials from AUS				
	TOTAL ITEM 600 - PIPES AND FITTINGS			**A$**	$ 24,340.00

	STORAGE TANKS AND PUMPS				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
700	**STORAGE TANKS AND PUMPS**				
701	Raw water tanks - Supply, install and commission 22 kL interlinked covered tanks of non-corrosive and high uv resistant material. Including 63mm OD PE drain down pipes and valves connected to brine discharge system. Connection to intake from borehole pumps and to backwashing units for muli-media filters. Connection to low pressure line pumps for intake to filters. All as indicated on drawings, including freight, handling, port charges and insurances.	2	no.	$ 12,000.00	$ 24,000.00
702	Permeate tanks - Supply, ship, install and commission 30 kL interlinked covered tanks of non-corrosive and high uv resistant material. Including 63mm OD PE drain down pipes and valves connected to brine discharge system. Connection to intake from RWO units. Connection to lift pumps for intake to elevated tank. All as indicated on drawings, including freight, handling, port charges and insurances.	2	no.	$ 15,000.00	$ 30,000.00
703	Brine tank - Supply, ship, install and commission 22 kL covered tank of non-corrosive and high uv resistant material. Including 63mm OD PE drain down pipe and valve connected to brine discharge system. Connection to intake from SWRO modules. Connection to discharge pipe into water body. All as indicated on drawings, including freight, handling, port charges and insurances.	1	no.	$ 12,000.00	$ 12,000.00
704	Elevated tank - Supply, ship, install and commission 22 kL covered tank of non-corrosive and high uv resistant material. Including 63mm OD PE drain down pipes and valve. Connection to intake from lift pump from permeate tanks. Connection to discharge pipe into trunk main.	1	no.	$ 15,000.00	$ 15,000.00
705	Concrete pad for low level tanks - 400mm high concrete pad constructed from blocks filled with compacted sand and covered with 150mm reinforced concrete slab	200	m^2	$ 70.00	$ 14,000.00
706	Tower for elevated tanks - supply, ship and install 12m high galvinised steel tower, double coating paint suitable for marine environment. Completed with steps, safety bars and working platform. Assume 120kg/m length of trusses. All as indicated on drawings, including freight, handling, port charges and insurances.	1	Item	$ 80,400.00	$ 80,400.00
707	Lift pump - supply, install and commission 50 mm 316 grade stainless steel pump 10 l/s at 14m head discharging from ground level treated water tanks to elevated reaervoir at each Desalination plant 316 stainless impellor, anodes, tungsten carbide mechanical seals, thermal switches for protection, pump controller and corrosion resistant pressure tank, all as specified and depicted on drawings.	1	no.	$ 3,000.00	$ 3,000.00
	Calcite Beds and Chlorination				
708	Supply, freight and install calcite bed within 2m diameter shell for final water adjustment including media and all shipping, freight, handling costs and insurances. All as indicated in drawings.	1	no.	$ 55,000.00	$ 55,000.00
709	Supply, freight and install chorination unit complete with automatic monitoring and controls, including shipping, freight, handling costs and insurances.	1	no.	$ 15,000.00	$ 15,000.00
	TOTAL ITEM 700 - STORAGE TANKS AND PUMPS			**A$**	$ 248,400.00

	ELECTRICAL				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
800	**ELECTRICAL**				
801	100mm uPVC duct at 0 - 1.5m deep	75	m	$ 60.00	$ 4,500.00
802	Control cable: 2 sets of 4 x single core copper cable 6.2mm	150	m	$ 70.00	$ 10,500.00
803	200kVA 11kV/433V ONAN ground mount transformer. Outdoor type, 3phase, oil immersed and naturally cooled. Vector group Dyn11. Cost ex manufacturuer	1	no.	$ 20,750.00	$ 20,750.00
804	Transport and delivery of transformer to site and contractors mark-up	1	no.	$ 5,000.00	$ 5,000.00
805	Power cable 95mm^2, 3Core, PCW 6.35/11kV XLPE with wire armour - cable only	35	m	$ 50.21	$ 1,757.35
806	Trenching for cable and reinstatement	35	m	$ 30.00	$ 1,050.00
807	Connection and jointing to 11kVA main cable and placement of transformer and connection.	1	no.	$ 2,500.00	$ 2,500.00
808	Power aluminium cable: 3 phase light 60A/phase.	75	m	$ 50.00	$ 3,750.00
809	Central control switch board in the office (light industrial)	1	no.	$ 12,000.00	$ 12,000.00
810	Install and commission all control switches	1	LS	$ 1,000.00	$ 1,000.00
811	Security 500W flood light open type	4	no.	$ 300.00	$ 1,200.00
	TOTAL ITEM 700 - ELECTRICAL			**A$**	$ 64,007.35

COST BREAKDOWN

Based on construction duration of 16 weeks as per attached programme

Item	Description	Qty	Unit	Rate	Amount
101	Site visit say 7 days				
	Air fare	1	Item	$ 1,500.00	$ 1,500.00
	Per diem	7	day	$ 150.00	$ 1,050.00
	Wages	7	day	$ 1,600.00	$ 11,200.00
	Vehicle rent	7	day	$ 50.00	$ 350.00
	Total 101				**$ 14,100.00**
	Allow 25% per plant				**$ 3,525.00**
102	Insurance, contract value approx. $2.2 million per DS plant				
	Contractor all risk - 0.8% of contract value	1	Item	$ 17,600.00	$ 17,600.00
	Public liability - 0.3% premium of contract value	1	Item	$ 6,600.00	$ 6,600.00
	Vehicle x 3	1	Item	$ 1,500.00	$ 1,500.00
	Plant and equipment	1	Item	$ 3,000.00	$ 3,000.00
	Total 102				**$ 28,700.00**
312	Site office, storage and amenities				
	Construct 4x5m office	20	m^2	$ 1,250.00	$ 25,000.00
	Toilet including water connection and irrigation or evapotransporation bed	1	no.	$ 4,000.00	$ 4,000.00
	first aid	1	Item	$ 500.00	$ 500.00
	Safety equipment and handwashing facilities	1	Item	$ 5,500.00	$ 5,500.00
	security	1	Item	$ 1,000.00	$ 1,000.00
	Total 103				**$ 36,000.00**
	DESALINATION PLANT				
202	Installation and commisioning say 2 weeks for 2 technicians, labour provided by main contractor				
	Air fare x 2	2	Item	$ 1,500.00	$ 3,000.00
	Per diem x 2	28	day	$ 200.00	$ 5,600.00
	Wages x 2	28	day	$ 1,000.00	$ 28,000.00
	Vehicle cost	12	day	$ 50.00	$ 600.00
	Vehicle running cost	1.5	Week	$ 60.00	$ 90.00
	Total 202				**$ 37,290.00**
	BOREHOLES				
502	Drilling rig on-site plus crew	16	week	$ 8,200.00	$ 131,200.00
	Mobilization and demobilization	4	Container	$ 5,000.00	$ 20,000.00
	International flights	4	RT	$ 1,750.00	$ 7,000.00
	Accommodation and per diem	448	day	$ 120.00	$ 53,760.00
	Miscellaneous Items	1	LS	$ 5,000.00	$ 5,000.00
	In-country transport	16	week	$ 450.00	$ 7,200.00
	Contractor's mark-up and risk allowance	1	LS	$ 40,000.00	$ 40,000.00
					$ 264,160.00
	Estimated cost per metre				$ 471.71
				say	**$ 450.00**
	STORAGE TANKS				
705	Concrete pad 10x10mx 0.4H				

	Blockwork	16	m2	$ 80.00	$ 1,280.00
	150mm reinforced slab	15	m3	$ 300.00	$ 4,500.00
	Compacted fill	25	m3	$ 40.00	$ 1,000.00
	Total 705				**$ 6,780.00**
					per 100m2
				i.e. ~	$70 per m2
	TOWER FOR ELEVATED TANK				
706	Foundation 3x3x2m deep	18	m3	$ 300.00	$ 5,400.00
	Design, fabricate, pack and freight galvanised tower complete with platforms, ladders and guardrails	1	no.	$ 42,000.00	$ 42,000.00
	Erect and paint tower to marine grade three-cost finish	1	no.	$ 25,500.00	$ 25,500.00
	Miscellaneous items	1	no.	$ 7,500.00	$ 7,500.00
	Total 706				**$ 80,400.00**

Estimates and Quantities

Desalination Plant 3 (Bairiki 1)

	DESALINATION PLANT 3 (BAIRIKI 1) - SUMMARY			
ITEM	**DESCRIPTION**	**COST**	**DUTY**	**AMOUNT (A$)**
100	PRELIMINARY AND GENERAL	$ 43,875	$ -	$ 43,875.00
200	DESALINATION PLANT	$ 1,362,290	$ -	$ 1,362,290.00
300	CIVIL AND ANCILLIARY WORKS	$ 87,000	$ -	$ 87,000.00
400	GENERATORS	$ 52,500	$ -	$ 52,500.00
500	INTAKE BOREHOLES AND PUMPS AT EACH DS PLANT	$ 176,625	$ -	$ 176,625.00
600	PIPES AND FITTINGS	$ 21,940	$ -	$ 21,940.00
700	STORAGE TANKS AND PUMPS	$ 248,400	$ -	$ 248,400.00
800	ELECTRICAL	$ 63,606	$ -	$ 63,606.30
	Subtotal			$ 2,056,236.30
	Contigencies 12%			$ 246,748.36
	Engineering , Design and Supervisions 3%			$ 61,687.09
	TOTAL ESTIMATE IN AUSTRALIAN DOLLARS			**$ 2,364,671.75**
	Note: prices include profit			

	PRELIMINARY AND GENERAL				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
100	**PRELIMINARIES AND GENERAL**				
	The Contract will be based on the FIDIC Conditions of Contract for Works of Civil Engineering Construction				
	The Scope of this Contract is for a Candidate Subproject of the South Tarawa Sanitation Improvement Sector Project - Desalination Plants - and is a lump sum contract in all conditions found				
	This Bill of Quantities has been prepared generally in accordance with NZS 4224 : 1983 and no deviation from same shall form the basis of a claim				
	The site is located in Bairiki, South Tarawa, Kiribati and is designated as Desalination Plant 3 (Bairiki 1) in the desalination feasibility study report.				
	The following metric abbreviations for units have been used:				
	m^3: Cubic Metres				
	m^2: Square Metres				
	mm : Millimetres				
	no : Number				
	kg :Kilogram				
	kL : Kilolitre				
	MPa: Megapascal				
	Site Visit				
101	Allow to visit the site and ascertain all conditions affecting this Contract	1	Item	$ 3,525.00	$ 3,525.00
	Site Establishment				
102	Insurances	1	Item	$ 28,700.00	$ 28,700.00
103	Temporary services connection: water, power, phone and internet	1	Item	$ 800.00	$ 800.00
104	Site establishment and mobilisation of personnel and equipment to South Tarawa (per site).		Item	$ 10,000.00	$ 10,000.00
105	Temporary Services		Item	$ 850.00	$ 850.00
106	Miscellaneous Plant and Equipment		Item		$ -
107	Allow to provide care and security of the works outside normal working hours		Item		$ -
108	Allow for any special hours of work as may be required		Item		$ -
109	Day Rates (Unit Rates)				
a	Excavator		Day	$ 850.00	$ -
b	Roller		Day	$ 650.00	$ -
c	Bulldozer		Day	$ 800.00	$ -
d	Welding eqipment		Day	$ 400.00	$ -
e	Misc/ small stools		Day	$ 100.00	$ -
f	Allow for testing of materials		Item	$ 4,000.00	$ -
g	Site clean up and de-establishment		Item	$ 5,000.00	$ -
	Note: This Schedule should not be used as an ordering list of materials. Shipping expenses covered item 900				
	TOTAL ITEM 100 - PRELIMINARY AND GENERAL				$ 43,875.00

	DESALINATION PLANT				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
200	**DESALINATION PLANT**				
201	Desalination plants each comprising 3 x 190 PX SWRO modules, with each RWSO module in a 20 foot skid mounted container including factory testing before dispatch. Price including low-pressure feed pumps, multi-media fliters and micron filters for the three units in an additional 20-foot container, switch/control boards, and back washing provisions, all complete ready for site placement and for connection to site placed pipes and electrical cabling provided and priced separately. SWRO modules to include pipes/valves, high-pressure pumps, RO units, airconditioning, switchboard and electic fittings and installation, all including containers to specification.	1	no.	$ 1,300,000.00	$ 1,300,000.00
202	Installation and commissioning of desalination plants in South Tarawa. Cost to include air flights, accommodation and living allowance, labour and local land transport. (per plant)	1	LS	$ 37,290.00	$ 37,290.00
	Transport and Freight from manufacturer to South Tarawa including all handling, port charges and insurance				
203	SWRO modules and filters, 20' containers	4	no.	$ 5,000.00	$ 20,000.00
204	Miscellaneous equipment and materials, 20 foot container	1	no.	$ 5,000.00	$ 5,000.00
	TOTAL ITEM 200 - DESALINATION PLANT			**A$**	$ 1,362,290.00

	CIVIL AND ANCILLIARY WORKS				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
300	**CIVIL AND ANCILLIARY WORKS**				
301	Site clearance - remove vegetation, trim topsoil and prepare site for engineered fill	740	m^2	$ 2.00	$ 1,480.00
302	Engineered filled - supply and place engineered fill with coral mud to levels shown in drawings	160	m^3	$ 40.00	$ 6,400.00
303	Concrete blocks retaining wall - supply and install concrete block to height and location shown in drawings.	10	m^2	$ 80.00	$ 800.00
304	Seawall - supply and install sand cemment bags seawall with 0.5m high nib to height and location shown in drawings	20	m^2	$ 380.00	$ 7,600.00
305	Access to site - Construct 3m wide 200mm thick compacted coral aggregate site accessway to dimensions and location shown in drawings incl. parking area in front of the office and generators	30	m^3	$ 35.00	$ 1,050.00
306	Fence - Supply and install galvanized post and galvanized chain link mesh security fence. 1.5 m high with 0.3 m topping of razor wire to details and location shown in drawings.	110	m	$ 200.00	$ 22,000.00
307	Entrance gate - Supply of materials and construction of 4m wide entrance gate to desalination plant compound. Secure with galvanized chain and padlock with key matched to all sites.	1	no.	$ 400.00	$ 400.00
308	Drainage V-channel - Supply and consctruct 2m wide x 100mm thick unreinforced concrete drainage V-channel at the perimeter of the site to location as shown on drawings	0	m^3	$ 300.00	$ -
309	Vehicle crossing - supply and construct 3m wide x 4m long x 150mm thick reinforced concrete crossing (V shape) at site entrance.	2	m^3	$ 340.00	$ 680.00
310	Concrete pad - supply and construct 4.3 x 4.6 x 120mm thick reinforced concrete pad forplacement of standby generator.	2.4	m^3	$ 340.00	$ 816.00
311	Concrete containment bund - 200x300H upstand.	1.1	m^3	$ 340.00	$ 374.00
312	Office - Strip and convert old desalination plant building and reconfigure as filter house, store and site office Office to include desk and chairs (3), layout table, opening winndows with security bars, lights, adequate power points and air conditioning. Incorporate toilet and handwashing facilities,	1	LS	$ 25,000.00	$ 25,000.00
313	Landscaping - to the layout and details illustrated on the site drawing and layout plan.	1	LS	$ 5,000.00	$ 5,000.00
314	Calcite bed and Chlorination unit shed - supply and construct 4.0x6.0m open, carport like shed between container units with corrugated iron sheeting incl. galvinised steel post and foundation.	24	m^2	$ 350.00	$ 8,400.00
315	Supply and install concrete filled mattress to protect brine discharge pipes	1	LS	$ 6,000.00	$ 6,000.00
316	Supply and install precast diffuser units fore brine discharge	2	No.	$ 500.00	$ 1,000.00
	TOTAL ITEM 300 - CIVIL AND ANCILLIARY WORKS			**A$**	$ 87,000.00

	GENERATORS				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
400	**GENERATOR**				
401	Shed - Supply and construct 4.3 x 4.6m open, carport like shed with corrugated iron sheeting including timeber post and foundation to house the generator	20	m^2	$ 350.00	$ 7,000.00
403	Generator - supply and install and comission 120kVA diesel generator. Include control switch installed inside the main office. Note: external cabling is covered under item 800 electrical.	1	No.	$ 35,000.00	$ 35,000.00
404	Generator - transport, sea freight, port charges and placement, commissioning on site including insurances	1	no.	$ 5,000.00	$ 5,000.00
405	Fuel tank - supply and install 1.6kL stainless steel fuel tank including support and pipeworks connected to the generator.	1	no.	$ 5,000.00	$ 5,000.00
406	Fuel tank - transport, sea freight, port charges and placement, commissioning on site including insurances	1	no.	$ 500.00	$ 500.00
	TOTAL ITEM 400 - GENERATOR			**A$**	$ 52,500.00

	INTAKE BOREHOLES AND PUMPS AT EACH DS PLANT				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
500	**INTAKE BORHOLES AND PUMPS**				
	Well Construction (4 boreholes)				
501	Mobilise drill rig and establishment including shipping (allowance per site)	1	LS	$ 5,000.00	$ 5,000.00
502	Drill 250mm dia into sand, coral and fractured limestone	140	m	$ 450.00	$ 63,000.00
503	Supply and install 150mm dia PVC casing, finish 1m proud of ground level	72	m	$ 280.00	$ 20,160.00
504	Supply and install 150mm dia PVC screen	68	m	$ 280.00	$ 19,040.00
505	Well development	4	LS	$ 1,000.00	$ 4,000.00
506	Water Quality test	4	LS	$ 1,000.00	$ 4,000.00
	Pumps and Pump Controls				
507	Supply and install 100mm dia 20m^3/hr @ 25 m head 904L stainless steel submersible pumps (1 spare)	4	no.	$ 10,500.00	$ 42,000.00
508	Supply and install 63OD PE riser pipe	105	m	$ 45.00	$ 4,725.00
509	Supply and install power supply cable from ground level to pump single 60A phase	105	m	$ 20.00	$ 2,100.00
510	Supply and install control cable from ground level to pump	105	m	$ 20.00	$ 2,100.00
511	Supply, intall and commission control panel in office	1	LS	$ 500.00	$ 500.00
512	Supply materials and construct reinforced concrete box ground well unit with inner dimensions of 1.2m x 1.2m by 1 m height, complete with hinged and lockable galvanised steel lid, 316 SS pump support cable hook. All as indicated on drawings.	4	ea	$ 1,000.00	$ 4,000.00
513	Supply, intall and commission manifold pipeworks and valves	4	LS	$ 1,500.00	$ 6,000.00
	All electrical and control cables to switch/control board mounted in site office provided for under 600 and 800				
	TOTAL ITEM 500 - BOREHOLES AND PUMPS			**A$**	$ 176,625.00

	INTAKE GALLERIES AND SUMPS AT DS PLANT (ALTERNATIVE)				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
500.1	**INTAKE GALLERIES AND SUMPS**				
501.1	Seawater Galleries and Intake - Install new seawater galleries and intake to pump. Supply and install slotted saltwater gallery pipes with poly weave fabric and gravel pack around the pipe, end caps and backwash arrangments, all as specified and detailed on drawings.	1	no.	$ 125,000.00	$ 125,000.00
502.1	Supply , install and commission marinized 409L grade stainless steel 5 kW standby and duty pumps discharging to Arkal filter. include 316 stainless impellor, anodes, tungsten carbide mechanical seals, thermal switches for protection, pump controller and corrosion resistant pressure tank, all as specified and detailed on drawings. Including shipping, freight, cost to site and installation.	2	no.	$ 7,500.00	$ 15,000.00
503.1	Supply and install 1050mm dia. fibre glass intake cylinders including interconnection pipes and fittings	2	no.	$ 7,000.00	$ 14,000.00
504.1	Arkal Mechanical Filter - Arkal filter - Spin Klin SeaWater 20 micron filtration system utilizing online backwash, pre plumbed and wired including installation into raw water supply and backwash controller and connection of backwash to brine discharge pipe line. Including shipping, freight, cost to site and installation.	1	no.	$ 47,500.00	$ 47,500.00
505.1	Concrete pad - supply materials and construct 2 x 2m 100mm thick reinforced concrete pad for Arkal mechanical pre-filter on intake pipe line prior to raw water storage tanks.	0.5	m^3	$ 340.00	$ 170.00
	TOTAL ITEM 500.1 -SEAWATER INTAKE GALLERIES			**A$**	$ 201,670.00

	PIPES AND FITTINGS				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
600	**PIPES AND FITTINGS**				
	Pipeworks				
601	63mm ODPE at 0 - 1.5m deep	15	m	$ 45.00	$ 675.00
602	65mm uPVC SN16 at 0 - 1.5m deep	60	m	$ 60.00	$ 3,600.00
603	100mm uPVC SN16 at 0 - 1.5m deep	180	m	$ 75.00	$ 13,500.00
	90 degree bends				
604	65mm	14	No	$ 30.00	$ 420.00
605	100mm	8	No	$ 50.00	$ 400.00
	Tees				
606	100/65mm	4	No	$ 150.00	$ 600.00
607	100/100mm	2	No	$ 65.00	$ 130.00
608	100/200mm	1	No	$ 350.00	$ 350.00
	Valves				
609	50mm	5	No	$ 60.00	$ 300.00
610	65mm	9	No	$ 85.00	$ 765.00
611	100mm	2	No	$ 600.00	$ 1,200.00
	Note: Price include shipping of materials from AUS				
	TOTAL ITEM 600 - PIPES AND FITTINGS			**A$**	$ 21,940.00

	STORAGE TANKS AND PUMPS				
ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT (A$)
700	**STORAGE TANKS AND PUMPS**				
701	Raw water tanks - Supply, ship, install and commission 22 kL interlinked covered tanks of non-corrosive and high uv resistant material. Including 63mm OD PE drain down pipes and valves connected to brine discharge system. Connection to intake from borehole pumps and to backwashing units for muli-media filters. Connection to low pressure line pumps for intake to filters. All as indicated on drawings, including freight, handling, port charges and insurances.	2	no.	$ 12,000.00	$ 24,000.00
702	Permeate tanks - Supply, ship, install and commission 30 kL interlinked covered tanks of non-corrosive and high uv resistant material. Including 63mm OD PE drain down pipes and valves connected to brine discharge system. Connection to intake from RWO units. Connection to lift pumps for intake to elevated tank. All as indicated on drawings, including freight, handling, port charges and insurances.	2	no.	$ 15,000.00	$ 30,000.00
703	Brine tank - Supply, ship, install and commission 22 kL covered tank of non-corrosive and high uv resistant material. Including 63mm OD PE drain down pipe and valve connected to brine discharge system. Connection to intake from RWO units. Connection to discharge pipe into water body. All as indicated on drawings, including freight, handling, port charges and insurances.	1	no.	$ 12,000.00	$ 12,000.00
704	Elevated tank - Supply, ship, install and commission 22 kL covered tank of non-corrosive and high uv resistant material. Including 63mm OD PE drain down pipes and valve. Connection to intake from lift pump from permeate tanks. Connection to discharge pipe into trunk main. All as indicated on drawings, including freight, handling, port charges and insurances.	1	no.	$ 15,000.00	$ 15,000.00
705	Concrete pad for low level tanks - 400mm high concrete pad constructed from blocks filled with compacted sand and covered with 150mm reinforced concrete slab	200	m^2	$ 70.00	$ 14,000.00
706	Tower for elevated tank - design, supply, ship and install 12m high galvinised steel tower, double coating paint suitable for marine environment. Completed with steps, safety bars and working platform. Assume 120kg/m length of trusses. All as indicated on drawings, including freight, handling, port charges and insurances.	1	no.	$ 80,400.00	$ 80,400.00
707	Lift pump - supply, install and commission 50 mm 316 grade stainless steel pump 10 l/s at 14m head discharging from ground level treated water tanks to elevated reaervoir at each Desalination plant 316 stainless impellor, anodes, tungsten carbide mechanical seals, thermal switches for protection, pump controller and corrosion resistant pressure tank, all as specified and depicted on drawings.	1	no.	$ 3,000.00	$ 3,000.00
	Calcite Beds and Chlorination				
709	Supply, freight and install calcite bed within 2m diameter shell for final water adjustment including media and all shipping, freight, handling costs and insurances. All as indicated in drawings.	1	no.	$ 55,000.00	$ 55,000.00
710	Supply, freight and install chorination unit complete with automatic monitoring and controls, including shipping, freight, handling costs and insurances.	1	no.	$ 15,000.00	$ 15,000.00
	TOTAL ITEM 700 - STORAGE TANKS AND PUMPS			**A$**	$ 248,400.00

	ELECTRICAL				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
800	**ELECTRICAL**				
801	100mm uPVC duct at 0 - 1.5m deep	75	m	$ 60.00	$ 4,500.00
802	Control cable: 2 sets of 4 x single core copper cable 6.2mm	150	m	$ 70.00	$ 10,500.00
803	200kVA 11kV/433V ONAN ground mount transformer. Outdoor type, 3phase, oil immersed and naturally cooled. Vector group Dyn11. Cost ex manufacturer	1	no.	$ 20,750.00	$ 20,750.00
804	Transport and delivery of transformer to site and contractors mark-up	1	no.	$ 5,000.00	$ 5,000.00
805	Power cable 95mm^2, 3Core, PCW 6.35/11kV XLPE with wire armour - cable only	30	m	$ 50.21	$ 1,506.30
806	Trenching for cable and reinstatement	30	m	$ 30.00	$ 900.00
807	Connection and jointing to 11kVA main cable and placement of transformer and connection.	1	no.	$ 2,500.00	$ 2,500.00
808	Power aluminium cable: 3 phase light 60A/phase.	75	m	$ 50.00	$ 3,750.00
809	Central control switch board in the office (light industrial)	1	no.	$ 12,000.00	$ 12,000.00
810	Install and commission all control switches	1	LS	$ 1,000.00	$ 1,000.00
811	Security 500W flood light open type	4	no.	$ 300.00	$ 1,200.00
	TOTAL ITEM 700 - ELECTRICAL			**A$**	$ 63,606.30

COST BREAKDOWN

Based on construction duration of 16 weeks as per attached programme

Item	Description	Qty	Unit	Rate	Amount
101	Site visit say 7 days				
	Air fare	1	Item	$ 1,500.00	$ 1,500.00
	Per diem	7	day	$ 150.00	$ 1,050.00
	Wages	7	day	$ 1,600.00	$ 11,200.00
	Vehicle rent	7	day	$ 50.00	$ 350.00
	Total 101				**$ 14,100.00**
	Allow 25% per plant				**$ 3,525.00**
102	Insurance, contract value approx. $2.2 million per DS plant				
	Contractor all risk - 0.8% of contract value	1	Item	$ 17,600.00	$ 17,600.00
	Public liability - 0.3% premium of contract value	1	Item	$ 6,600.00	$ 6,600.00
	Vehicle x 3	1	Item	$ 1,500.00	$ 1,500.00
	Plant and equipment	1	Item	$ 3,000.00	$ 3,000.00
	Total 102				**$ 28,700.00**
312	Site office, storage and amenities				
	Construct 4x5m office	20	m^2	$ 1,250.00	$ 25,000.00
	Toilet including water connection and irrigation or evapotransporation bed	1	no.	$ 4,000.00	$ 4,000.00
	first aid	1	Item	$ 500.00	$ 500.00
	Safety equipment and handwashing facilities	1	Item	$ 5,500.00	$ 5,500.00
	security	1	Item	$ 1,000.00	$ 1,000.00
	Total 103				**$ 36,000.00**
	TIME RELATED COST				
105	Communication				
	Mobile x 5	16	Week	$ 100.00	$ 1,600.00
	Landline x 1	16	Week	$ 5.00	$ 80.00
	Internet x 1	16	Week	$ 50.00	$ 800.00
	Total 105				**$ 2,480.00**
113	Surveyor				
	Air fare	1	Item	$ 1,500.00	$ 1,500.00
	Per diem	21	day	$ 150.00	$ 3,150.00
	Wages	15	day	$ 1,200.00	$ 18,000.00
	Total 113				**$ 22,650.00**
	DESALINATION PLANT				
202	Installation and commisioning say 2 weeks for 2 technicians, labour provided by main contractor				
	Air fare x 2	2	Item	$ 1,500.00	$ 3,000.00
	Per diem x 2	28	day	$ 200.00	$ 5,600.00
	Wages x 2	28	day	$ 1,000.00	$ 28,000.00
	Vehicle cost	12	day	$ 50.00	$ 600.00
	Vehicle running cost	1.5	Week	$ 60.00	$ 90.00
	Total 202				**$ 37,290.00**
	BOREHOLES				
502	Drilling rig on-site plus crew	16	week	$ 8,200.00	$ 131,200.00

	Mobilization and demobilization	4	Container	$ 5,000.00	$ 20,000.00
	International flights	4	RT	$ 1,750.00	$ 7,000.00
	Accommodation and per diem	448	day	$ 120.00	$ 53,760.00
	Miscellaneous Items	1	LS	$ 5,000.00	$ 5,000.00
	In-country transport	16	week	$ 450.00	$ 7,200.00
	Contractor's mark-up and risk allowance	1	LS	$ 40,000.00	$ 40,000.00
					$ 264,160.00
	Estimated cost per metre				$ 471.71
				say	**$ 450.00**
	STORAGE TANKS				
705	Concrete pad 10x10mx 0.4H				
	Blockwork	16	m2	$ 80.00	$ 1,280.00
	150mm reinforced slab	15	m3	$ 300.00	$ 4,500.00
	Compacted fill	25	m3	$ 40.00	$ 1,000.00
	Total 705				**$ 6,780.00**
					per 100m2
				i.e. ~	$70 per m2
706	Tower for elevated tank				
	Foundation 3x3x2m deep	18	m3	$ 300.00	$ 5,400.00
	Design, fabricate, pack and freight galvanised tower complete with platforms, ladders and guardrails	1	no.	$ 42,000.00	$ 42,000.00
	Erect and paint tower to marine grade three-cost finish	1	no.	$ 25,500.00	$ 25,500.00
	Miscellaneous items	1	no.	$ 7,500.00	$ 7,500.00
	Total 706				**$ 80,400.00**

Estimates and Quantities

Desalination Plant 4 (Bairiki 2)

	DESALINATION PLANT 4 (BAIRIKI 2) - SUMMARY			
ITEM	DESCRIPTION	COST	DUTY	AMOUNT (A$)
100	PRELIMINARY AND GENERAL	$ 43,875	$ -	$ 43,875.00
200	DESALINATION PLANT	$ 1,370,690	$ -	$ 1,370,690.00
300	CIVIL AND ANCILLIARY WORKS	$ 97,200	$ -	$ 97,200.00
400	GENERATORS	$ 52,500	$ -	$ 52,500.00
500	INTAKE BOREHOLES AND PUMPS AT EACH DS PLANT	$ 176,625	$ -	$ 176,625.00
600	PIPES AND FITTINGS	$ 18,595	$ -	$ 18,595.00
700	STORAGE TANKS AND PUMPS	$ 248,400	$ -	$ 248,400.00
800	ELECTRICAL	$ 63,606	$ -	$ 63,606.30
	Subtotal			$ 2,071,491.30
	Contigencies 12%			$ 248,578.96
	Engineering , Design and Supervisions 3%			$ 62,144.74
	TOTAL ESTIMATE IN AUSTRALIAN DOLLARS			**$ 2,382,215.00**
	Note: prices include profit			

	PRELIMINARY AND GENERAL				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
100	**PRELIMINARIES AND GENERAL**				
	The Contract will be based on the FIDIC Conditions of Contract for Works of Civil Engineering Construction				
	The Scope of this Contract is for a Candidate Subproject of the South Tarawa Sanitation Improvement Sector Project - Desalination Plants - and is a lump sum contract in all conditions found				
	This Bill of Quantities has been prepared generally in accordance with NZS 4224 : 1983 and no deviation from same shall form the basis of a claim				
	The site is located in Nanikai, South Tarawa, Kiribati and is designated as Desalination Plant 4 (Bairiki 2) in the desalination feasibility study report.				
	The following metric abbreviations for units have been used:				
	m^3: Cubic Metres				
	m^2: Square Metres				
	mm : Millimetres				
	no : Number				
	kg :Kilogram				
	kL : Kilolitre				
	MPa: Megapascal				
	Site Visit				
101	Allow to visit the site and ascertain all conditions affecting this Contract	1	Item	$ 3,525.00	$ 3,525.00
	Site Establishment				
102	Insurances	1	Item	$ 28,700.00	$ 28,700.00
103	Temporary services connection: water, power, phone and internet	1	Item	$ 800.00	$ 800.00
104	Site establishment and mobilisation of personnel and equipment to South Tarawa (per site).		Item	$ 10,000.00	$ 10,000.00
105	Temporary Services		Item	$ 850.00	$ 850.00
106	Miscellaneous Plant and Equipment		Item		$ -
107	Allow to provide care and security of the works outside normal working hours		Item		$ -
108	Allow for any special hours of work as may be required		Item		$ -
109	Day Rates (Unit Rates)				
a	Excavator		Day	$ 850.00	$ -
b	Roller		Day	$ 650.00	$ -
c	Bulldozer		Day	$ 800.00	$ -
d	Welding eqipment		Day	$ 400.00	$ -
e	Misc/ small stools		Day	$ 100.00	$ -
f	Allow for testing of materials		Item	$ 4,000.00	$ -
g	Site clean up and de-establishment		Item	$ 5,000.00	$ -
	Note: This Schedule should not be used as an ordering list of materials. Shipping expenses covered item 900				
	TOTAL ITEM 100 - PRELIMINARY AND GENERAL				$ 43,875.00

	DESALINATION PLANT				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
200	**DESALINATION PLANT**				
201	Desalination plants each comprising 3 x 190 PX SWRO modules, with each RWSO module in a 20 foot skid mounted container including factory testing before dispatch. Price including low-pressure feed pumps, multi-media fliters and micron filters for the three units in an additional 20-foot container, switch/control boards, and back washing provisions, all complete ready for site placement and for connection to site placed pipes and electrical cabling provided and priced separately. SWRO modules to include pipes/valves, high-pressure pumps, RO units, airconditioning, switchboard and electic fittings and installation, all including containers to specification.	1	no.	$ 1,300,000.00	$ 1,300,000.00
202	Installation and commissioning of desalination plants in South Tarawa. Cost to include air flights, accommodation and living allowance, labour and local land transport. (allowance per plant).	1	LS	$ 45,690.00	$ 45,690.00
	Transport and Freight from manufacturer to South Tarawa including all handling, port charges and insurance				
203	SWRO modules and filters, 20' containers	4	no.	$ 5,000.00	$ 20,000.00
204	Miscellaneous equipment and materials, 20 foot container	1	no.	$ 5,000.00	$ 5,000.00
	TOTAL ITEM 200 - DESALINATION PLANT			**A$**	$ 1,370,690.00

	CIVIL AND ANCILLIARY WORKS				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
300	**CIVIL AND ANCILLIARY WORKS**				
301	Site clearance - remove vegetation, trim topsoil and prepare site for engineered fill	740	m^2	$ 2.00	$ 1,480.00
302	Engineered filled - supply and place engineered fill with coral mud to levels shown in drawings	280	m^3	$ 40.00	$ 11,200.00
303	Concrete blocks retaining wall - supply and install concrete block to height and location shown in drawings.	30	m^2	$ 80.00	$ 2,400.00
304	Seawall - supply and install sand cemment bags seawall with 0.5m high nib to height and location shown in drawings	30	m^2	$ 380.00	$ 11,400.00
305	Access to site - Construct 3m wide 200mm thick compacted coral aggregate site accessway to dimensions and location shown in drawings incl. parking area in front of the office and generators	30	m^3	$ 35.00	$ 1,050.00
306	Fence - Supply and install galvanized post and galvanized chain link mesh security fence. 1.5 m high with 0.3 m topping of razor wire to details and location shown in drawings.	110	m	$ 200.00	$ 22,000.00
307	Entrance gate - Supply of materials and construction of 4m wide entrance gate to desalination plant compound. Secure with galvanized chain and padlock with key matched to all sites.	1	no.	$ 400.00	$ 400.00
308	Drainage V-channel - Supply and consctruct 2m wide x 100mm thick unreinforced concrete drainage V-channel at the perimeter of the site to location as shown on drawings	0	m^3	$ 300.00	$ -
309	Vehicle crossing - supply and construct 3m wide x 4m long x 150mm thick reinforced concrete crossing (V shape) at site entrance.	2	m^3	$ 340.00	$ 680.00
310	Concrete pad - supply and construct 4.3 x 4.6 x 120mm thick reinforced concrete pad forplacement of standby generator.	2.4	m^3	$ 340.00	$ 816.00
311	Concrete containment bund - 200x300H upstand.	1.1	m^3	$ 340.00	$ 374.00
312	Office - Strip and convert old desalination plant building and reconfigure as filter house, store and site office Office to include desk and chairs (3), layout table, opening winndows with security bars, lights, adequate power points and air conditioning. Incorporate toilet and handwashing facilities,	1	LS	$ 25,000.00	$ 25,000.00
313	Landscaping - to the layout and details illustrated on the site drawing and layout plan.	1	LS	$ 5,000.00	$ 5,000.00
314	Calcite bed and Chlorination unit shed - supply and construct 4.0x6.0m open, carport like shed between container units with corrugated iron sheeting incl. galvinised steel post and foundation.	24	m^2	$ 350.00	$ 8,400.00
315	Supply and install concrete filled mattress to protect brine discharge pipes	1	LS	$ 6,000.00	$ 6,000.00
316	Supply and install precast diffuser units fore brine discharge	2	No.	$ 500.00	$ 1,000.00
	TOTAL ITEM 300 - CIVIL AND ANCILLIARY WORKS			**A$**	$ 97,200.00

	GENERATORS				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
400	**GENERATOR**				
401	Shed - Supply and construct 4.3 x 4.6m open, carport like shed with corrugated iron sheeting including timeber post and foundation to house the generator	20	m^2	$ 350.00	$ 7,000.00
402	Generator - supply and install and comission 120kVA diesel generator. Include control switch installed inside the main office. Note: external cabling is covered under item 800 electrical.	1	No.	$ 35,000.00	$ 35,000.00
403	Generator - transport, sea freight, port charges and placement, commissioning on site including insurances	1	no.	$ 5,000.00	$ 5,000.00
404	Fuel tank - supply and install 1.6kL stainless steel fuel tank including support and pipeworks connected to the generator.	1	no.	$ 5,000.00	$ 5,000.00
405	Fuel tank - transport, sea freight, port charges and placement, commissioning on site including insurances	1	no.	$ 500.00	$ 500.00
	TOTAL ITEM 400 - GENERATOR			**A$**	$ 52,500.00

	INTAKE BOREHOLES AND PUMPS AT EACH DS PLANT				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
500	**INTAKE BORHOLES AND PUMPS**				
	Well Construction (4 boreholes)				
501	Mobilise drill rig and establishment including shipping (allowance per site)	1	LS	$ 5,000.00	$ 5,000.00
502	Drill 250mm dia into sand, coral and fractured limestone	140	m	$ 450.00	$ 63,000.00
503	Supply and install 150mm dia PVC casing, finish 1m proud of ground level	72	m	$ 280.00	$ 20,160.00
504	Supply and install 150mm dia PVC screen	68	m	$ 280.00	$ 19,040.00
505	Well development	4	LS	$ 1,000.00	$ 4,000.00
506	Water Quality test	4	LS	$ 1,000.00	$ 4,000.00
	Pumps and Pump Controls				
507	Supply and install 100mm dia 20m^3/hr @ 25 m head 904L stainless steel submersible pumps (1 spare)	4	no.	$ 10,500.00	$ 42,000.00
508	Supply and install 63OD PE riser pipe	105	m	$ 45.00	$ 4,725.00
509	Supply and install power supply cable from ground level to pump single 60A phase	105	m	$ 20.00	$ 2,100.00
510	Supply and install control cable from ground level to pump	105	m	$ 20.00	$ 2,100.00
511	Supply, intall and commission control panel in office	1	LS	$ 500.00	$ 500.00
512	Supply materials and construct reinforced concrete box ground well unit with inner dimensions of 1.2m x 1.2m by 1 m height, complete with hinged and lockable galvanised steel lid, 316 SS pump support cable hook. All as indicated on drawings.	4	ea	$ 1,000.00	$ 4,000.00
513	Supply, intall and commission manifold pipeworks and valves	4	LS	$ 1,500.00	$ 6,000.00
	All electrical and control cables to switch/control board mounted in site office provided for under 600 and 800				
	TOTAL ITEM 500 - BOREHOLES AND PUMPS			**A$**	$ 176,625.00

	INTAKE GALLERIES AND SUMPS AT DS PLANT (ALTERNATIVE)				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
500.1	**INTAKE GALLERIES AND SUMPS**				
501.1	Seawater Galleries and Intake - Install new seawater galleries and intake to pump. Supply and install slotted saltwater gallery pipes with poly weave fabric and gravel pack around the pipe, end caps and backwash arrangments, all as specified and detailed on drawings.	1	no.	$ 125,000.00	$ 125,000.00
502.1	Supply , install and commission marinized 409L grade stainless steel 5 kW standby and duty pumps discharging to Arkal filter. include 316 stainless impellor, anodes, tungsten carbide mechanical seals, thermal switches for protection, pump controller and corrosion resistant pressure tank, all as specified and detailed on drawings. Including shipping, freight, cost to site and installation.	2	no.	7500	15000
503.1	Supply and install 1050mm dia. fibre glass intake cylinders including interconnection pipes and fittings	2	no.	$ 7,000.00	$ 14,000.00
504.1	Arkal Mechanical Filter - Arkal filter - Spin Klin SeaWater 20 micron filtration system utilizing online backwash, pre plumbed and wired including installation into raw water supply and backwash controller and connection of backwash to brine discharge pipe line. Including shipping, freight, cost to site and installation.	1	no.	$ 47,500.00	$ 47,500.00
505.1	Concrete pad - supply materials and construct 2 x 2m 100mm thick reinforced concrete pad for Arkal mechanical pre-filter on intake pipe line prior to raw water storage tanks.	0.5	m^3	$ 340.00	$ 170.00
	TOTAL ITEM 500.1 -SEAWATER INTAKE GALLERIES			**A$**	$ 201,670.00

	PIPES AND FITTINGS				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
600	**PIPES AND FITTINGS**				
	Pipeworks				
601	63mm ODPE at 0 - 1.5m deep	15	m	$ 45.00	$ 675.00
602	65mm uPVC SN16 at 0 - 1.5m deep	60	m	$ 60.00	$ 3,600.00
603	100mm uPVC SN16 at 0 - 1.5m deep	180	m	$ 75.00	$ 13,500.00
	90 degree bends				
604	65mm	14	No	$ 30.00	$ 420.00
605	100mm	8	No	$ 50.00	$ 400.00
	Tees				
606	100/65mm	4	No	$ 150.00	$ 600.00
607	100/100mm	2	No	$ 65.00	$ 130.00
608	100/200mm	1	No	$ 350.00	$ 350.00
	Valves				
609	50mm	5	No	$ 60.00	$ 300.00
610	65mm	9	No	$ 85.00	$ 765.00
611	100mm	2	No	$ 600.00	$ 1,200.00
	Note: Price include shipping of materials from AUS				
	TOTAL ITEM 600 - PIPES AND FITTINGS			**A$**	$ 18,595.00

	STORAGE TANKS AND PUMPS				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
700	**STORAGE TANKS AND PUMPS**				
701	Raw water tanks - Supply, ship, install and commission 22 kL interlinked covered tanks of non-corrosive and high uv resistant material. Including 63mm OD PE drain down pipes and valves connected to brine discharge system. Connection to intake from borehole pumps and to backwashing units for muli-media filters. Connection to low pressure line pumps for intake to filters. All as indicated on drawings, including freight, handling, port charges and insurances.	2	no.	$ 12,000.00	$ 24,000.00
702	Permeate tank - Supply, ship, install and commission 30 kL interlinked covered tanks of non-corrosive and high uv resistant material. Including 63mm OD PE drain down pipes and valves connected to brine discharge system. Connection to intake from RWO units. Connection to lift pumps for intake to elevated tank. All as indicated on drawings	2	no.	$ 15,000.00	$ 30,000.00
703	Permeate tanks - Supply, ship, install and commission 30 kL interlinked covered tanks of non-corrosive and high uv resistant material. Including 63mm OD PE drain down pipes and valves connected to brine discharge system. Connection to intake from RWO units. Connection to lift pumps for intake to elevated tank. All as indicated on drawings, including freight, handling, port charges and insurances.	1	no.	$ 12,000.00	$ 12,000.00
704	Elevated tank - Supply, ship, install and commission 22 kL covered tank of non-corrosive and high uv resistant material. Including 63mm OD PE drain down pipes and valve. Connection to intake from lift pump from permeate tanks. Connection to discharge pipe into trunk main. All as indicated on drawings, including freight, handling, port charges and insurances.	1	no.	$ 15,000.00	$ 15,000.00
705	Concrete pad for low level tanks - 400mm high concrete pad constructed from blocks filled with compacted sand and covered with 150mm reinforced concrete slab	200	m^2	$ 70.00	$ 14,000.00
706	Tower for elevated tank - design, supply, ship and install 12m high galvinised steel tower, double coating paint suitable for marine environment. Completed with steps, safety bars and working platform. Assume 120kg/m length of trusses. All as indicated on drawings, including freight, handling, port charges and insurances.	1	Item	$ 80,400.00	$ 80,400.00
707	Lift pump - supply, install and commission 50 mm 316 grade stainless steel pump 10 l/s at 14m head discharging from ground level treated water tanks to elevated reaervoir at each Desalination plant 316 stainless impellor, anodes, tungsten carbide mechanical seals, thermal switches for protection, pump controller and corrosion resistant pressure tank, all as specified and depicted on drawings.	1	no.	$ 3,000.00	$ 3,000.00
	Calcite Beds and Chlorination				
708	Supply, freight and install calcite bed within 2m diameter shell for final water adjustment including media and all shipping, freight, handling costs and insurances. All as indicated in drawings.	1	no.	$ 55,000.00	$ 55,000.00
709	Supply, freight and install chorination unit complete with automatic monitoring and controls, including shipping, freight, handling costs and insurances.	1	no.	$ 15,000.00	$ 15,000.00
	TOTAL ITEM 700 - STORAGE TANKS AND PUMPS			**A$**	$ 248,400.00

	ELECTRICAL				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT (A$)**
800	**ELECTRICAL**				
801	100mm uPVC duct at 0 - 1.5m deep	75	m	$ 60.00	$ 4,500.00
802	Control cable: 2 sets of 4 x single core copper cable 6.2mm	150	m	$ 70.00	$ 10,500.00
803	200kVA 11kV/433V ONAN ground mount transformer. Outdoor type, 3phase, oil immersed and naturally cooled. Vector group Dyn11. Cost ex manufacturer	1	no.	$ 20,750.00	$ 20,750.00
804	Transport and delivery of transformer to site and contractors mark-up	1	no.	$ 5,000.00	$ 5,000.00
805	Power cable 95mm^2, 3Core, PCW 6.35/11kV XLPE with wire armour - cable only	30	m	$ 50.21	$ 1,506.30
806	Trenching for cable and reinstatement	30	m	$ 30.00	$ 900.00
807	Connection and jointing to 11kVA main cable and placement of transformer and connection.	1	no.	$ 2,500.00	$ 2,500.00
808	Power aluminium cable: 3 phase light 60A/phase.	75	m	$ 50.00	$ 3,750.00
809	Central control switch board in the office (light industrial)	1	no.	$ 12,000.00	$ 12,000.00
810	Install and commission all control switches	1	LS	$ 1,000.00	$ 1,000.00
811	Security 500W flood light open type	4	no.	$ 300.00	$ 1,200.00
	TOTAL ITEM 700 - ELECTRICAL			**A$**	$ 63,606.30

COST BREAKDOWN

Based on construction duration of 16 weeks as per attached programme

Item	Description	Qty	Unit	Rate	Amount
101	Site visit say 7 days				
	Air fare	1	Item	$ 1,500.00	$ 1,500.00
	Per diem	7	day	$ 150.00	$ 1,050.00
	Wages	7	day	$ 1,600.00	$ 11,200.00
	Vehicle rent	7	day	$ 50.00	$ 350.00
	Total 101				**$ 14,100.00**
	Allow 25% per plant				**$ 3,525.00**
102	Insurance, contract value approx. $2.2 million per DS plant				
	Contractor all risk - 0.8% of contract value	1	Item	$ 17,600.00	$ 17,600.00
	Public liability - 0.3% premium of contract value	1	Item	$ 6,600.00	$ 6,600.00
	Vehicle x 3	1	Item	$ 1,500.00	$ 1,500.00
	Plant and equipment	1	Item	$ 3,000.00	$ 3,000.00
	Total 102				**$ 28,700.00**
312	Site office, storage and amenities				
	Construct 4x5m office	20	m^2	$ 1,250.00	$ 25,000.00
	Toilet including water connection and irrigation or evapotransporation bed	1	no.	$ 4,000.00	$ 4,000.00
	first aid	1	Item	$ 500.00	$ 500.00
	Safety equipment and handwashing facilities	1	Item	$ 5,500.00	$ 5,500.00
	security	1	Item	$ 1,000.00	$ 1,000.00
	Total 103				**$ 36,000.00**
	DESALINATION PLANT				
202	Installation and commisioning say 2 weeks for 2 technicians, labour provided by main contractor				
	Air fare x 2	2	Item	$ 1,500.00	$ 3,000.00
	Per diem x 2	28	day	$ 300.00	$ 8,400.00
	Wages x 2	28	day	$ 1,200.00	$ 33,600.00
	Vehicle cost	12	day	$ 50.00	$ 600.00
	Vehicle running cost	1.5	Week	$ 60.00	$ 90.00
	Total 202				**$ 45,690.00**
	BOREHOLES				
502	Drilling rig on-site plus crew	16	week	$ 8,200.00	$ 131,200.00
	Mobilization and demobilization	4	Container	$ 5,000.00	$ 20,000.00
	International flights	4	RT	$ 1,750.00	$ 7,000.00
	Accommodation and per diem	448	day	$ 120.00	$ 53,760.00
	Miscellaneous Items	1	LS	$ 5,000.00	$ 5,000.00
	In-country transport	16	week	$ 450.00	$ 7,200.00
	Contractor's mark-up and risk allowance	1	LS	$ 40,000.00	$ 40,000.00
					$ 264,160.00
	Estimated cost per metre				$ 471.71
				say	**$ 450.00**
	STORAGE TANKS				
705	Concrete pad 10x10mx 0.4H				
	Blockwork	16	m2	$ 80.00	$ 1,280.00

	150mm reinforced slab	15	m3	$	300.00	$	4,500.00
	Compacted fill	25	m3	$	40.00	$	1,000.00
	Total 705					**$**	**6,780.00**
						per 100m2	
				i.e. ~		$70 per m2	
706	Tower for elevated tank						
	Foundation 3x3x2m deep	18	m3	$	300.00	$	5,400.00
	Design, fabricate, pack and freight galvanised tower complete with platforms, ladders and guardrails	1	no.	$	42,000.00	$	42,000.00
	Erect and paint tower to marine grade three-cost finish	1	no.	$	25,500.00	$	25,500.00
	Miscellaneous items	1	no.	$	7,500.00	$	7,500.00
	Total 706					**$**	**80,400.00**

Appendix E

South Tarawa Desalination Plants Environmental Assessment

SOUTH TARAWA SANITATION IMPROVEMENT SECTOR PROJECT

SALT WATER REVERSE OSMOSIS SUBPROJECT

INITIAL ENVIRONMENTAL EXAMINATION

Contents

SCHEDULE OF TABLES:

SCHEDULE OF FIGURES:

SOUTH TARAWA SANITATION IMPROVEMENT SECTOR PROJECT

SALT WATER REVERSE OSMOSIS SUBPROJECT

INITIAL ENVIRONMENTAL EXAMINATION

I. INTRODUCTION

1. This initial environmental examination (IEE) covers the installation and operation of four desalination units on the island of South Tarawa, to be carried as a subproject of the South Tarawa Sanitation Improvement Sector Project (STSISP). The installation of increased desalination capacity is essential to make good the shortfall in supply from groundwater and rainwater sources and current and projected demand. This IEE examines the potential impacts of the installation and operation of the four desalination units and identifies mitigation measures to avoid adverse impacts and maximize beneficial impacts to the extent possible. The IEE is prepared according to the ADB's Safeguards Policy Statement, 2009 and in accordance with the Environment Act, 1999 and the Environment (Amendment) Act, 2007.

2. This IEE has been prepared following site visits, consultations, field investigations, and detailed feasibility studies carried out by the project preparation TA team, and the review of secondary sources of information and scientific literature relating to recent experience and current technology for desalination, and the local environment.

II. POLICY LEGAL AND ADMINISTRATIVE FRAMEWORK

A. National Legislation for Environmental Protection

3. The constitution of the Republic of Kiribati, which is the supreme law, vests the natural resources of Kiribati in the people and Government, and affords protection to public health, the health of animals and plants and the conservation of the environment. Specific legislation on environmental protection and management is provided for in the Environment Act (1999) and a number of other items of legislation. The Environment Act of 1999 is entitled "An act to provide for the protection improvement and conservation of the environment of the Republic of Kiribati and for connected purposes" is amended by the Environment (Amendment) Act 2007 and is supported by the Environmental (General) Regulations of 2009 (which repeals previous regulations to the act). Further relevant items of legislation are (i) the Public Utilities Ordinance of 1977 which vests responsibility for the protection and security of water resources in the Public Utilities Board, and includes regulations for the protection of water reserves, (ii) the Public Health Ordinance of 1926, (iii) Public Health Regulations of 1926, both of which provide for public health measures including sanitation, solid waste collection and drainage, (iv) the Foreshore and Land Reclamation Ordinance of 1969, which regulates extraction of material such as sand, gravel, reef mud and rock, (v) the Marine Zones (Declaration) Act of 1983 which provides for protection and conservation of the marine environment, where these are not otherwise covered by national or international law and (vi) the Local Government Act, 1984 which empowers local government bodies to issue by-laws relating to environmental protection. Kiribati is a signatory to several international laws that relate to protection of the marine environment and upholds international environmental laws through being a signatory to several conventions. These are detailed in the environmental assessment and review framework (EARF) prepared for the STSISP.

B. Specific Requirements for Environmental Assessment

4. Requirements of the Republic of Kiribati for Environmental Assessment are set out in the Environment (Amendment) Act of 2007 and Environment (General) Regulations, 2009. The act assigns primary responsibility for undertaking environmental assessment of projects to the project developer. The Ministry of Environment, Lands and Agricultural Development (MELAD), under the direction of the Principal Environment Officer (PEO), is responsible for review and approval of environmental assessment reports, prescription of requirements for publication and disclosure environmental assessment reports, issuance of environment licenses, and prescription of any conditions to the licenses. Environment licenses are required for all activities that are deemed environmentally significant, as listed in a scheduled by the Minister (of Environment, Lands and Agricultural Development). Legal requirements are set out in detail in the EARF.

III. DESCRIPTION OF THE SUBPROJECT

A. Project Category

5. The appropriate category for the installation and operation of desalination units according to the ADB's classification is B[1], where impacts are site-specific, few (if any) are irreversible and mitigation measures for them can be designed more readily than for Category A subprojects (which has significant adverse impacts that are irreversible, diverse, or unprecedented). This corresponds to the requirement for a basic environmental impact assessment report, as described in Part 4 of the Environment (General) Regulations, 2009.

B. The Sector Project

6. The subprojects will be implemented under the South Tarawa Sanitation Improvement Sector Project (STSISP), which has the following stated outputs: (i) sanitation and hygiene practices among South Tarawa's population are improved, (ii) sewerage in South Tarawa is effectively collected, treated and disposed of by PUB, (iii) MPWU and PUB have the capacity to effectively and efficiently plan and manage water and sanitation services in South Tarawa, (iv) adequate funds are available to PUB to finance required sanitation system maintenance activities, (v) project management services within MPWU ensure efficient and effective project implementation.

C. Need for the Subproject

7. The draft South Tarawa Water Supply and Sanitation Roadmap 2011-2030 prepared under TA-7359 KIR finds that primary and secondary groundwater lenses for South Tarawa are at considerable risk, and that water abstraction from freshwater galleries at Bonriki, and the Bonriki water treatment plant require upgrading and improvement. Furthermore, the present rates exceed sustainable capacity of groundwater reserves by about 20%. The distribution system beyond the main transmission pipeline and service reservoirs is failing with leaks in the system as well as high wastage within households, resulting in 67% losses and while this will be substantially improved, significant losses are likely to remain, or reoccur periodically. Of even

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[1] An Environmental Assessment Checklist and Environmental Categorization form for the sector project was submitted to the ADB Chief Compliance Officer on 18 Feb 2011.

greater concern is the growing demand for safe water supplies associated with population growth. In order to ensure that at least 50 litres per person per day is available to meet the needs of the population, and that this is maintained, existing groundwater and rainwater supplies must be substantially augmented.

8. The additional source of water for South Tarawa needs to be established quickly, at an affordable capital cost, and to have the ability to be expanded as the population increases, such that 24-hour pressurized potable water is maintained to allow efficient operation of the piped water system.

9. All tests of the urban groundwater lenses in South Tarawa have confirmed the unsuitability of water for potable uses. Increasing competition with non-potable uses and predicted population growth would eventually place the secondary lenses under pressure and compromise their ability to provide water for bathing and washing.

10. Rainwater harvesting will assist overall supplies during “wet” weather but cannot be relied on as a continuous source of water because of the severe ENSO-related droughts in Tarawa, the limited roof catchment areas, the rain tank volumes that can be made available economically and the large and increasing number of people per household.

11. An analysis of options for future supply, including a comparison of unit production costs was undertaken for the preparation of the Tarawa Water Supply and Sanitation Roadmap. This identified saltwater reverse osmosis (SWRO) or desalination as the most cost-effective option for the supply of water beyond what is available from groundwater and rainwater, to meet demand. SWRO is not only the most affordable supply; it is also the only available future supply. Previous water supply projects in South Tarawa have however rejected the use of SWRO to supplement water supply because of its cost, energy consumption and complexity. However, recent technological advances and development have improved ease of operation and maintenance, costs and economic life of SWRO plants.

D. Proposed Implementation Schedule

12. The sector project was approved in October 2011 and implementation is due to start with mobilization of the project management consultants in May 2012. Implementation of the SWRO project is considered urgent, and is expected to be implemented shortly after commencement of the sector project.

E. Location and Installation of the Desalination Plant

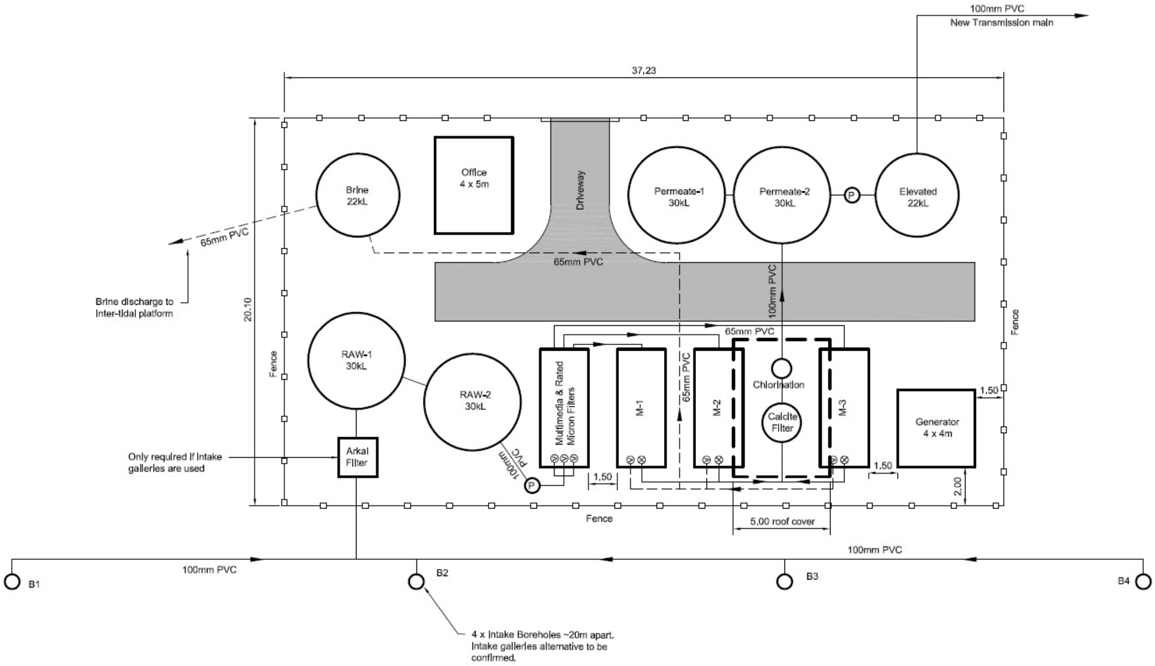
13. Four desalination plants will be installed. Each will consist of three SWRO units. Each plant will be capable of producing approximately 528 kL (m^3) per day, or a total production of 2,112 kL per day. Two plants will be sited at Betio, one at Bairiki/Nainikai and one at Teaoraereke/Antemai. The locations are shown in Figure 1, Figure 2 and Figure 3 and a schematic diagram of the installation to be made at each site is shown in Figure 4. Each plant will have a freshwater reservoir which will feed into the existing transmission main, then the service reservoirs and on to the distribution networks. The present system on South Tarawa will be divided into service areas (zones) for efficient operation, management and loss control, with the zone in the western area of South Tarawa between Betio and Antemai being balanced to align with the capacity of the desalination plants. The remainder of South Tarawa from Antemai to Bonriki in the east will continue to be supplied from the existing Bonriki and Buota groundwater reserves.

Figure 1: Location of Betio 1 and 2 Desalination Plant

Figure 2: Location of Bairiki 1 Desalination Plant

Figure 3: Location of Bairiki 2 (Nanikai) Desalination Plant

Figure 4: Schematic diagram of the installation at each site



1. Feed water sources

14. Feed waters will be drawn from boreholes sunk approximately 35m into the fractured and weathered limestone base material underlying South Tarawa, at the edge of the freshwater lens near the ocean foreshore. The fractured limestone will act as a natural filter for the intake waters, and will draw on saltwater from below the freshwater lens, avoiding impacts on the size and integrity of the lens. The filtering through the limestone will remove extraneous materials and as the abstraction is well below sea-level all marine organisms will either not be present or will be filtered out. Experience from previous SWRO plants has shown that marine organisms drawn into plants from shallow seawater intakes were a constant cause of blockage of the membranes. The saltwater feed requirement at each site will be 60kL/hour. Four bores will be dug at each site: three duty bores with a pump each and one standby bore with no pump. The bores will be 200mm in diameter with 150mm PVC internal casings and screens equipped with 100mm borehole pumps to provide the necessary flow rate. The bores will be 20 – 30m apart, and located ideally 40 – 50m from the high tide mark or on the lagoon side of the island. There is no risk at any of the four selected sites of interfering with the freshwater lens under Betio and Bairiki because the freshwater lenses do not extend to the areas selected for SWRO plant location.

15. In the unlikely event that a bore field proves to be unsatisfactory, a shallow infiltration gallery will be installed near the shoreline, using the design prepared for seawater extraction galleries proposed for seawater flushing of the sewers, under another subproject. In brief, two galleries will be installed, each 25m long comprising an engineered slotted pipe laid under the seabed not less than 1.5m below the lower tide level onto the lagoon flat and overlain with graded aggregate. The gallery will feed through a buried and weighted collector pipe to an intake chamber for pumping (one duty and one standby pump) to the raw water storage tanks.

2. Pre-treatment

16. Each module will be fitted with a low-pressure pump to send water from the raw water tanks to a multimedia filter, rated 20 microns, to remove solids from the raw water, preventing fouling of the membranes by fine particles or biological growth, and reducing the risk of damage to high-pressure pump components. When pressure across the multimedia bed reaches a pre-determined value the media will be automatically backwashed to waste using treated water from the elevated reservoir. The backwash water will be diluted with the waste brine stream in the brine tank prior to discharge. The backwash water will not be highly coloured or contain high concentrations of solids. The backwash cycle will take place at intervals between 2 and 7 days depending on the condition of the feed water. A single 1.6m diameter multimedia filter tank will be installed before each SWRO module.

3. Cartridge filtration

17. The water will then pass through a further cartridge filter, rated at approximately 3 microns, and housed in a canister some 1m in length. The filter unit contains seven cartridges of approximately 50mmin diameter that run the length of the filter. The cartridges will be replaced on average monthly, and are disposed of to landfill.

4. Seawater reverse osmosis module

18. Each of the four South Tarawa sites will have three SWRO modules. A SWRO module is made up of membranes rolled into fifteen 150-200mm diameter pressure tubes about 5m in

length complete with pumps and ancillary equipment packed into an air conditioned marinised 20ft container. The containers will be fitted between the raw seawater tanks and the permeate (treated water) tank. An additional container placed before the SWRO modules will house the raw water pre-treatment filtration units and the permeate will be chemically stabilized by means of a calcite filter to adjust the pH and chlorinated prior to storage in the low level freshwater tanks.

19. Each set of module membranes is fed by a high pressure pump (of the order 25kW creating pressures of the order 65-85bar) rated at 19kL/h and although power requirements are high, a modern design to be selected for South Tarawa will incorporate energy recovery systems that will achieve an energy cost reduction of the order 40%. This is achievable because the hydraulic energy is recovered from the reject brine stream. Pelton wheel impulse turbines energy recovery systems have good efficiency because they are less sensitive to changes in the reject brine flow.

20. Permeate from each membrane module will be combined and then passed through a calcite contact bed treatment prior to storage in the treated water (permeate) storage tank at a rate of 8kL/hr per SWRO module (24kL/h per site). A waste stream, called the brine stream, with a higher concentration of salt and other major ions will be discharged at a rate of 11kL/ hr per module or 33kL/h per site - a recovery rate of 42%.

21. The membranes cannot be backwashed in a similar manner to sand or media filters but must be kept clean. This will be achieved by the continuous controlled dosing of an anti-scaling agent (0.2-0.8g/m^3) and regular chemical cleaning of the SWRO membranes to ensure that they continue to perform satisfactorily. Under normal circumstances it is expected that four such regular cleaning cycles per year will be required. The key to successful membrane longevity is to do preventative cleaning i.e. do it before the membranes become irreversibly fouled. The cleaning cycle will typically be optimized after consideration of feed water quality, pre-treatment effectiveness and time taken for the normal flux permeate conductivity to increase by about 10-15% or the normal permeate flux to reduce by 10 – 15% or the differential pressure to increase by 10-15%. The SWRO will be set up with a wide range of automatic monitoring systems through a computer but the level of automation and remote monitoring required will be reassessed at a later time when the results of the proposed upgrade of the South Tarawa internet service are known.

22. In order to overcome potential difficulties arising from fluctuations in the mains power supply, an auxiliary power source will be used for the membrane washing operations. Onsite back-up power generators will therefore be installed as part of the project to provide back-up power.

5. Post-treatment

23. The treated water (permeate) with all the major ions and 99-99.5% of the salt removed is very corrosive to metals and concrete so needs to be stabilized. The permeate water will be pumped through a single calcite contact bed in a filter vessel about 2m in diameter at a conservative rate of 9-9.5kL/m^2/h to reintroduce ions such as calcium and magnesium and to regulate the pH. The final water will be marginally scale forming or marginally corrosive.

24. The calcite contact bed will need to be periodically backwashed to remove fines and again the waste will be mixed with the brine waste stream prior to disposal through the brine

discharge outfall. Typically the calcite level in the contact tank will need to be topped up annually.

6. Brine waste stream

25. The brine waste stream will be pumped to a 22kL balancing tank and from there disposed of to the receiving waters at a controlled rate using the head available in the balancing tank. The normal salt concentration of the brine will be about 1.5-2 times that of normal seawater and will be rapidly diluted at the outlet by wave action.

26. The multimedia filter backwash cycle water will generate about 2kL of dirty water per filter unit which can be diluted up to 9-10 times in the brine tank by manually closing the brine tank outlet until the tank fills and then allowing discharge as per normal through the outfall. The solids content of the backwash water will be low (about 0.1%) and careful sequencing of the backwash operations to coincide with high tides will further reduce concentrations of solids in the discharge water. The approach can also be adopted for the chemical cleaning cycles that are expected to be required about 4 times per year.

27. The anti-scaling agent will be applied in very small doses and further diluted to a significant extent in the brine tank prior to normal discharge through the ocean outfall. Manufacturer’s Material Safety Data Sheets for anti-scaling agents records negligible environmental risk from discharge in its concentrated form and the acid based product will have no impact on the pH or chemistry of the brine waste stream or receiving water.

28. Periodic back flushes of the calcite filter may cause higher levels of calcium but once again in-brine tank dilution and dilution at the outfall will minimize any potential calcium precipitation problems (ambient levels of calcium will be high, because of the chemical composition of the coral and the limestone sand and rock).

29. The brine stream from Plant No. 1 will be discharged into the lagoon, in the inner anchorage close to Betio Port while the brine stream from Plants 2, 3 and 4 will be discharged into the intertidal platform on the ocean side of the island.

7. System Installation

30. Each individual SWRO module (nine, in all) will be supplied in a 20ft container, with an additional container at each of desalination plants 1, 3 and 4 for the multimedia and rated micron filters. The existing building at desalination plant 2 will be converted to an office, store and filter room. Two raw water tanks, two tanks holding clean permeate at ground level, one elevated tank for distribution of the permeate and one holding tank for the brine will be provided at each site. Each site shall also have an office, perimeter fence, inlet filter and pipework and electric cables connecting the pumps, modules, filter and tanks. Site preparation prior to installation shall include the provision of approximately 90 cu m of fill material will be laid at each site to ensure that the machinery is kept clear of stormwater buildup during periods of high rainfall and to provide free board above the predicted sea level rise and wave surge established by KAP II.

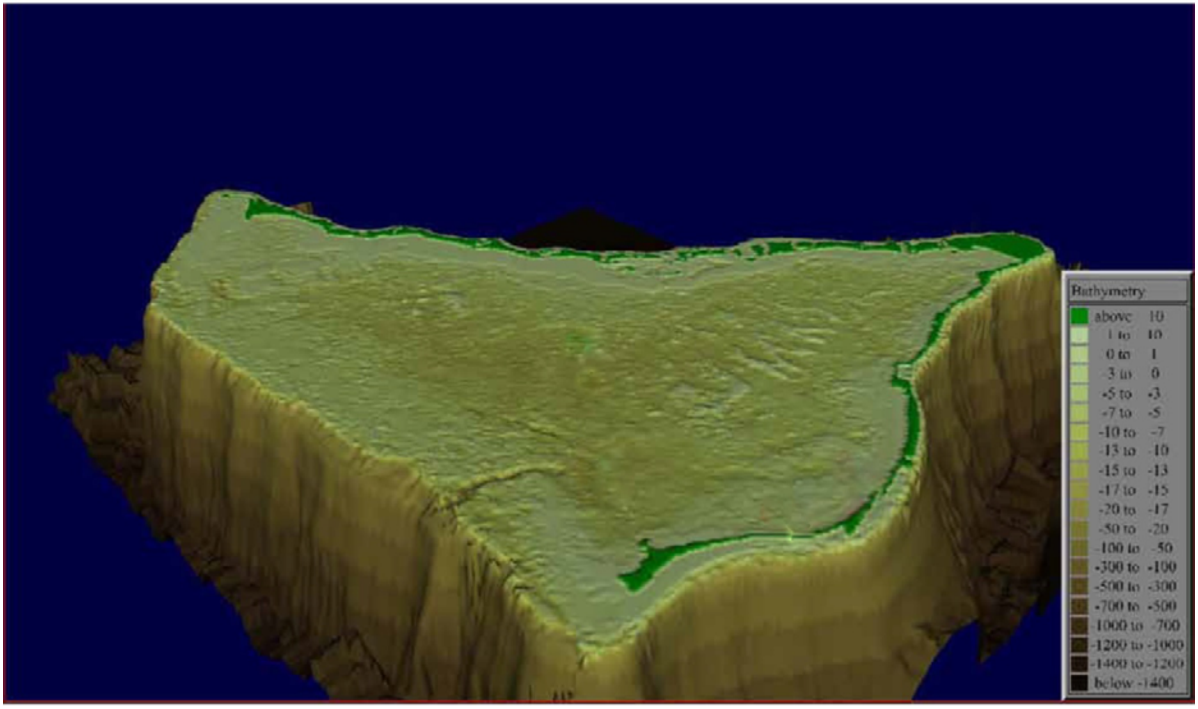
IV. DESCRIPTION OF THE ENVIRONMENT

A. Physical Resources

1. Geology Topography and Soils

31. South Tarawa comprises a series of islets, oriented east-west and connected by causeways. It adjoins North Tarawa, which similarly, comprises a series of islets, orientated approximately north-west south-east to form Tarawa atoll. It lies at a latitude of 10°20' North and 172 – 173° East, and is approximately 150km north of the equator. The atoll developed from a volcano which appeared between 55 million and 65 million years ago (during the Paleocene geologic epoch). Over time, the peak of the volcano has sunk below sea level as a result of subsidence of the ocean floor. As an atoll, the island surface is formed by successive coral deposits around the old and now submerged volcano. Atolls originate as coral reef formations at the tidal level at the rim of the original volcano, which gradually rise as a rock base forms from the calcium carbonate deposits of dead coral. At various times in the growth of the reef, the sea surface is reached and coral ceases to grow. The rock is variable in consistency, reflecting the growth patterns of the coral, which forms dense colonies (coral heads) and large voids between the heads. Partial dissolution of the rock, acting mainly along bedding planes, develops voids, or karst formations. Coral growth resumes again when the atoll drops below the surface of the sea. The vertical growth from this process keeps the reefs at or near the surface of the ocean as the volcano subsides. The atolls of North and South Tarawa, and the surrounding reef delineate the edges of the lagoon which occupies the site of the former volcanic core. The atolls and the lagoon form the top of the former volcano, which rises sharply from the sea bed, as shown in Figure 5. South Tarawa has a narrow coral sand beach leading to the lagoon along its north side, and an intertidal platform on its south side, adjoining the ocean.

Figure 5: Surface and Bathymetry of Tarawa Islands and Lagoon



Source: SOPAC (2008). Kiribati Technical Report: Hydrodynamic Model of Tarawa Water Circulation and Applications

32. The atolls have soils derived exclusively from coral deposits which are predominantly sandy in texture, with a significant silt component formed from abrasion within the sand deposits. Over much of the island, deposition and breakdown of organic matter has led to the formation of a thin layer of topsoil. The soils are free draining when uncompacted, have poor nutrient status and are generally alkaline. The surface relief is extremely low, attaining a maximum of 3m above sea level. Measurements show that gradual uplift is taking place, as a result of the dynamics of ocean floor movements, in the order of 1mm per year[2]. However, sea level rise, linked to the phenomenon of climate change, is occurring at a rate of between 3 to 4mm per year[3].

2. Climate

33. Tarawa has a maritime tropical climate. Two seasons occur, characterised mainly by global wind patterns and rainfall. Between October and March, easterly tradewinds predominate and rainfall is generally higher, while between April and September, more variable winds occur including westerlies, which can be strong and rainfall is lower. Temperatures generally vary between 28°C and 32°C, averaging 31°C, though monthly averages remain very constant between 26°C (February) and 28°C (September). Rainfall averages 2,027 mm annually, however this varies widely, between 398mm and 4,333mm. Rainfall patterns are influenced by the convergence patterns of tradewinds. The South Pacific Convergence Zone (SPCZ) which occurs within the Intertropical Convergence Zone (ITCZ) has a strong influence on the occurrence of rainfall. The ITCZ is characterized by diverse weather patterns, which can include thunderstorms and periods of stagnant calm (the occurrence of calm periods led to colloquial reference to the ITCZ as the "doldrums") and is influenced by the El Niño/Southern Oscillation (ENSO): during El Niño events it moves towards the equator bringing higher rainfall to Tarawa while during La Niña events the reverse happens and periods without rain can be extended. The effects of El Niño/La Niña notwithstanding, climate variability is strongly apparent. The island is subject to intermittent droughts, when the drier season can extend well beyond the months of April to September. Unlike many other Pacific islands, Tarawa rarely experiences cyclones.

3. Climate Change

34. The incidence and severity of droughts can be expected to worsen with the occurrence of climate change. Climate change is of intense concern, and also carries risks of higher sea surges, hotter or cooler periods, loss of land area and constriction of freshwater lenses. Predictions from a World Bank study[4] suggest that South Tarawa could lose between 25% and 54% of its land mass by 2050, and in the recently prepared Tarawa Water Master Plan[5], it is predicted that the thickness of the freshwater lenses below South Tarawa may be reduced by 18% to 19%. The main existing sources of freshwater, the underground lens and rainwater, are threatened by climate change. The threat is exacerbated by increased demand for water

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[2] Geoscience Australia (2009) South Pacific Sea Level and Climate Monitoring Project (SPSLCMP) Survey Report February/March 2009: EDM Height Traversing Levelling Survey. The report provides comparisons of data between 1992 – 2009 showing relative movement of bench marks on Tarawa over time. This is updated by personal communication with the Geoscience Australia surveyor who visited Tarawa in May 2011.

[3] South Pacific Sea Level and Climate Monitoring Project (2009) Pacific Country Report on Sea Level and Climate Change: Their Present State for Kiribati.

[4] World Bank (2000). *Cities, Seas and Storms: Managing Change in Pacific Island Economies. Vol IV: Adapting to Climate Change*, World Bank, Washington

[5] White, I (2011): *Tarawa Water Master Plan Te Ran, Groundwater*, Government of Kiribati

supplies once stored rainwater runs out and groundwater supplies are limited during drought events.

4. Freshwater Resources

35. Rainwater that is not returned to the atmosphere via evapotranspiration flows into the ground and collects through infiltration via the soil layers, into a lens that forms in the underlying strata of the atoll. The lens is convex in profile, and thickest at the centre. The size of the lens is strongly dependent on the width of the island. While this provides a valuable source of freshwater extracted through wells, it is subject to pollution from human and animal waste as well as depletion from over-extraction, and climate variability. Ground water from a designated water reserve at Bonriki in South Tarawa currently feeds a reticulated system, which supplies water disinfected by chlorination to consumers. Neighboring Buota in North Tarawa, which has significantly lower population densities, has additional reserves of groundwater and supplies water to South Tarawa via a pipeline which has currently been rehabilitated. The draft South Tarawa Water Supply and Sanitation Roadmap 2011-2030 confirms that there is a current and growing deficit between water supply and need, and that, while a reduction in leaks will mitigate this, a supplementary source, beyond groundwater and rainwater, is needed. The options for supplementary sources are examined in further detail in section VI of this IEE.

5. Marine Resources

36. Shallow marine waters around South Tarawa, namely the lagoon to the north and the water in the intertidal reef platform to the south, are used for fishing and bathing. The lagoon is also an abundant source of shellfish which form a large part of the local diet, and is used for transport, particularly between North and South Tarawa. Beyond the reef, fishing takes place in the ocean waters.

37. The quality of water both in the lagoon and the intertidal reef flat area is influenced by sewerage discharge, illegal dumping of solid waste, the practice of open defecation and current deficiencies in the operation of the island’s four ocean outfalls (the outfalls are to be rebuilt under a further subproject of the South Tarawa Sanitation Improvement Sector Project). A study of solid waste generation and disposal practices carried out in 2010[6] estimated 51.2% (approximately 3,522 T/yr) of generated waste is illegally dumped. Typically, this is by disposal to the lagoon or sea (34.5% - 2,377 T/yr), or sometimes as fill for private seawalls (17.7% - 1,145 T/yr).

38 Bore water samples were taken from observation bores constructed under the KAP II project at 18m depth in Betio and Bairiki and additionally two sea water samples were taken one from the lagoon directly in line with the boat underpass on the Betio-Bairiki causeway and the other from the sea also directly in line with the same causeway. The approximate locations were 0.6km either side of the causeway. The results recorded in the field are shown in Table 2.

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[6] Finnigan, S.M. (2010), Kiribati Solid Waste Management Report prepared for the New Zealand Aid Programme.

Table 1: Field Results for the Four Test Locations

No	Location	Date	Temperature	Conductivity mS/m	Salinity (calc) g/m^3
1	Bairiki Bore **N** 1^o 24'36.7'' **E** 173^o 6'45.6''	24/02/12	30.4	3,120	20,280
2	Betio Bore **N** 1^o 19'46.4'' **E** 173^o 58'35.5''	24/02/12	30.6	37,70	24,505
3	Lagoon - from Bairiki causeway		28.5	5,270	34,255
4	Ocean -from Bairiki causeway		26.5	5,460	35,490

39 Regular water quality monitoring is yet to be successfully established. Although the Environmental Health and Laboratory Units under the Ministry of Health and Medical Services have facilities and have undertaken water quality measurements, recently collected data has been lost. Data is available from prior studies undertaken at South Tarawa. The studies show that water quality is generally poor. For example a study undertaken in 1991[7] found that concentrations of faecal coliform in water in the intertidal flat reaches up to 1,000 MPN / 100 mL, representing a high level of pollution. Substantial improvements are expected to arise from other components of the sector project, including (i) rehabilitation of the sewerage systems in the urban areas of Bikenibeu, Bairiki and Betio and (ii) the community engagement program, which will address harmful practices such as open defecation. Further improvements can also be expected from improvements in solid waste collection, treatment and disposal, being supported by the New Zealand Aid Programme.

B. Ecological Resources

1. Marine Ecosystems

40 Mangrove and coral ecosystems have significant ecological importance. Mangroves occur on reef mud flats at the lagoon margins at certain areas, and provide a coastal protection function as well as an important habitat for marine organisms. Mangroves have been subject to depletion, but mangrove forest areas have been rehabilitated by the government under the World Bank funded Kiribati Adaptation Project, phase II (KAP II). Sea grass beds, which provide an important habitat for shellfish and other organisms, occur extensively within the lagoon particularly toward the southeast. Measurements suggest that the extent of seagrass beds is in fact expanding[8].

41 Coral formations occur within the lagoon and on a gently sloping terrace that extends out from the reef edge, into ocean waters. Very limited flora and fauna occur on the intertidal reef flat, due to repeated exposure to the sun during low tides. Beyond the intertidal reef flat, on the

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[7] Naidu, S.; Aalbersberg, W.G.L.; Brodie, J.E.; Fauvao, V.A.; Maata, M.; Naqasima, M.; Whippy, P.; Morrison, R.J. (1991). Water quality studies on selected South Pacific lagoons. UNEP Regional Seas Reports and Studies No. 136. SPREP Reports and Studies No. 49. UNEP.

[8] Paulay, G (2000). *Benthic Ecology and Biota of Tarawa Atoll Lagoon: Influence of Equatorial Upwelling, Circulation, and Human Harvest*. Atoll Research Bulletin No. 487. National History Museum, Smithsonian Institution, Washington

ocean side of the island, coral colonies are generally healthy but sparse, and become less diverse and more sparse with depth. A team of divers was engaged under the PPTA during May 2011 to examine the current condition of the outfalls, take depth measurements and make observations on the appearance of coral. Live coral and an abundance of small fish were observed, consistent with earlier surveys and studies[9,10]. Underwater surveys undertaken for the preparation of an Environmental Impact Assessment for the extraction of aggregate for the Environmentally Safe Aggregates for Tarawa (ESAT)[11] reveal that the lagoon bed is typically covered predominantly by small rubble with rock outcrops, and some living coral, covering about 2% of the surface.

42 Pelagic fish form an important part of the local economy, both through commercial fishing activities and game fishing, focusing on tuna and tuna like fish. Fishing activity focuses on areas known to be abundant and these occur throughout Kiribati waters and include a number of favored sites around Tarawa, usually distant to the coast, well away from the site of brine discharge.

2. Terrestrial Ecosystems

43 The present day vegetation cover on the island is substantially influenced by human habitation and has little biodiversity conservation significance and includes species such as papaya (Carica papaya) and flame tree (Delonix regia) which originate from outside the Pacific region.

3. Protected Areas

44 While Kiribati has a number of protected areas, none of these occur on or around South Tarawa but mangrove, coral and seagrass ecosystems, which occur around South Tarawa, are of conservation significance. Corals occur in the project area.

C. Culture

45 The original inhabitants of Kiribati are Gilbertese, a group of Micronesian origin. Culture and traditional practices are strongly upheld by island communities. Having evolved in a high degree of isolation, there are strong indigenous customs. The communities have absorbed the creeds of a number of churches, introduced to the islands by missionaries operating in the Pacific since the late eighteenth century, and church services and functions are an important part of daily life.

46 During the second world war, Tarawa was the scene of significant combat between Japanese and American forces. The large guns installed by Japanese forces remain in place and provide a strident reminder of the events in the 1940s.

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[9] Lovell, E. (2000) *Coral Reef Benthic Surveys of Tarawa and Abiang Atolls, Republic of Kiribati*. SOPAC Technical Report 310.

[10] Sykes, Helen R (2001). Assessment of Marine Resources, Temaiku Subdivision, South Tarawa Island, Kiribati. Report to Sustainable Towns Project .

[11] The ESAT project is being undertaken by the Ministry of Fisheries and Marine Resources Development, the South Pacific Commission (SPC) and the South Pacific Applied Geoscience Commission (SOPAC). The ESAT project aims to protect the vulnerable beaches of South Tarawa from damage caused by aggregate mining and provide an alternative supply of material through environmentally safe lagoon dredging.

D. Human and Economic Development

1. Population Levels

47 South Tarawa is densely populated, with inhabitants originating from islands throughout the group as well as South Tarawa itself. Even between the main urban areas of Bonriki, Bikenibeu, Bairiki and Betio, land is almost entirely taken up by residential, commercial and communal buildings and their surrounding compounds. The population stands at some 50,402 people representing an average population density of around 3,193 people per sq km over the 15km^2 of land area. Within the urban areas, such as Betio, it reaches 8,990 people per sq km and is very high among Pacific capitals (the population density in Apia is 6,534 people per sq km, in Majuro 2,628, Nuku'alofa 2,073 and 1,872 in Funafuti. While measures were taken in the past to encourage migration to outlying atolls, at present extensive in-migration occurs and the population of South Tarawa is growing by 3.87% per year[12]. In 2010, at the time of the last census, the population of South Tarawa represented some 48% of the total population of Kiribati. The average household size is large, at 7.5 persons per household and households with 15 or more inhabitants are not uncommon.

2. Economy

48 The economy of Kiribati features the extreme distances between its islands (the two gaps between the three island groups are both approximately 1000km), paucity of natural resources and distances to international markets. Fishing licenses, copra and seaweed provide some international revenue, and many Kiribati families are reliant on remittances from family members working offshore, often in international shipping. Some tourism takes place. Competition is high among Pacific nations to market traditional attractions such as tranquil secluded beach locations, and Pacific culture, and Kiribati is not well located in terms of proximity to the major markets of the United States, Japan, Australia and New Zealand and therefore does not compete easily with other tourist destinations in the Pacific. However war relicts, game fishing and the millennium islands, (whose proximity to the international dateline provides them with the distinction of being the first to celebrate each New Year) encourage some visitors. Visitors number between 3,000 and 4,000 each year and bring some significant revenue.

49 The economy of South Tarawa reflects its function both as the nation's capital and the main sea port and international airport. The service sector accounts for most employment and 80% of jobs are with the public sector.

3. Public Health

50 The incidence of illnesses relating to deficiencies in water supply and sanitation are highly significant. According to the WHO, the infant mortality rate is 46 per 1000 live births, which is the highest in the Pacific and is attributed mainly to diarrhea, to which infants are very vulnerable. Diarrhea is also rife among the adult population, with significant outbreaks occurring as frequently as twice a year, according to local clinics and the WHO.

51 Clearly, the high incidence of diarrheal and other water related disease is a major causal factor of poor public health. The prevalence of these diseases results from a number of disease transmission pathways, where pathogens and toxins are spread from human, animal and solid

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[12] TA 7359-KIR population growth and urban development component

waste via seawater in the lagoon, seawater on the reef flats, water from the contaminated freshwater lens and unsanitary living conditions, to humans. Infections occur through ingestion or via wounds or soft tissue while bathing, through eating shellfish, or from drinking contaminated water, while nutrients such as nitrates that concentrate in the groundwater become toxic and cause problems such as blood disorders in infants.

52 These pathways to disease are perpetuated by declining sanitary living conditions and established behavior relating to water use and personal hygiene. To reverse the situation, a range of interventions are needed ranging from immediate infrastructure improvements to long term community engagement programs to elicit changes in behavior (such as reduced open defecation). One of the improvements essential to block pathways to disease is the supply, on a reliable basis, of clean drinking water, sufficient to meet the needs of the current and future population of the island.

V. ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

A. Overview

53 The proposed installations will fill a vital need both to augment existing clean water sources that are fast becoming inadequate and also to have a readily expandable source of safe water for drought situations or other emergencies. In combination with other initiatives, particularly in terms of sanitation improvements and some aspects of public behavior change, highly significant improvements in public health will result. Potential negative impacts include construction impacts and some risks associated with operation of the plant. The following sections outline these risks and describe mitigation required to bring them to acceptable levels.

B. Method of Assessment

54 Potential impacts were assessed by means of site visits from the engineering team, discussions with local residents, MPWU and PUB staff, discussion with the project preparation team, and review of literature and other secondary sources of information. The assessment involves consideration of each phase of design, construction and installation, and operation of the desalination plant.

C. Direct Impacts related to Operation

1. Effects of the discharge of brine on marine ecosystems

55 The desalination process produces a clear water permeate accounting for 42% of feed water, while the remaining 58% becomes the brine solution which is discharged into surrounding waters. While salinity levels above or below ambient salt water levels can alter the species composition of benthic formations, and affect the behavior of demersal and pelagic species, any such effects will be strongly reduced by mixing with surrounding water, enhanced by current flow and wave action. Brine from Plant No. 1 will enter lagoon waters near the Betio wharf, while brine from Plant 2, 3 and 4 will be discharged into the intertidal platform, entering water that is subject to tidal movement and wave action.

56 Tests undertaken during the feasibility study found that seawater in the area has a salinity of approximately 35,000 g/m^3 (or 35 practical salinity units – psu). The brine discharged from each desalination plant will have a salinity of approximately 59 psu. The rate at which this solution mixes with ambient water and is returned to near ambient levels of salinity is dependent on current, temperature and volume of surrounding water for brine for plant 1 near Betio wharf, and on wave action for the other plant. An indication of the rate of mixing for the brine discharged from plant 1 was obtained by running the three dimensional updated merge model UM3, which is incorporated into VPLUME software produced by the United States Environmental Protection Agency[13]. Assuming a minimal current of 0.01 m/s, dilution is still very rapid, reaching a factor of around 100 within approximately 1m. Figure 6 below shows the predicted dilution factor and salinity levels within 1m of the point of release, using values determined from the UM3 model. Within the intertidal area, brine is discharged either into moving tidal water, for periods of up to six hours, or discharged into pooled water that lies still

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[13] http://www.epa.gov/ceampubl/swater/vplume

until the arrival of the flow tide. A typical sequence of tides over a period of one week is shown in Figure 7. Still water conditions, when the tidal levels are below the level of the intertidal platform occur for approximately 25% of the time. For the remaining 75%, water is moving with tidal flow and strongly agitated by wave action, creating conditions for rapid mixing, and restoration of normal seawater levels of salinity.

Figure 6: Predicted dilution factor and salinity levels within 1m of the point of brine discharge obtained from the United States EPA's updated merge model UM3

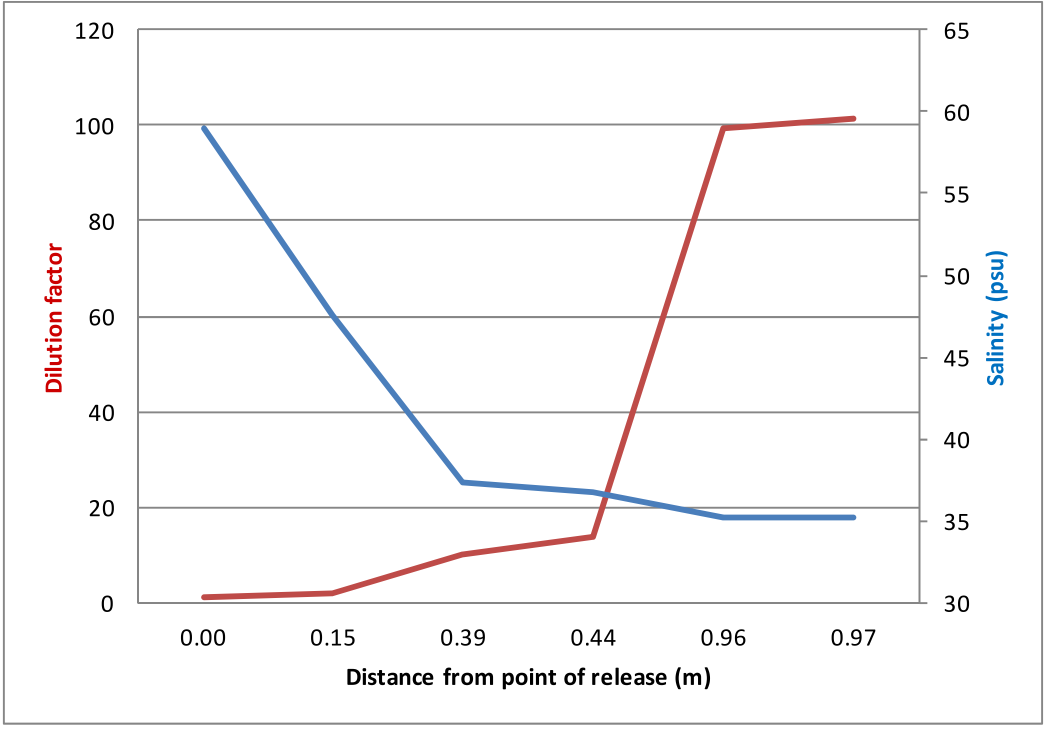
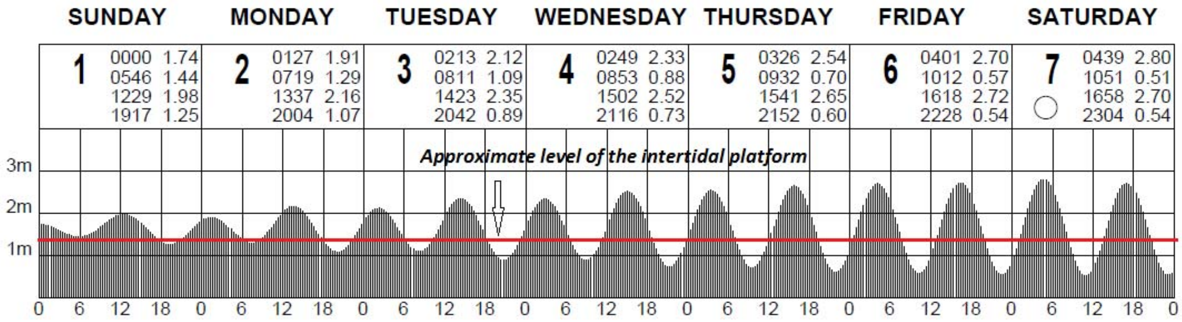


Figure 7: typical tidal cycle over a one week period



57 When brine is discharged into still pools of water, the salt concentration will increase, particularly when high temperatures and winds cause rapid evaporation. However, the water in the intertidal flats are subject to strong insolation, creating a depauperate environment for living organisms. The localized, temporary higher concentrations of salt in these areas are not expected to have any effect on biodiversity.

2. Other waste

58 Besides brine, backwash water will also be discharged from the plants. Backwash water will contain some inert solids, and also will be subject to rapid mixing and therefore dispersal of the solids.

59 Spent filter cartridges are a further waste product. Each module has a cartridge filter unit, which will contain seven cartridges of approximately 1m in length and 50mm in diameter. These have to be replaced monthly, and the spent cartridges disposed of at the landfill. The total volume of spent cartridges each year is approximately 2.5 m^3. The landfill at Betio (the nearest landfill to all four plant) is to be equipped with a tapered foot roller which can crush the cartridges to approximately half their volume. The annual burden on the landfill is therefore approximately 1.25 m^3, against a total capacity of 54,000 m^3.

3. Use of disinfection and anti-scaling agents

60 Treatment of the water involves disinfection after the desalination process, using chlorine compounds. The application of a descaling agent will be part of regular routine maintenance. The composition and optimal dosage of descaling agents has been developed for SWRO plant by the manufacturer consulted as part of the feasibility study. The firm is able to confirm that the chemical, which is based on phosphoric acid only needs to be applied at very low concentrations. Procedures for use of the chemicals provide for mixing with the discharged brine, to bring concentrations to acceptable levels prior to discharge into receiving waters. Toxicological data and exo-toxicological data indicate no environmental issues. However, if stores of anti-scaling agent are mishandled, or if it wrongly, these chemicals may pose a health hazard to workers and the public. The risk is controlled by (i) engagement of staff with a technical background including training in plant operation and maintenance (ii) provision of start-up training and plant operation manuals on commissioning and (iii) storage of hazardous chemicals in a locked, secure location.

4. Risks associated with plant failure

61 Accidental failure of any of the desalination modules (for example, rupture of the membrane) or of the post treatment systems could result in the release of salty or infected water entering the water transmission and distribution system. These risks are limited by high manufacturing tolerances (verified by the feasibility study team’s visit to the desalination plant manufacturer), regular routine maintenance and daily inspections to detect incipient problems.

5. Noise generation

62 Each site will have electric pumps, that operate regularly, and backup generators, that operate occasionally, as and when required. This machinery will be fitted with exhaust baffles (the generators will be fitted with acoustic packages), and will be required to conform to international regulations on noise abatement standards (as required for plant to be used during construction). No sites adjoin residential areas and so potential impacts are very limited.

6. Air quality

63 The pump and generator machinery may give off fumes. Fume generation will be mitigated by the use of exhaust baffles (which also significantly reduce noise emissions) and the effect will be insignificant if the machinery is subject to adequate routine maintenance.

D. Direct Impacts related to Construction and Installation

64 **Construction noise**. Some noise generation will arise from site preparation work, including delivery, spreading and compaction of fill material and some tasks that take place to install the plant, such as welding, will be limited and temporary. The use of vehicles, plant and equipment conforming to international standards of construction equipment noise emission14 will be compulsory. To verify this, recent inspection certificates, valid for the time of delivery of equipment on Tarawa and for at least six months thereafter, which have been issued by an approved inspection authority in a country with international standards, such as Australia, Japan or the United States will be required for all vehicles and machinery prior to the Contractor being allowed to commence work. The Contractor will arrange routine maintenance of plant and equipment and submit records of maintenance and repairs to the employer, or supervision consultant.

65 **Effects on Air Quality**. The haulage, delivery and placing of fill material to each site will give off some dust. However, the available material is relatively coarse textured and will therefore not fall more than a few metres beyond each worksite, or cause any deterioration in air quality. The operation of vehicles and plant during construction, and of backup generators during operation, will emit exhaust gasses.

66 In order to ensure that emissions from diesel generators, vehicles and other machinery are kept within acceptable measures, the Contractor will be required to provide equipment that conforms to international emission standards, verified by emission test certificates and maintenance records, as in the case of control of noise emissions.

67 **Safety hazards to workers and the public.** The work will involve some hazard to workers and the public, mainly from vehicle movements, handling of containers, power connection work and any excavation work, resulting from excavation. Safety to workers and the public will be enhanced by requiring the Contractor to:

(i) Provide briefing and training of workers on safety precautions, and their responsibilities for the safety of themselves and others,

(ii) Provide protective clothing including hard hats, protective footwear, and high visibility jackets for use should any construction activity is to take place at night. These should be compliant with relevant international standards, compatible with International Labour Organization Recommendation Concerning Safety and Health in Construction (No. 175, Geneva, 1988),

(iii) Ensure that plant and vehicle operators hold licenses where applicable, and have been trained specifically in the operation of each item of equipment,

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[14] Appropriate noise emission standards include (i) Part 204 of US Federal Regulations - Noise Emission Standards for Construction Equipment (40 CFR 204) or (ii) Directive 2000/14/EC of the European Parliament and of the Council of 8 May 2000 on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors

(iv) Arrange for the provision of first aid facilities, training of at least one member of staff at each site in first aid, emergency transport to the hospital, and allocate responsibility for ensuring that these arrangements are continually in place,

(v) Arrange for regular safety checks of vehicles and material

(vi) Provide hazard warning signs around excavation sites, and direct vehicle and pedestrian traffic away from work sites.

68 **Risk of damage to property.** The sites are distant from private homes and scope for damage to property is very low.

69 **Risk of accidental damage to utilities**. Each site has been surveyed, and the positions of water transmission lines, power and phonelines are known. Risk of damage within the relatively limited scope of work is very low.

70 **Risks associated with hazardous materials**. Potentially hazardous materials used in construction and installation work include fuel and minor quantities of paint and lubricant, while toxic compounds, including chlorine based disinfection agents and anti-scaling agents, will be stored and used for operation of the plant (these will be present at the construction and installation stage for commissioning. Fuel will be obtained and handled at normal commercial facilities. The Contractor will ensure that paints, lubricant, disinfection compounds and any other potentially hazardous substances are kept in a secure location.

71 Sanitation arrangements will be made at worksites, ensuring that no raw sewage is released directly into the soil or into lagoon or coastal water. These arrangements will be either (i) arrangements with nearby homes or institutions that are connected to the sewer system or (ii) use of portable toilets which are emptied daily into manholes within the sewer system. On-site sanitation with environmentally designed evapotranspiration beds will be installed for permanent site amenities.

E. Indirect Impacts

72 **Secondary impacts from public health improvements.** The improved water supply will, if successfully complemented by improvements to sanitation infrastructure, as is planned under the sector project, contribute to substantial improvements in human health. These in turn are likely to improve the economic situation of poor households (through reducing the financial burden of repeated treatment and loss of productivity) and also lead to further, wider economic benefits. However, unless and until behavior change takes place and unhealthy or risky practices such as open defecation and lack of management of free roaming pigs are abandoned, the public health benefit will be compromised.

73 **Materials Extraction.** A substantial quantity of fill material will be required to raise ground levels at each site, to reduce exposure of the equipment to flooding. Indirect impacts from materials extraction can, if some existing practices such as digging directly near the coastline or bulldozing from the lagoon floor, encourage coastal erosion and can damage precious ecosystems such as mangrove and coral. However, these will be avoided by sourcing material that is to be obtained through planned and licensed extraction work undertaken for other projects, notably the Tamaiku subdivision improvements funded by the New Zealand Aid Programme and the World Bank / ADB funded Kiribati Road Rehabilitation Project.

F. Cumulative Impacts

74 The installation and operation of the plant will involve training and provide experience to managers and operators. This helps to build a cadre of technicians with first hand experience in managing and maintaining utility installations. A long term and positive capacity building impact is therefore expected. Risks associated with operation, such as uncontrolled release of chemicals used for disinfection and anti-scaling will be limited, localized and sporadic, rather than cumulative. The use of seawater extracted well below the freshwater lens avoids issues of potential lens depletion, and the use of network modeling to identify optimal sites for the plant avoids skewed loading of the water supply network.

G. Treatment of Risks associated with Climate Change and Variability

75 The current climate change assessment report of the Inter Governmental Panel on Climate Change15 emphases risks related to sea level rise, sea surge risks, temperature rise, decreases in rainfall (whether long term or in terms of extreme dry years or season) and storm severity. Increased risk of more frequent and prolonged periods of drought are potentially very significant, causing both intense short term difficulty long term damage to the freshwater lenses that exist beneath the islets. In the absence of a reliable supplementary source of drinking water, increased extraction of groundwater during drought periods will exacerbate the damage to the lenses. The selection of desalination of seawater as a supplementary water source ensures that a highly reliable source is used during drought periods that can be increased as necessary to alleviate severe droughts.

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[15] The Intergovernmental Panel on Climate Change is a scientific body established by the United Nations Environment Programme and the World Meteorological Organization in 1988 as the leading international body on the assessment of climate change, and is based in Geneva.

H. Summary of Subproject Impacts and Mitigation

Table 2: Screening of Impacts and Mitigation

Potential Environmental Impact	**Nature and duration**	**Location**	**Mitigation measure(s)**	**Assessment of impact** **With/without recommended mitigation**	**Temporary or Permanent**
Impacts due to Location					
Impacts on marine ecosystems	Very limited	Points of release of brine for each site (lagoon for plant 1 and the intertidal platform on the ocean side of the island for plant 2 – 4)	n/a	Not significant	n/a
Damage to terrestrial ecosystems	Very limited. There are no plant and animal communities on Tarawa that are of conservation significance. Vegetation in the vicinity of the four sites is mainly weed cover.	All four sites	n/a	n/a	n/a
Historical/cultural monuments and values	No monuments or relicts of cultural value exist in the project area.	n/a	n/a	n/a	n/a
Resettlement / Loss or damage to property	Government land has been identified for each site. The sites are readily accessible by large vehicles and plant on the public road network.	All four sites	Should accidental damage occur, compensation as provided for in the Resettlement Plan for the sector project.	Minor / Minor	Temporary

Potential Environmental Impact	**Nature and duration**	**Location**	**Mitigation measure(s)**	**Assessment of impact** **With/without recommended mitigation**	**Temporary or Permanent**
Impacts related to Construction					
Accidental damage to utilities	Minimal risk as sites have been identified and inspected in detail. Network modelling confirms appropriate siting and that the existing water transmission and distribution network will not be at risk of overloading	All four sites	Ensuring that installation work is adequately supervised.	Not significant	n/a
Generation of construction waste	Material produced by excavations will be sold or distributed for re-use. Waste products from construction works will include empty fuel drums and other packaging materials.	Work sites at sewage networks and near each outfall location	Arrangement for sale or distribution of excavated materials. Use of bins and skips at construction site for the collection of waste. Removal of non hazardous waste to landfill. Separate collection of fuel drums and any other containers that have held hazardous chemicals and removal from the island on demobilization. Prohibiting any sea dumping	Minor / Eliminated	Temporary
Noise nuisance from construction activities.	Some noise generation will be generated by the operation of vehicles and plant for site preparation work, including delivery, spreading and compaction of fill and tasks such as welding.	All four sites	Vehicles, plant and equipment are to conform to international of noise emission and upkeep.	Minor / Minor	Temporary

Potential Environmental Impact	Nature and duration	Location	Mitigation measure(s)	Assessment of impact With/without recommended mitigation	Temporary or Permanent
Air quality	Some dust will be produced by haulage, delivery and placing of fill material to each site. Exhaust will be produced by diesel generators, vehicles and other machinery	All four sites	Use of vehicles and equipment that conforms to international emission standards, verified by emission test certificates and maintenance records, as in the case of control of noise emissions.	Minor / Not significant	Temporary
Pollution from chemicals and fuels	Improper storage and handling of chemicals and fuels used in the works pose a risk at construction sites. The impact is temporary, as the risk will be confined to the construction period.	All four sites	Fuel will be obtained and handled at normal commercial facilities. Paints, lubricants, disinfection compounds and any other potentially hazardous substances shall be kept in a secure location.	Minor / Not significant	Temporary
Safety hazards to workers and the public	Workers or members of the public may be exposed to the risk of accidents during construction. The risk is temporary, and confined to built up areas during the construction period.	Work sites near each outfall location	Requirement for the Contractor to ensure: (i) briefing of workers on safety precautions, for themselves and others and for implementing emergency procedures, (ii) provision of protective clothing and equipment to workers as appropriate, (iii) ensuring that vehicle and equipment operators are properly licensed and trained, (iv) arranging for provision of first aid facilities and emergency evacuation procedures (v) provision for regular safety checks of vehicles and plant, (vi) provision of hazard warning signs at the construction sites	Minor / Minor	Temporary
Effects of materials extraction	Some existing practices to obtain construction materials can cause environmental damage such as coastal erosion and damage of coral, sea grass or mangrove communities	All potential extraction sites	Obtaining material from licensed sources, where material is extracted in a sustainable manner	Minor / none	Temporary

Potential Environmental Impact	Nature and duration	Location	Mitigation measure(s)	Assessment of impact With/without recommended mitigation	Temporary or Permanent
Impacts during Operation					
Use of hazardous materials during operation	Operation of the plan involves the use of chlorine compounds for disinfection of the treated water (permeate) and of a descaling agent during routine maintenance	All four sites	Engagement of suitably capable technicians to undertake day to day management of the plant, training and provision of operational manuals and storage of potentially hazardous materials in controlled, secure, locations.	Significant / Minor	Permanent
Accidental plant failure	Failure of the plant or post treatment systems may result in unsafe water being released in to the transmission and distribution system	All four sites and the water transmission / distribution network	Choice of machinery and components manufactured to high tolerances, briefing and training of operators in proper routine maintenance and daily inspections	Significant / Minor	Permanent
Noise	Pumps will operate regularly and back-up generators on occasion on an as and when basis.	All four sites	All plant will conform to international noise abatement standards (as required for Construction plant).	Minor / Not significant	Permanent
Air quality impacts	Pumps and backup generators will emit exhaust fumes	All four sites	Use of exhaust baffles, regular routine maintenance	Minor / Not significant	Permanent
Effects on marine ecosystems	Minimal. The principal discharge, brine, poses no significant threat to biodiversity as it is non toxic and the salt concentration is rapidly returned to ambient levels by mixing action.	All four sites	n/a	Not signficiant	Permanent

VI. ANALYSIS OF ALTERNATIVES

A. Alternatives to the Subproject

76 At present South Tarawa relies mainly on groundwater or rainwater for freshwater supplies, but these sources are limited and desalination plant are already in use at hospital, school and commercial premises to ensure continuity of supply. The use of groundwater and rainwater is effectively close to its maximum potential and while the situation will be substantially alleviated by improved control of leakages, the demand for drinking water will increase substantially with population growth. Even with substantial improvements to the groundwater extraction and distribution system, the existing shortfall will grow. The Tarawa Water Master Plan 2010 – 2030[16] provides an estimate of potential water supply from combined North and South Tarawa groundwater sources and rainwater collection and storage and the draft South Tarawa Water Supply and Sanitation Roadmap 2011-2030, confirms a current deficit between available sources and current demand (partially attributable to a very high level of loss of treated water, estimated at 67%). The first priority identified in the Master Plan and endorsed in the Roadmap is to address leakage, and at least two forthcoming projects, the Kiribati Adaption Program phase III and the South Tarawa Sanitation Improvement Sector Project have components aimed at both infrastructural and institutional improvements to implement technical and managerial measures to reduce leakages. The roadmap confirms however, that supplementary sources are necessary to meet current demand and that the need for these sources will increase.

77 The Tarawa Water Master Plan examines alternative supplementary sources, including bulk importation by ship, constructed rainwater catchments, recycling, and the construction of a further island, as well as desalination. Bulk importation by ship is extremely expensive, and suitable for only emergency situations, while the construction of rainwater catchments is constrained by vulnerability to prolonged dry seasons, shortage of space, high costs, and difficulties with keeping the water free of contamination (improvements in collection and storage of rainwater were included under the SAPHE project, with mixed success). Scope for increased recycling of water is limited, as extensive recycling of second-class local groundwater through household wells to homes already occurs throughout Tarawa. The construction of a new island to serve as a supplementary groundwater source would be highly capital intensive, and would result in severe environmental impacts, chiefly from local mining of materials. The Tarawa Water Master Plan concluded that SWRO desalination was the most economic means of augmenting the South Tarawa water supply, provided it can be effectively maintained over a period of ten years or more. The roadmap examined desalination options in detail and found that containerized SWRO units are available that can be installed and started quickly, producing high quality water, and requiring only a small land area, substantially averting land acquisition difficulties. The units can be located in areas of highest demand with direct connection into existing water supply pipelines, and energy recovery systems are now available to reduce running costs. The ensuing feasibility study has examined technical issues (including network modeling to identify optimum locations), costs and viable options for effective operation and maintenance through maintenance contracts and training.

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[16] White, I (2011). Tarawa Water Master Plan 2010 – 2030. National Adaptation Steering Committee under Office Te Beretitenti / National Water and Sanitation Coordination Committee, Ministry of Public Works and Utilities / Kiribati Adaptation Programme Phase II Water Component 3.2.1, World Bank, AusAID, NZAID

B. Alternatives within the Subproject

78 Alternatives within the subproject relate to methods of desalination, feed water sources, size and capacity of desalination plant and power sources.

79 SWRO is based on the use of membranes with controlled pore sizes, separating water from the saline solution in liquid form (without the need to vaporize the water). Desalination can be achieved by distillation, and two principal methods are in use: multiple-effect distillation (MED), and multi-stage flash (MSF) distillation. The MED process features the use of steam in metal tubes to heat and vaporize feed water, through a series of stages (or “effects”) from which the freshwater condensate is progressively collected. The method is energy efficient compared to simpler distillation processes, simple to operate and reliable, and has long been a popular method of desalination to provide potable water in seagoing vessels. Modern MED systems involve spraying feed water at an optimal rate, and are more efficient and develop scale less rapidly than earlier systems. However, MED does not operate well in situations where power production and demand varies diurnally and requires skilled operation and high levels of maintenance. MSF is a more sophisticated process, well suited to large scale operations and is widely in use, particularly in the Middle East. The system uses vacuum chambers to cause vaporization at lower temperatures, is relatively efficient and the technique, which came into use in the 1960’s has been refined to reduce scale buildup and increase corrosion resistance and energy efficiency. However, as with MED, the technique also calls for high levels of technical input for operation and maintenance.

80 SWRO is essentially a filtration rather than a distillation method, and no phase change of the water is involved in the desalination process. The method is still energy intensive, requiring water to be pumped to a pressure higher than the osmotic pressure of seawater against a membrane. The pressure reverses the normal tendency for water to flow to a more concentrated solution, and instead flows across the membrane. SWRO currently has, as a result of rapidly improving technology, increased appeal over distillation based alternatives. Improvements in materials technology especially have brought down the cost of the membranes and improved their performance. Modern plant use sheet type polyamide membranes, rolled up onto long pressure vessels. The membranes, the most sensitive part of the system, can easily be replaced when overhauling or when repairs are necessary. In the Tarawa context, where few skilled technicians are available to the Public Utilities Board to carry out maintenance, this simplification of maintenance is almost a pre-requisite for feasibility of operation and maintenance, which the distillation based processes do not have.

81 Alternative sources of feed water are brackish, polluted groundwater with lower salinity and therefore reduced energy requirements for desalination, as well as lower biota concentrations in the water, and therefore reduced tendency to clog the membranes. However, the variable concentrations of solutes in the water would in fact lead to operational difficulties. Against the alternative drawing feed water straight from the sea, the use of deep vertical wells drilled to levels below the aquifer will ensure water that is naturally filtered and has more constant solute and impurity levels.

82 Achieving economies of scale by using larger SWRO modules is not possible in South Tarawa because shipping restrictions limit container size to 20ft.

83 Consideration was given in the feasibility study to the possibility of use of solar power. The use of solar power is attractive as a clean, free source of power, unaffected by periodical spikes in global oil prices. Solar power is already used for various forms of water purification, including desalination, although invariably on a smaller scale. Small, stand-alone units that produce volumes of up to 6 kilolitres of potable water per day from seawater sources are commercially available. Producing potable water by desalination on a municipal scale, however, involves several challenges relating to the extent of the field of capture of solar energy, difficulties in meeting demand at night and during cloudy weather, difficulties in storing energy and, where solar energy may be a partial source, practical difficulties in integrating more than one energy source. With consumption of around 360,000kWh a year for the RO modules alone and a total of 685,400kWh for the full plant including all pumps, equipment and miscellaneous power needs, each desalination plant would require a battery of PV cells some 4,200 m^2 in extent, which would be problematic on South Tarawa at present. To enable continuity of supply during the night and cloudy weather, a backup source of power would be necessary, and the integration of the two power sources would provide a high level of complexity. For these reasons, technology and practice for solar powered desalination on a municipal scale is in its infancy. One scheme, planned in South Australia, employs with several high technology features to overcome inherent constraints. These include the use of parabolic troughs to concentrate solar power and therefore allow a slightly smaller area on which to situate photovoltaic cells, a complex energy storage system, and the use of gas as a backup power source.

C. The “no project” alternative

84 In the absence of the proposed subproject, significant difficulty would be faced by the people of South Tarawa in the immediate term, until improvements to the existing water distribution system are made, under the forthcoming Kiribati Adaptation Program Phase III. Any delays in the implementation of this program will heighten this difficulty. Once losses are substantially reduced, the situation will be alleviated but reliance on desalination plant at hospitals, schools hotels and on availability of commercially operated plant will continue, but extreme difficulty will continue to be faced by numerous poor households who have limited ability to meet the costs of commercially available bottled water. The situation will become increasingly serious as demand increases. Increasing water shortages would result in the compounded effects both of exposure to disease and the inability to provide patients the opportunity to recover in safe and sanitary living conditions, leading to the danger of severe loss of life. Such a situation would inevitably prompt emergency action which would include the provision of desalination plant, but at a far greater cost, with limited impact and without the measures to ensure optimal placement of the plant, long term economic operation and effective maintenance.

VII. INFORMATION DISCLOSURE, CONSULTATION AND PARTICIPATION

85 The proposed components of the sector project, the expected environmental impacts, and environmental issues to be addressed has been disclosed to the wider public on South Tarawa during the course of project preparation. Information was provided to a range of focus groups, villagers at planned meetings and to local councils, and feedback sought at each stage. The main concerns and points of relevance raised by consultees were (i) existing supplies are inadequate for household needs, especially in larger households, (ii) many households are completely dependent on the water supply system and feel vulnerable to shortages as a result (others have a backup source such as a rainwater tank), (iii) there are also significant problems with the use of domestic rainwater tanks, (iv) around 19% of households use unsafe well water as a source of drinking water (vi) some households rely on boiling to render drinking water safe, even though this is very expensive (vii) there is significant support for the concept of metered water if it means the service is reliable. These findings strongly underline the need for increased supplies of safe drinking water.

86 Specific information on the process and siting of SWRO units was disclosed, along with a summary of potential impacts to a range of stakeholders including the main councils the TUC and BTC as well as MPWU, PUB, MELAD and personnel working with other projects in the sector. These consultations ensured a public voice in the identification of sites for SWRO plant. A detailed evaluation of site selection criteria is included in the feasibility study report. The sites are all located on government land, and are not adjacent to residential areas.

VIII. INSTITUTIONAL REQUIREMENTS FOR ENVIRONMENTAL MANAGEMENT

87 A detailed institutional analysis for environmental management of STSISP subprojects has been carried out and appropriate recommendations incorporated into project design. A summary of the findings of the analysis is presented here.

A. Implementation arrangements

88 The executing agency for the STSISP is the MFED. Within MFED, an existing Project Management Unit (PMU) has been established to oversee current infrastructure improvement projects and will assume management functions for the STSISP. Additional consultant support to the PMU will be provided in the form of a national project coordination officer, national project finance officer and international procurement specialist (the PMU consultants) to ensure that there is sufficient human resource capacity for effective and efficient project management. The implementing agency is the Ministry of Public Works and Utilities (MPWU), where a project implementation unit (PIU) will be established to oversee project implementation, again supported by a team of consultants (the PIU consultants) with responsibility for project management support, construction supervision, capacity building and technical support to the preparation of further subprojects. The agency responsible for reviewing environmental assessments and issuing licenses, and appropriate conditions on those licenses, is the Environment and Conservation Division within the Ministry of Environment, Lands and Agriculture Development (MELAD). On receipt of the environment license, the MPWU is responsible for compliance, acting through the Project Implementation Unit (PIU). For conditions relating to operation, the Public Utilities Board

(PUB) within the MPWU has primary responsibility, through its mandate to operate public infrastructure and to provide monitoring reports for MELAD review.

B. Existing capacities relating to subproject preparation

1. Review of environmental assessments and issue of environment licenses.

89 The Environment and Conservation Division within MELAD have a clear understanding of the requirements of the Environment Act which, in substance, meets the requirements of the ADB[17]. Capacity to review environmental assessments and issue decisions and appropriate conditions of license is however constrained by the number of suitably trained and experienced staff.

C. Capacities relating to environmental management during construction

90 MPWU staff have little experience or capacity in the implementation of EMPs. Support for EMP implementation, including inspection of ongoing and completed work to check for compliance with EMP provisions and preparation of progress reports to government and ADB, will be provided by the PIU consultants. In order to be able to undertake these functions, technical MPWU staff need to acquire an understanding of contractual arrangements for construction, and the provisions under each EMP.

D. Capacities relating to operation and maintenance of Infrastructure:

91 Adequate operation and maintenance of water and sanitation infrastructure has not taken place to the standard and extent necessary to keep sanitation infrastructure in operable condition. This has been a factor in previous failure of SWRO systems on South Tarawa. Under the new National Water Resource and Sanitation Policies approved by cabinet during 2009 and 2010, the PUB is to prepare asset management plans for water and sanitation on South Tarawa, and provision of adequate funding for sanitation is to be supported under the STSISP. The PUB does not, however, currently have the capacity to prepare or implement an asset management plan, which would cover the resources required for competent operation, regular and periodic maintenance and phased replacement and upgrading of assets. The institutional development needs of the PUB have been identified under the current Technical Assistance 7359-KIR, and actions for capacity development are being planned, under the South Tarawa Sanitation Improvement Sector Project.

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[17] A comparison of ADB requirements and those of the Environment Act is provided in Appendix 2 of the Environmental Assessment and Review Framework prepared for the STSISP.

IX. ENVIRONMENTAL MANAGEMENT PLAN

A. Mitigation

92 Table 3 below describes the mitigation measures required for design, construction and operation of the improved sewer systems and outfalls, as well as the cost and responsibility allocation arrangements. Overall responsibility for implementing the Environmental Management Plan rests with the MPWU, which during design and construction will be supported by the PIU consultants. The requirements will apply equally to the candidate subproject for the four desalination plants.

Table 3: Environmental Mitigation Plan

Potential Environmental Impact	Location	Mitigation measure(s)	Conditions under which mitigation measures are required	Cost Allocation	Responsibility for Implementation
Construction Stage					
Generation of construction waste	Work sites at sewage networks and near each outfall location	Arrangement for sale or distribution of excavated materials. Use of bins and skips at construction site for the collection of waste. Removal of non hazardous waste to landfill. Separate collection of fuel drums and any other containers that have held hazardous chemicals and removal from the island on demobilization. Sea dumping not allowed	Continuously, during construction	Construction Cost	Contractor

Potential Environmental Impact	**Location**	**Mitigation measure(s)**	**Conditions under which mitigation measures are required**	**Cost Allocation**	**Responsibility for Implementation**
Accidental damage to private property and to public utilities	All work sites	Ensuring that all works operations take place in the presence of a supervisor nominated by the Contractor, who shall be responsible for taking all reasonable precautions to prevent damage to property.	Continuously, during construction	Construction Cost	Contractor
Noise nuisance from construction activities.	All four sites	Plant and equipment brought to South Tarawa are to conform to international of noise emission and upkeep, such as (i) Part 204 of US Federal Regulations - Noise Emission Standards for Construction Equipment (40 CFR 204) or (ii) Directive 2000/14/EC of the European Parliament and of the Council of 8 May 2000 on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors	Continuously, during construction Prior to Contractor's Mobilization	Construction Cost	Contractor
Air quality	All four sites	Ensuring that all equipment brought to South Tarawa conforms to international emission standards.	Prior to Contractor's Mobilization	Construction Cost	Contractor
Pollution from chemicals and fuels	Work sites near each outfall location	Fuel will be obtained and handled at normal commercial facilities. Paints, lubricants, disinfection compounds and any other potentially hazardous substances shall be kept in a secure location.	Continuously, during construction	Construction Cost	Contractor
Safety hazards to workers and the public	Work sites near each outfall location	Requirement for the Contractor to ensure: (i) briefing of workers on safety precautions, for themselves and others and for implementing emergency procedures, (ii) provision of protective clothing and equipment to workers as appropriate, (iii) ensuring that vehicle and equipment operators are properly licensed and trained, (iv) arranging for provision of first aid facilities and emergency evacuation procedures (v) provision for regular safety checks of vehicles and plant, (vi) provision of hazard warning signs at the construction sites	Continuously, during construction	Construction Cost	Contractor

Potential Environmental Impact	Location	Mitigation measure(s)	Conditions under which mitigation measures are required	Cost Allocation	Responsibility for Implementation
Effects of materials extraction	Potential extraction sites (mainly, the lagoon)	Obtaining material from licensed sources, where material is extracted in a sustainable manner	Continuously, during construction	Construction Cost	Contractor
Operation					
Use of hazardous materials during operation	All four sites	Engagement of suitably capable technicians to undertake day to day management of the plant, training and provision of operational manuals and storage of potentially hazardous materials in controlled, secure, locations.	Continuously, during operation	Maintenance Cost	MPWU
Accidental plant failure	All four sites and the water transmission / distribution network	Choice of machinery and components manufactured to high tolerances, briefing and training of operators in proper routine maintenance and daily inspections	Continuously, during operation	Maintenance cost	MPWU
Noise	All four sites	All plant will conform to international noise abatement standards (as required for Construction plant).	Continuously, during operation	Maintenance cost	MPWU
Air quality impacts	All four sites	Use of exhaust baffles, regular routine maintenance	Continuously, during operation	Maintenance cost	MPWU

B. Environmental Monitoring

93 The impact of STSISP is improved health of South Tarawa's population, and the outcome is enhanced access of the island's population to improved sanitation infrastructure and services. The design and monitoring framework includes public health indicators, such as levels of infant mortality. The objective of monitoring in relation to SWRO subproject itself is to gauge the performance of the SWRO four plants in terms of sustained delivery of safe water into the distribution network, and to monitor the quality of the brine discharge to ensure that it does not carry any significant pollutants. Monitoring of brine water quality Monitoring is required during construction and installation to ensure compliance with the EMP and during operation, to ensure that the water being delivered through the SWRO plants is safe to drink.

94 The monitoring plan, Table 4, summarizes the required monitoring activities, parameters to monitor, responsibilities and costs of testing.

Table 4: Summary of Monitoring Activities and Responsibilities

Impact to be Monitored	Means of Monitoring	Construction and Installation			Operation		
		Frequency	Responsible Agency	Indicative Annual Cost (USD)	Frequency	Responsible Agency	Indicative Annual Cost (USD)
Water quality monitoring	Laboratory testing of output water into the distribution network	n/a	n/a	n/a	Four times a year	PUB	$16,640[18]
	Laboratory testing of the brine discharge	n/a	n/a	n/a	Twice a year	PUB	$8,320
Compliance with the provisions of the EMP during construction	Regular inspections of ongoing and completed work	Daily	MPWU / PIU Consultants	Included in cost for PIU consultants	N/A		

C. Implementation Arrangements

1. Implementation Schedule

95 Implementation is due to start in the third quarter of 2012 and supply and installation of the SWRO plants shortly after commencement of the sector project, also during the second quarter of 2012. Construction is expected to take sixteen months and therefore be completed in mid 2014.

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[18] The cost of one set of tests is USD1,040, covering reagents, incidental expenses and transport.

2. Institutional and Organizational Arrangements

96 As described in above, the executing agency is the MFED, which will provide project management overview and the implementing agency is the MPWU). The MPWU is the project owner, within the meaning of the Environment Act, 1999 (amended 2007). Under the STSISP, a project implementation unit (PIU) will be established within MPWU to oversee project implementation and will be supported by a team of consultants (the PIU consultants) with responsibility for project management support, construction supervision, capacity building and technical support to the preparation of further subprojects.

97 The Team Leader and Deputy Team Leaders of the PIU will manage the day to day activities, including safeguard activities.

98 An environment specialist and safeguards officer, recruited for STISP, will support MPWU in its application for an Environmental License for the subprojects and oversee monitoring. Monthly compliance reports will be prepared and submitted to the MELAD and will be incorporated into the quarterly progress reports, for which formats are provided in the EARF for the STISP. The contract for supply and installation of the plant will contain appropriately scaled remedies for non-compliance.

3. Specific Responsibilities

99 As project owner and implementing agency, the MPWU will have overall responsibility on the project's compliance with safeguard requirements. The MPWU therefore has overall responsibility for implementing the Environmental Management Plan. During design and construction the MPWU will be supported by the PIU consultants.

100 The firm undertaking supply and installation of the four plants will be responsible for the implementation of the EMP as it relates to the construction phase. During construction and installation, the contractor will disclose information to the public on the location, duration and of construction operations. Costs of monitoring compliance are met within the STSISP.

D. GREIVANCE REDRESS

101 Due to the location of plant away from residential areas, scope for grievances is limited. However members of the public will have rights to make grievances known to the MPWU and for them to be addressed promptly, to the extent practicable and reasonable, and for complaints to be made without retribution. A grievance redress mechanism has been established for STSISP, and will be in place should any grievances arise. The firm undertaking construction and installation must appoint a staff member as the person responsible for handling any grievances. This person will record any grievance and convey it to MPWU for action in accordance with the grievance redress mechanism.

X. FINDINGS AND RECOMMENDATIONS

102 Environmental screening and assessment has included site visits undertaken during the feasibility study, consultations with a range of project stakeholders, consultations with SWRO manufacturers, computer modeling of water flows and a review of documentation. With implementation of the mitigation measures identified, no significant negative environmental impacts are envisaged. The analysis of alternatives confirms that the use of SWRO is the only practicable means of augmenting existing freshwater supplies in the quantities required for the future population of South Tarawa. The Water Supply and Sanitation Roadmap demonstrates that provision of supplementary supplies of safe drinking water are essential and urgent.

103 The Environmental Management Plan (EMP) and monitoring plan cover key design considerations related to sound construction and long term effectiveness of the SWRO plants.

XI. CONCLUSION

104 The overall finding of the IEE is that the subproject will not cause significant environmental problems and that potential adverse impacts are manageable through the implementation of the EMP. No further environmental assessment is therefore required.

105 The subproject can therefore be classified under Category B: Projects judged to have some adverse environmental impacts, but of lesser degree or significance than those for Category A projects.

Appendix F

South Tarawa Desalination Economic Assessment

SOUTH TARAWA SANITATION IMPROVEMENT SECTOR PROJECT

SALT WATER REVERSE OSMOSIS SUBPROJECT

ECONOMIC ASSESSMENT

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SOUTH TARAWA SANITATION IMPROVEMENT SECTOR PROJECT

SALT WATER REVERSE OSMOSIS SUBPROJECT

ECONOMIC ASSESSMENT

I. INTRODUCTION

1. South Tarawa faces a severe water supply crisis. Due to mismanagement, exacerbated to some extent by land ownership and access issues, available groundwater supplies are becoming increasingly contaminated and their productive capacities are dwindling. The piped water supply system, on which the great majority of people and businesses depend[1], suffers high losses (67%), encroachment on and contamination of the principal fresh water resource (the Bonriki/Buota reserves), only a very small volume of metered consumption (all domestic and most business water customers face flat monthly rates and no incentive to use water efficiently), and high vulnerability to drought. The population of South Tarawa already exceeds 50,000 persons and is growing in excess of 3% per year.

2. The water supply in South Tarawa is the responsibility of the Public Utilities Board (PUB). The PUB must undertake urgent remedial tasks to reduce transmission and distribution losses to a maximum of 20% by 2020 and shore up the Bonriki/Buota reserves to restore its long term productive capacity, improve water treatment, and reduce contamination at source. These measures, however, will not in themselves ensure an adequate water supply for South Tarawa. As described in this feasibility study report, the fresh water supply must be augmented by a significant new source. The most feasible option for this is desalination of seawater through reverse osmosis (SWRO), for which the procurement and installation of 4 plants capable of producing approximately 709,600 kL of potable water annually is proposed. This section of the feasibility study presents an economic analysis of the proposed plants, evaluates costs and revenue needs to keep the plants operating in the long term, and considers tariff, affordability, and subsidy issues with accompanying recommendations to support a sustainable supply[2].

II. ECONOMIC ANALYSIS

A. Context

3. It is assumed that refurbishment of the network and rehabilitation of the Bonriki/Buota reserves and the water treatment plant at Bonriki will proceed over the three year period 2013-2015. In accordance with the approach outlined in this feasibility study, the South Tarawa water supply system is divided into two districts: (i) east – Antemai to Bonriki/Buota and (ii) west – Betio to Antemai (see map p 38 in the main feasibility study report). Each district contains approximately half of the network and half of the connected consumers[3].

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[1] Rainwater harvesting and additional groundwater resources exist, but these are small, contaminated, and unreliable due to frequent droughts.

[2] The context for the discussion of affordability, tariff, and subsidy issues is established by (i) the report "Political Economy Analysis of Water and Sewerage Services in South Tarawa and Implications for Tariff Reform" and (ii) the Fees and Charges – Sustainability section of the Tarawa Water and Sanitation Roadmap 2011-2030 prepared under this PPTA; and (iii) a Household Income and Expenditure Survey conducted by the Government of Kiribati in 2006.

[3] In 2012, there are approximately 7,200 household connections and 500 business connections.

The piped network in each district must be suspended while remedial work is carried out on the network in that district. It is assumed that piped water delivery in each district is sequentially suspended for a period of 18 months beginning with the west district, i.e., the west district will be suspended from the beginning of 2013 to mid-2014, followed by suspension of the eastern district from mid 2014 to the end of 2015. This allows time for (i) leak repair and loss reduction in the piped network in each district, (ii) refurbishment of all customer connections (and detection and elimination of illegal connections) and installation of volume meters for all connections, (iii) establishment of supply kiosks to service customers during the suspension period (discussed below), and (iv) installation or rehabilitation of water-source works (i.e., the SWRO plants in the west district and rehabilitation of Bonriki/Buota in the east district). At the end of the suspension period in each district, the piped network will be of high integrity with low losses, all connections will be metered, and sources of fresh water supply will be reliable.

4. A ‘With project’ scenario is compared directly to a ‘Without project’ scenario in order to make explicit the benefits of the project and its incremental costs over the project lifetime. To be conservative, the analysis is based on the assumption that the full potential of existing groundwater resources is exploited whether or not the SWRO plants are introduced[4], i.e., that the urgent network maintenance outlined above (loss reduction and rehabilitation of Bonriki/Buota) is undertaken by PUB under both the with project and without project scenarios. Therefore the network suspensions occur in each district as described above, in both scenarios.

5. It is assumed that this work is undertaken in the period 2012-2015, as summarised in Table 1 below. There is little doubt that these expenditures, totaling approximately A$5 million over four years, will need to be externally funded. However, for economic analysis purposes, they are not included in the total economic costs associated with the with project scenario.

Table 1: Estimated Costs and Schedule of Remedial Works

	2012	2013	2014	2015
Leak repairs	$260,000	$200,000	$200,000	$200,000
Demand management (bulk meters)	58,000			
Reservoir repairs		82,500		
Supply connections (incl consumer meters)			398,084	413,103
Reconnect Buota supply	37,000			
Supply protection (Bonriki/Buota)	80,000	60,000	60,000	
Bonriki improvements:				
Clearing of palms	272,000			
Infilling old borrow pits		2,500,000		
Gallery management	98,500			
Water treatment plant improvements	141,000			
Totals	$946,500	$2,842,500	$658,084	$613,103

B. Without Project Scenario

6. The current water supply system in South Tarawa is in such straits that Kiribati faces an existential choice: either address the looming water supply deficit or face the prospect of South Tarawa becoming progressively uninhabitable. For this analysis, a standard for South

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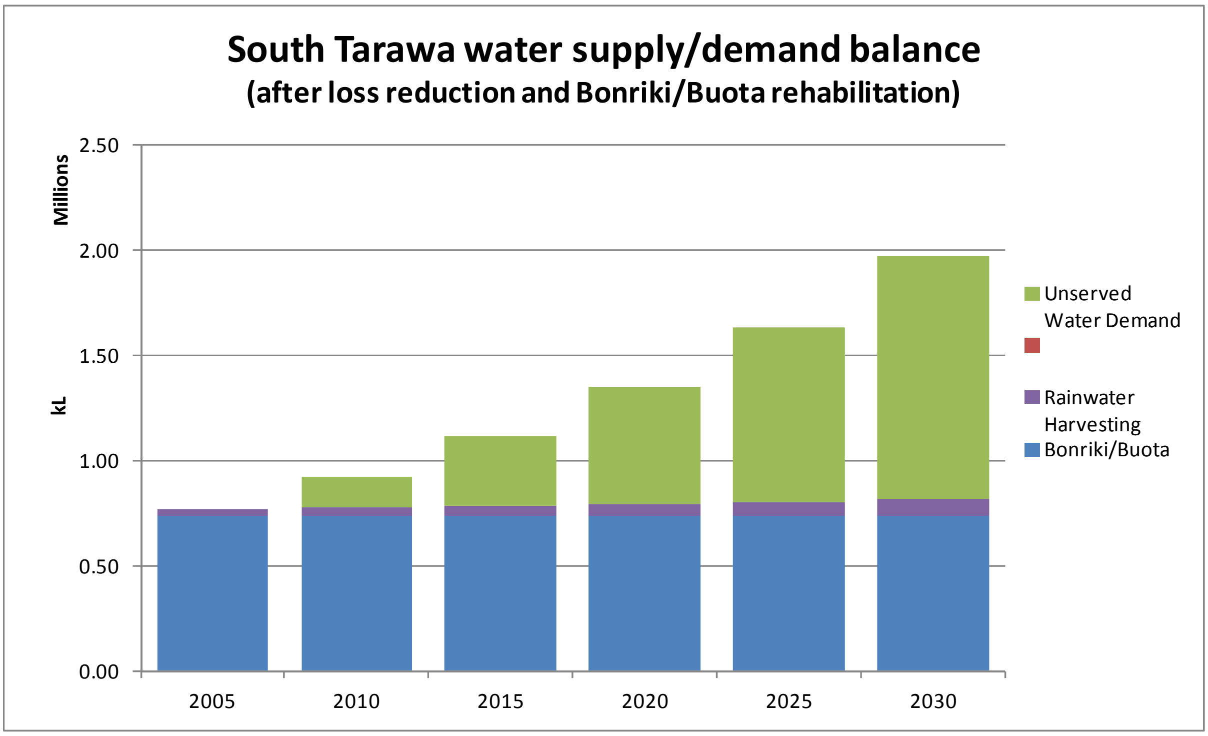
[4] It is emphasised that without this assumption, the ‘without project’ scenario becomes untenable, as approximately 2/3 of the water supply cannot be delivered to consumers. As tank trucks have limited capacity; a viable piped network is required for effective delivery of water to consumers for survival under either scenario.

Tarawa of 40 l/c/d for domestic consumption[5] has been adopted to define a “needs based” water demand subject to expected population growth. Under this definition of minimal water needs, the prospect for South Tarawa without the project (but with the network and Bonriki/Buota maintenance completed as described above) is illustrated in Figures 1 and 2 below, showing a progressive increase in “unserved water demand” and a declining ability of the system to deliver water to consumers, expressed in litres per capita per day.

Figure 1: Water Supply Supply/Demand Balance



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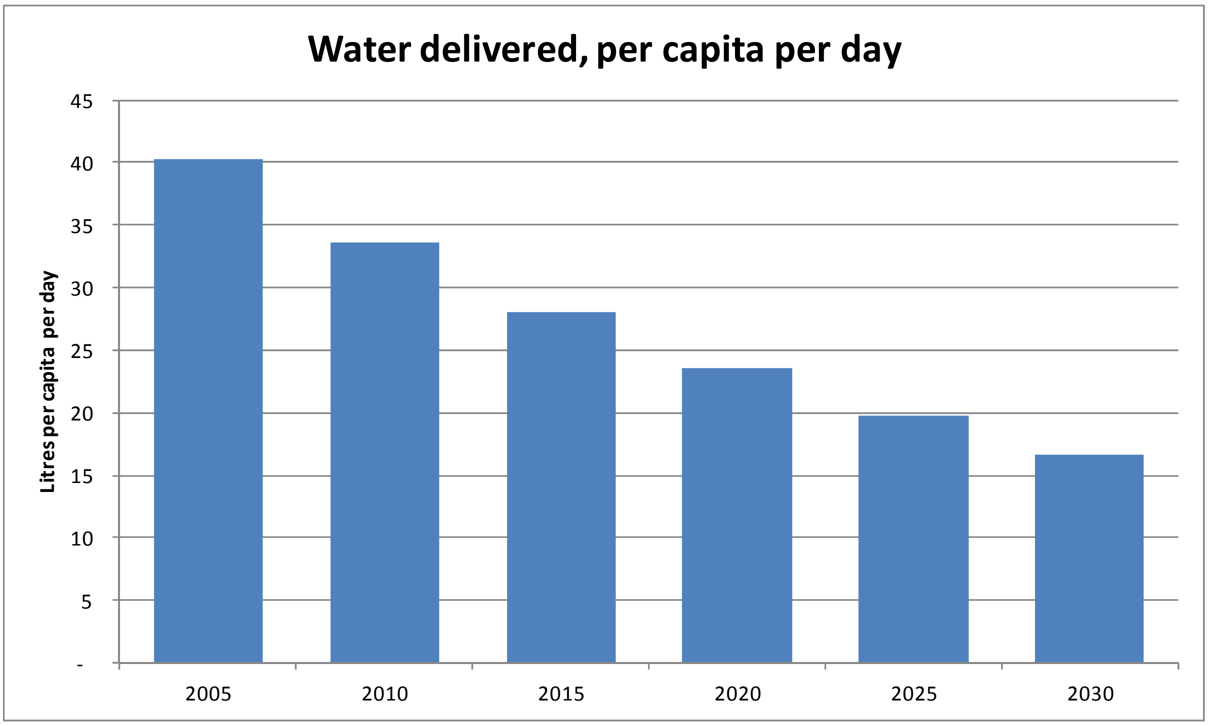
[5] The Water and Sanitation Roadmap 2011-2030 contains an estimate of 50 l/c/d of overall water demand, based on consumption by commercial and government users that is higher than the average per capita, which leaves a consumption estimate for the domestic sector of slightly greater than 40 l/c/d.

Figure 2: Water Delivered per Capita per Day



7. The increasing incapacity of the current water supply system to provide for the minimal water needs of the population of South Tarawa will have number of possible consequences. The without project scenario outlined below is an attempt to select the most likely (and least cost) of these and thus present a conservative analysis. Because the existential issue for South Tarawa is so stark, plausible consequences of the without project scenario include a steady deterioration of the quality of life, mounting disease, rapidly increasing rates of death of the most vulnerable (the old and the young), and forced migration. However, as a practical matter, it is prudent to expect a series of ad hoc emergency responses to water shortages, mounted as needed by the government with assistance from outside agencies (e.g., bilateral aid donors). It is assumed that the emergency response would be to bring in water from overseas to alleviate immediate shortages, as has been done in response to past droughts in other Pacific island countries (in recent years in FSM, Palau, Tuvalu, and Tokelau). In a typical instance, temporary arrangements are set up onshore to handle storage and distribution needs which, once the short term crisis has passed, are dismantled. In the without project scenario in South Tarawa, the extent of water shortages through time can be predicted, leading to (in the myopic nature of short term emergency responses) an increasingly-frequent series of repetitive costs. To facilitate analysis (and to be conservative in characterising the costs associated with the without project scenario), the PPTA consultants have estimated the costs of setting up a permanently available bulk water supply import mechanism for South Tarawa to offset anticipated water shortages over the next 30 years. Such costs will not exceed, and are very likely to be less than, the sum of costs of mounting an actual series of ad hoc emergency responses. The avoided costs of the without project scenario, based on the estimated bulk-import costs and briefly summarized in Table 2 below, are the basis for quantifying the benefits of the with project scenario. (In the without project scenario, the volume of the water imported each year is equivalent to the expected production of the SWRO plants.)

Table 2: Estimated Monthly Costs of Shipping and Distribution of Bulk Water Supplies

Item	Unit	Rate	Quantity	Amount	Rationale and Comment
Purchase of water - say Fiji	kL	$1.50	59,000	$89,000	
Shipping of Bulk Supplies	per load	$350,000	1	$350,000	Volume to meet water deficit
Port handling & clearance costs	per load	$15,000	1	$15,000	Based on cost of pumping to tanks at 2% of freight costs
Drivers for tankers	Per month	$600	10	$6,000	Based on $9,000 annual salary/wages per driver, taxes removed, 10 tankers
Vehicle maintenance	unit	$250	10	$2,500	Estimated at 5% of capital cost annually
Monthly fuel cost for tankers	litres	$1.20	3,000	$3,600	Based on average mileage of 100 km a day (5 loads and 10 litres per 100 km
Tanker leasing costs for 'floating storage'	Per month	$450,000	1	$450,000	Based on leasing costs of 1 tanker of 60,000 kL (tonne) capacity, at $15,000/day
Subtotal, Monthly				$916,100	

Consultant estimates.

8. Shipping and tank truck costs are subject to expected real increases in the price of fuel, in the 'basecase' assumed to be 1.9% per annum.

9. A 'permanent' bulk-import scenario for South Tarawa is constrained mainly by the lack of available land for water storage of sufficient capacity to allow tankers of suitable capacity (most economical for shipping) to unload on arrival. As an alternative to onshore storage, therefore, the without project scenario assumes that tankers would be leased and retained in port as 'floating storage' until their cargoes could be offloaded and distributed. (It is noted that approaches made to one of the main shipping companies serving South Tarawa, Reef Shipping, have returned cost estimates for shipping and floating storage that greatly exceed the estimates used in this analysis, because the company's vessels can only carry relatively small water cargoes. This may well be the case in any real emergency response that may be needed in South Tarawa in the future, indicating that actual without project scenario costs are likely to be substantially higher than those estimated.)

C. With Project Scenario

10. The SWRO project operating period is 30 years following full commissioning of the desalination investments in 2013. All benefits and costs are expressed in constant 2012 prices on an incremental basis. The domestic price level is adopted for tradable inputs, from which applicable taxes and duties have been removed[6]. A shadow wage rate for labour of 90 percent of the market wage rate has been applied to the unskilled labour component of the operations and maintenance costs. Kiribati uses the Australian dollar (A$) as its domestic currency, and Australia is the country's main trading partner. A shadow exchange rate factor of 1.0 (indicating no adjustment to the official domestic currency exchange rate with respect to the US dollar or other foreign currencies) is adopted for the analysis.

11. Project economic costs include (i) the initial costs of the SWRO works and equipment, including piping, electrical and other ancillary equipment, costs for which are

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[6] Import duty on SWRO and ancillary equipment is zero. Labour income is taxed at 20%. Fuel taxes in Kiribati are zero.

incurred from late 2012 to mid 2014; (ii) annual and periodic O&M expenditures on the SWRO system through its useful life; and (iii) consulting services for project supervision. The project physical contingency (12%) is included in the total economic costs. Initial investment costs (financial basis) of the four plants, disbursed mainly in 2013[7], are summarised in Table 3.

Table 3: Estimated Financial Investment Costs of the Proposed SWRO Plants

DESCRIPTION	ESTIMATED COST				TOTAL
	BET1	BET2	BAI1	BAI2	
Preliminary and General	43,875	43,875	43,875	43,875	175,500
Desalination Plant	1,362,290	1,362,290	1,362,290	1,370,690	5,457,560
Civil and Ancillary	90,680	82,780	87,000	97,200	357,660
Generators	52,500	52,500	52,500	52,500	210,000
Intake Boreholes and Pumps	176,625	176,625	176,625	176,625	706,500
Pipes and Fittings	93,940	24,340	21,940	18,595	158,815
Storage Tanks and Pumps	248,400	248,400	248,400	248,400	993,600
Electrical	46,679	64,007	63,606	63,606	237,898
Subtotal	**2,114,989**	**2,054,817**	**2,056,236**	**2,071,491**	**8,297,533**
Contingencies 12%	253,799	246,578	246,748	248,579	995,704
Engineering, design and supervision 3%	63,450	61,645	61,687	62,145	248,926
Total Estimate A$	**2,432,237**	**2,363,040**	**2,364,671**	**2,382,215**	**9,542,163**

12. In addition to SWRO plant investment, the with project scenario includes investment in 27 ‘kiosks’ to provide for the delivery of water services during the 3-year period when portions of the piped network are suspended, as discussed above. The kiosks are intended as the water lifeline in South Tarawa while the system is being upgraded, and will also play a role in demonstrating to the public that the system upgrading is indeed resulting in an appreciable increase in water quality (reliable supply of potable water at affordable cost), thus ‘priming’ the public to be willing to pay cost-recovery tariffs (subject to subsidisation as discussed in the next section) once the upgrading is completed and the network is re-pressurised. At that time, all connected customers will have volumetric meters. The kiosks will operate as collection points for households and businesses to obtain water with their own transport, but will also operate a tank-truck delivery service, for which customers will be charged full cartage costs. The kiosks will, to the extent feasible (yet to be determined), offer showers and toilets, the latter using a salt-water flush system where these systems exist, further supporting the delivery of high quality water sector services while also helping to reduce urgent sanitation problems. For present purposes, it is assumed that all 27 kiosks are equipped with shower blocks, and of these, 10 are also equipped with toilet blocks.

13. Financial operating costs of the SWRO plants are extracted from the Operating Cost Appendix to the feasibility study report, and have been adjusted to economic value by removing taxes and applying a shadow wage rate for local labour, as discussed above. Routine operating costs include electricity valued at $0.70/kWh, labour costs for operators, replenishment of chemicals, filters, and membranes (inclusive of shipping costs for these), a services contract for SWRO maintenance of estimated $200,000 per year, an inventory of spares, and a contingency allowance (10%). Kiosk operating costs (including tank truck operations) as discussed above are included in the with project routine operating costs.

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[7] Estimated expenditure in 2012: 25%.

14. The largest single item in operating costs is the electricity requirement, estimated at 2,742 MWh per year, implying an expense of $1.92 million per year at the current price of $0.70/kWh. (In subsequent years, electricity costs are assumed to increase at the rate of 1.9% per annum in real terms.)

15. In addition to routine operating costs, it is estimated that certain pumps, valves, filters, and the calcite bed in each plant will need to be replaced every 15 years at a cost of $2 million per replacement, and the chlorination unit in each plant will need to be replaced every 10 years, at a cost of $60 thousand per replacement.

D. EIRR and ENPV

16. Given the very high, but nevertheless conservatively estimated, costs of the without project scenario (and hence the avoided costs ascribed as benefits in the with project scenario), it is to be expected that the EIRR of the project will be correspondingly high. The EIRR is calculated under the above assumptions at 70.0%, with an economic NPV of $46.1 million. The calculation table (Table 5) is shown overleaf.

E. Sensitivity Analysis

17. Sensitivity analysis has been carried out on reasonable (20%) adverse changes in (i) SWRO capital costs (including the kiosk and tank truck components); (ii) O&M and asset replacement costs; (iii) the fuel price escalation rate, and (iv) avoided costs (equivalent to a decrease in benefits).

18. Given the high economic returns to the project, it is not surprising that none of these parameters is notably sensitive in terms of affecting the viability of the project. The EIRR remains above 50% for each of the variations individually, and above 38% when all variations are invoked simultaneously. The most 'sensitive' parameter is the aggregate avoided costs, showing a sensitivity indicator (SI) of 1.7. The SIs of all other parameters are less than unity. The sensitivity analysis results are summarised in Table 4 below.

Table 4: Sensitivity Analysis

Test Case	Test Variation (+/- %)	ENPV	EIRR	SI	Basecase Parameter	SV	SV (+/-%)
Base (reference case)		46,146,487	70.0%				
Increases in Costs							
Capital Cost	20%	44,184,604	57.1%	0.21	9,542,163	54,431,402	470.4%
O&M and Asset Replacement Costs	20%	41,082,316	63.2%	0.55	2,319,248	6,546,006	182.2%
Decrease in Benefits							
Fuel Price Escalation Rate	-20%	45,502,897	69.8%	0.07	1.9%	N/A	No SV
Decrease in Avoided Costs	-20%	29,891,135	48.3%	1.76	7,300,132	3,155,338	-56.8%
Initial Costs Increased (+) and Benefits Decreased (-)	20%	22,562,876	34.9%				

EIRR=economic internal rate of return, ENPV=economic net present value, SI= Sensitivity Indicator, SV=Switching Value

Table 5: Calculation Table EIRR and ENPV

	With-Project Scenario									Without-Project Scenario (avoided costs)							
	Initial Costs			Asset Replacements		O&M Costs				Initial Costs		O&M Costs					
Year	RO Plants	Kiosks	Tanker Trucks	Pumps, valves, etc	Chlor units	RO Plants	Kiosks	Tanker Trucks	Total With-Project Costs	Tanker Trucks	Metering Points	Bulk Water Purchase	Shipping & Port Charges	Storage Charges	Tanker Trucks	Total Avoided Costs	Net Benefits
2012	2,385,541	-	163,500	-	-	-	-	-	2,549,041	-	-	-	-	-	-	-	(2,549,041)
2013	7,156,622	975,000	-	-	-	1,211,597	388,800	71,225	9,803,244	735,000	317,000	456,169	1,979,911	2,314,171	145,200	5,947,451	(3,855,793)
2014	-	-	-	-	-	1,858,813	388,800	71,635	2,319,248	-	-	690,935	2,958,026	3,505,150	146,021	7,300,132	4,980,884
2015	-	-	-	-	-	2,091,511	388,800	72,054	2,552,365	-	-	767,472	3,324,384	3,893,424	146,857	8,132,137	5,579,772
2016	-	-	-	-	-	2,235,835	388,800	-	2,624,635	-	-	809,859	3,561,090	4,108,456	147,709	8,627,114	6,002,479
2017	-	-	-	-	-	2,471,977	388,800	-	2,860,777	-	-	883,789	3,939,846	4,483,506	148,578	9,455,719	6,594,942
2018	-	-	-	-	-	2,722,246	388,800	-	3,111,046	-	-	960,580	4,344,177	4,873,071	149,463	10,327,291	7,216,244
2019	-	-	-	-	-	2,987,451	388,800	-	3,376,251	-	-	1,040,343	4,775,643	5,277,712	150,365	11,244,062	7,867,811
2020	-	-	-	-	-	3,097,501	388,800	-	3,486,301	-	-	1,064,448	4,971,468	5,400,000	151,284	11,587,200	8,100,899
2021	-	-	-	-	-	3,139,105	388,800	-	3,527,905	-	-	1,064,448	5,062,506	5,400,000	152,220	11,679,174	8,151,269
2022	-	-	-	-	-	3,181,500	388,800	-	3,570,300	-	-	1,064,448	5,155,273	5,400,000	153,174	11,772,896	8,202,596
2023	-	-	-	-	60,000	3,224,700	388,800	-	3,673,500	-	-	1,064,448	5,249,804	5,400,000	154,147	11,868,398	8,194,898
2024	-	-	-	-	-	3,268,721	388,800	-	3,657,521	-	-	1,064,448	5,346,130	5,400,000	155,137	11,965,715	8,308,194
2025	-	-	-	-	-	3,313,579	388,800	-	3,702,379	-	-	1,064,448	5,444,286	5,400,000	156,147	12,064,881	8,362,502
2026	-	-	-	-	-	3,359,289	388,800	-	3,748,089	-	-	1,064,448	5,544,308	5,400,000	157,176	12,165,931	8,417,843
2027	-	-	-	-	-	3,405,867	388,800	-	3,794,667	-	-	1,064,448	5,646,230	5,400,000	158,224	12,268,902	8,474,235
2028	-	-	-	2,000,000	-	3,453,330	388,800	-	5,842,130	-	-	1,064,448	5,750,088	5,400,000	159,292	12,373,828	6,531,698
2029	-	-	-	-	-	3,501,695	388,800	-	3,890,495	-	-	1,064,448	5,855,920	5,400,000	160,381	12,480,748	8,590,253
2030	-	-	-	-	-	3,550,979	388,800	-	3,939,779	-	-	1,064,448	5,963,762	5,400,000	161,490	12,589,700	8,649,921
2031	-	-	-	-	-	3,601,200	388,800	-	3,990,000	-	-	1,064,448	6,073,654	5,400,000	162,620	12,700,722	8,710,722
2032	-	-	-	-	-	3,652,374	388,800	-	4,041,174	-	-	1,064,448	6,185,633	5,400,000	163,772	12,813,853	8,772,679
2033	-	-	-	-	60,000	3,704,521	388,800	-	4,153,321	-	-	1,064,448	6,299,740	5,400,000	164,946	12,929,134	8,775,813
2034	-	-	-	-	-	3,757,659	388,800	-	4,146,459	-	-	1,064,448	6,416,015	5,400,000	166,142	13,046,605	8,900,146
2035	-	-	-	-	-	3,811,806	388,800	-	4,200,606	-	-	1,064,448	6,534,499	5,400,000	167,361	13,166,308	8,965,702
2036	-	-	-	-	-	3,866,982	388,800	-	4,255,782	-	-	1,064,448	6,655,235	5,400,000	168,602	13,288,285	9,032,503
2037	-	-	-	-	-	3,923,207	388,800	-	4,312,007	-	-	1,064,448	6,778,264	5,400,000	169,868	13,412,580	9,100,573
2038	-	-	-	-	-	3,980,500	388,800	-	4,369,300	-	-	1,064,448	6,903,631	5,400,000	171,157	13,539,237	9,169,937
2039	-	-	-	-	-	4,038,881	388,800	-	4,427,681	-	-	1,064,448	7,031,380	5,400,000	172,471	13,668,300	9,240,619
2040	-	-	-	-	-	4,098,371	388,800	-	4,487,171	-	-	1,064,448	7,161,557	5,400,000	173,810	13,799,815	9,312,643
2041	-	-	-	-	-	4,158,992	388,800	-	4,547,792	-	-	1,064,448	7,294,206	5,400,000	175,175	13,933,829	9,386,037
2042	-	-	-	-	-	4,220,765	388,800	-	4,609,565	-	-	1,064,448	7,429,376	5,400,000	176,565	14,070,389	9,460,824
2043	-	-	-	2,000,000	60,000	4,283,711	388,800	-	6,732,511	-	-	1,064,448	7,567,114	5,400,000	177,982	14,209,544	7,477,033
ENPVs	8,775,382	870,536	163,500	385,847	24,590	21,594,990	3,143,442	171,987	35,130,275	656,250	283,036	7,225,963	35,224,282	36,657,685	1,229,546	81,276,762	46,146,487
EIRR																	70.0%

III. WATER SUPPLY EXPENSES, TARIFFS, AND SUBSIDIES

A. Background to the Calculations

19. The issue of water tariffs, affordability, and subsidies needs to be framed concisely for discussion and negotiation, the outcome of which is vital for the future habitability of South Tarawa and the future of Kiribati. The following represents an initial input to the discussion stage.

20. The following assumptions provide an essential structure to frame the discussion.

- Flat rates for all consumers are phased out in 2016, when metered piped connections become universal
- The water system is refurbished over the period 2013-2015 inclusive, when the network is repaired, meters installed for all customers wanting a connection, the SWRO plants are installed, and the Bonriki/Buota reserves are optimised
- The 'lifeline' tariff block for households is 5.0 kL/household/month, equivalent to 22 litres/capita/day for an average family of 7.5 members
- When piped supply meets 100% of a household's needs, rainwater harvesting by that household is zero. The analysis assumes that rainwater is not a significant source of water to consumers; the rainwater quantity is estimated assuming prolonged droughts.
- All business/social/government consumption is charged full cost recovery rate (+ cartage costs, as applicable) Household consumption exceeding 5.0 kL per month is charged a higher rate than the lifeline block (albeit still below cost).
- Poor households constitute 20% of all households[8]
- Business/social demand for water constitutes 10% of total demand[9]
- The long term population growth rate is 3.87%/year[10]
- Tank Truck (for water delivery) assumptions

– Number of PUB tank trucks	5
– Capacity per truck (litres)	5,000
– Average speed (delivering water, full load), kph	40
– Max driving time per day (hrs)	4
– Distance travelled per truck per day (km)	160
– Max no of loads per day per truck	10
– Fuel efficiency per truck (litres per 100 km)	10
– Max deliveries per day (by all trucks, kL)	250
– Driver's wages ($/year, economic cost)	$7,200
– Number of drivers (including relief)	10
– Days per year worked	360
– Number of days worked per year per driver	183
– Price of petrol, 2012 ($/litre)	$1.20
– Real rate of fuel price increase per annum	1.9%

21. It is assumed that, during the 3-year period of network suspension, poor households obtain their water supply chiefly from kiosks using their own transport (own vehicle, public

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[8] Reference – see footnote 2.

[9] Tarawa Water Master Plan, KAP II, Ian White, ANU, December 2010.

[10] Based on the demographic and land use component of TA 7359-(KIR), Fraser Thomas Partners 2011.

transport, or on foot). Better-off households and businesses also obtain water from the kiosks during this period, but use their own transport or purchase PUB's cartage service. To use the kiosk service, each household (and only households) will be entitled to purchase a ticket from PUB at distributed vending points for $10, which will entitle the household to take up to a total of 5,000 litres of water in the household's own containers from any kiosk. Only one ticket per household will be issued at any one time, and water taken on a single ticket will be recorded by some means (perhaps a hole punch) on the ticket. Alternative methods of obtaining water at a kiosk will be (i) to have a measured amount of water dispensed to a container in exchange for payment of a per-litre charge, with transport arranged independently by the customer, or (ii) the customer may hire PUB to deliver a requested amount of water, in which case the customer will pay the per-litre charge at the kiosk plus a cartage charge. Businesses and government consumers will not be eligible to buy the household $10 tickets, but will be required to purchase water from kiosks by one of the two alternative methods.

22. When the suspension period is fully lifted beginning in 2016, all consumers will be connected with meters to the upgraded network and it is assumed that the kiosks will be phased out, since water transport by road is a high cost which all consumers will wish to avoid. In particular, all households will be connected to the network, but will pay a lower 'lifeline' rate for consumption up to 5,000 litres/month (thus covering the needs of poor households), and will pay a full cost recovery rate for consumption exceeding that amount. Businesses and government consumers will pay a full cost recovery tariff for all consumption.

23. The suspension period, when the kiosks are in operation, will see consumption constrained below what it would normally be (i.e., there will be unserved water demand), because of limited capacity to transport water to consumers by road. Full water demand will be met by the upgraded piped network (supplied by fully operational SWRO plants and the refurbished Bonriki/Buota reserves) during the period 2016-2019. From 2020 onwards, demand will begin to exceed supply, highlighting the need for possible additional SWRO capacity at that time[11]. Expected changes over the period 2012-2021 are illustrated in Figure 3 and Tables 6 and 7 below.

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[11] Additional desalination capacity for 2020 and beyond is provided for in the financial forecasts incorporated in the Tarawa Water and Sanitation Roadmap 2011-2030, Fraser Thomas Partners TA7359-(KIR), 2011.

Figure 3: Water Delivered by Various Modes - With the Project

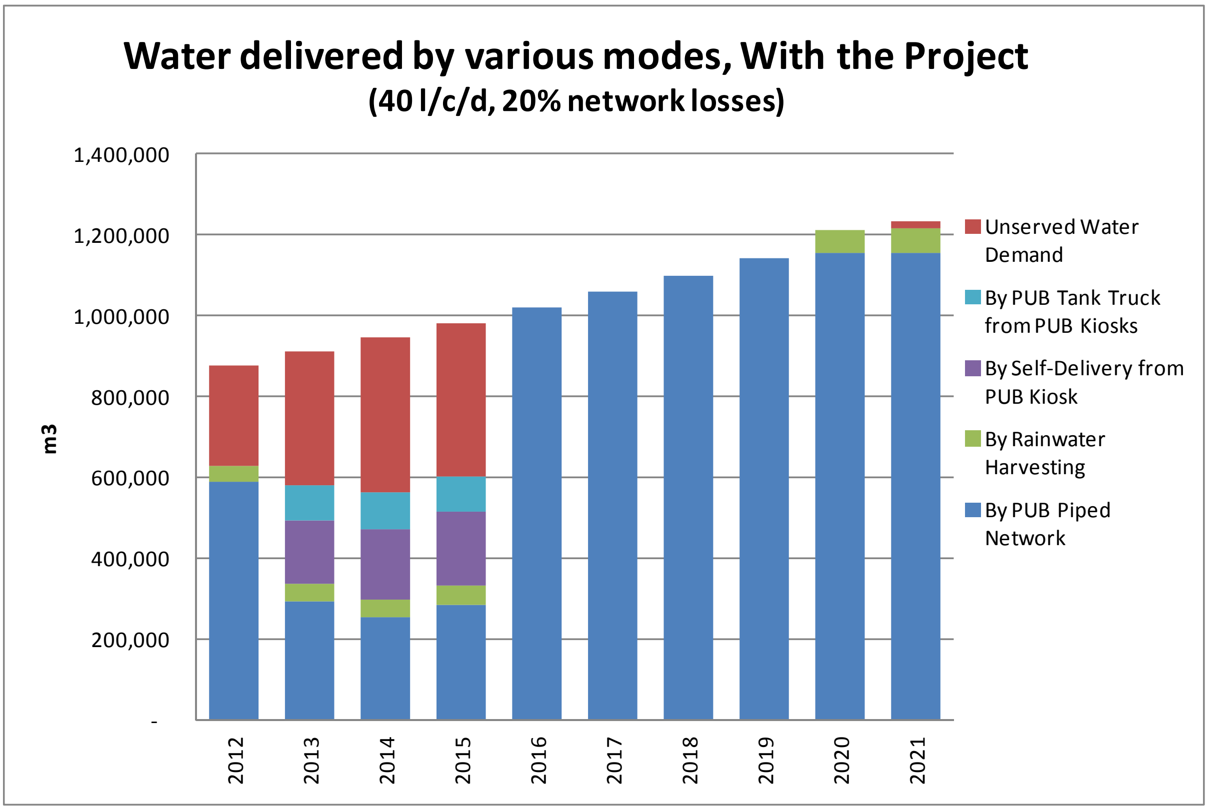


Table 6: Projected Water Demand and Supply 2012-2021

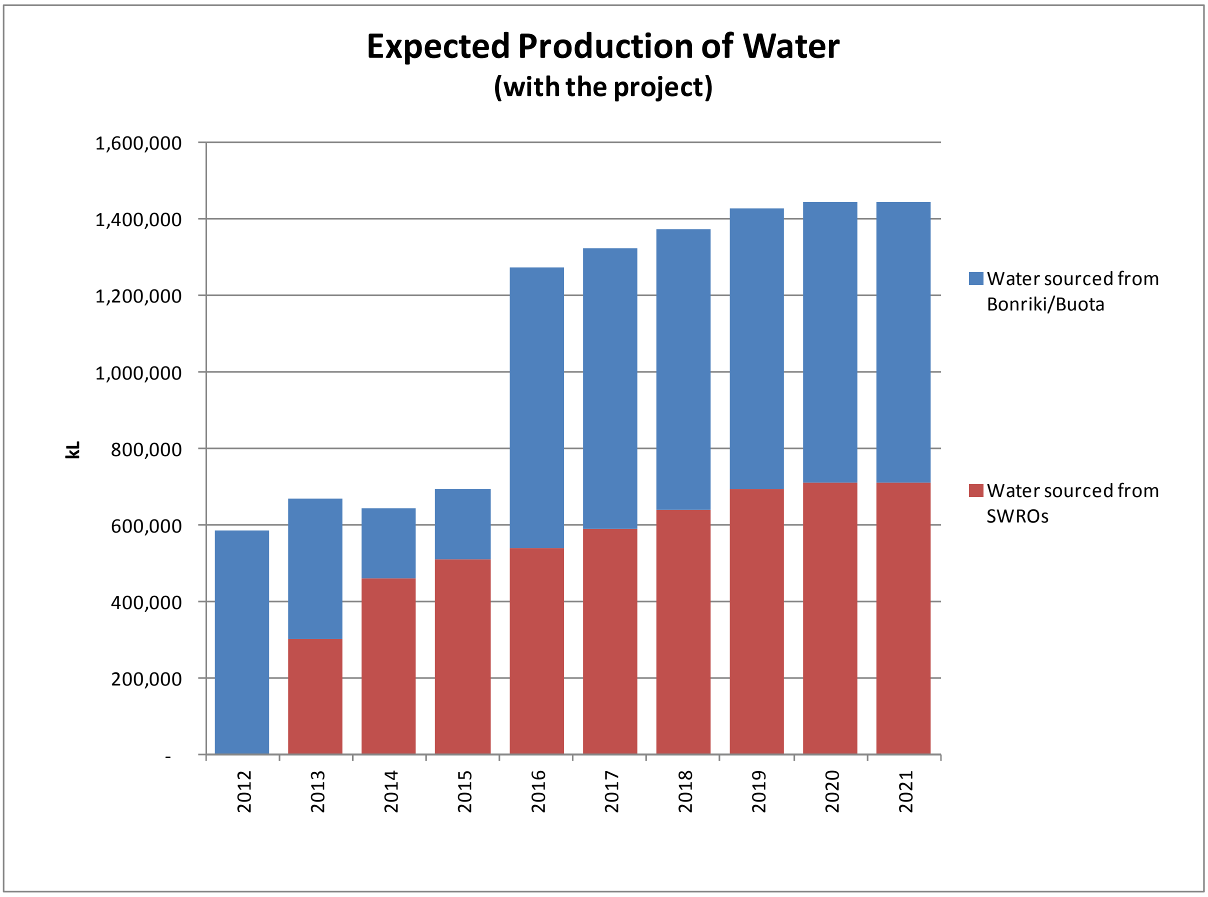
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Water Demand, Unconstrained by Water System or Transport Capacity (kL)										
Population served	53,956	56,044	58,213	60,465	62,805	65,236	67,761	70,383	73,107	75,936
Number of Households	7,194	7,473	7,762	8,062	8,374	8,698	9,035	9,384	9,748	10,125
Domestic demand (kL)	787,753	818,239	849,905	882,796	916,960	952,447	989,306	1,027,592	1,067,360	1,108,667
Number of business/social connections	495	495	500	500	500	500	500	500	500	500
Commercial/social demand (kL)	87,528	90,915	94,434	98,088	101,884	105,827	109,923	114,177	118,596	123,185
Total unconstrained demand (kL)	**875,281**	**909,154**	**944,339**	**980,884**	**1,018,845**	**1,058,274**	**1,099,229**	**1,141,769**	**1,185,956**	**1,231,852**
Water Consumption (partly constrained), PUB sourced (kL)										
Non-domestic consumers	58,692	56,621	53,648	57,812	101,884	105,827	109,923	114,177	118,596	123,185
Domestic consumers										
Poor households (consume up to 5.0 kL/mo)	86,329	45,003	46,745	48,554	100,489	104,378	108,417	112,613	116,971	121,498
Non-poor households (consume >5.0 kL/mo)	441,899	435,127	414,836	449,683	816,471	848,069	880,889	914,980	919,059	909,943
Total water consumption from PUB sources (kL)	**586,920**	**536,750**	**515,229**	**556,048**	**1,018,845**	**1,058,274**	**1,099,229**	**1,141,769**	**1,154,626**	**1,154,626**
Total water required from PUB sources including 20% losses (kL)	**733,650**	**670,938**	**644,036**	**695,060**	**1,273,556**	**1,322,842**	**1,374,036**	**1,427,212**	**1,443,282**	**1,443,282**
Water sourced from Bonriki/Buota	586,920	366,825	183,413	183,413	733,650	733,650	733,650	733,650	733,650	733,650
Water sourced from SWROs		304,113	460,623	511,648	539,906	589,192	640,386	693,562	709,632	709,632

Table 7: Water Delivered by Mode

Water Delivered, all sources (kL)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
By PUB Piped Network	586,920	293,460	253,175	283,853	1,018,845	1,058,274	1,099,229	1,141,769	1,154,626	1,154,626
By Rainwater Harvesting	42,705	44,410	46,115	47,820	-	-	-	-	57,852	59,858
By Self-Delivery from PUB Kiosk										
Poor Households (small personal containers)	-	45,003	46,745	48,554	-	-	-	-	-	-
Non Poor Households (private tank trucks)	-	90,013	105,979	113,215	-	-	-	-	-	-
Businesses (private tank trucks)	-	18,275	19,330	20,427	-	-	-	-	-	-
Total Self-Delivered	-	153,290	172,054	182,195	-	-	-	-	-	-
By PUB Tank Truck from PUB Kiosks										
Non Poor Households	-	81,000	81,000	81,000	-	-	-	-	-	-
Businesses	-	9,000	9,000	9,000	-	-	-	-	-	-
Maximum Total Delivered by PUB Tank Truck	-	90,000	90,000	90,000	-	-	-	-	-	-
Total Water Delivered, all sources	629,625	581,160	561,343	603,868	1,018,845	1,058,274	1,099,229	1,141,769	1,212,477	1,214,484
Total Water Delivered, PUB sources	586,920	536,750	515,229	556,048	1,018,845	1,058,274	1,099,229	1,141,769	1,154,626	1,154,626
Unserved Water Demand	245,656	327,994	382,995	377,017	-	-	-	-	-	17,369
Domestic water delivered per capita per day, all sources	28.77	25.57	23.78	24.63	40.00	40.00	40.00	40.00	40.89	39.44

24. The projected supply of water through the piped network, by source (either from the Bonriki/Buota reserves or from the SWRO plants) is illustrated in the Figure 4 below.

Figure 4: Expected Production of Water



B. Water Supply Expenses

25. Under the above assumptions, and based on current estimates of PUB's costs[12], the following cost estimates (Table 8 overleaf) have been developed for the period 2012-2021, covering PUB water sector activities in the east district, in the west district, and in operation of the proposed kiosks during 2013-2015.

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[12] Draft Asset Management Plan, PUB Water Sector Activities, prepared under TA 7359-KIR, 2011

Table 8: Projected Costs of Water Supply Activities, With the Project, 2012-2021

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Water Supply Expenses										
Bonfiki/Buota ("east") district operations										
Administration and Overheads	82,565	85,042	87,593	90,221	92,927	95,715	98,587	101,544	104,591	106,956
Groundwater production, transmission and distribution	371,127	382,051	393,303	404,892	416,829	429,123	441,787	454,831	468,266	478,698
Maintenance and leak detection - labour	198,693	204,653	210,793	217,117	223,630	230,339	237,249	244,367	251,698	257,390
Maintenance and leak detection - materials	105,463	108,627	131,886	135,842	163,250	168,148	173,192	178,389	183,740	202,947
Vehicles - fuel & maintenance	22,760	23,443	24,147	24,871	25,617	26,385	27,177	27,992	28,832	29,484
Staff costs	58,206	59,952	68,417	70,470	72,584	74,761	77,005	79,315	81,694	85,837
Depreciation					33,350	33,350	33,350	33,350	33,350	33,350
Total Bonriki/Buota operations	838,814	863,769	916,138	943,412	1,028,187	1,057,822	1,088,347	1,119,787	1,152,170	1,194,661
Desalination ("west") district operations										
Administration and Overheads	41,282	42,521	43,796	45,110	46,464	47,858	49,293	50,772	52,295	53,478
Groundwater production, transmission and distribution	182,064	187,526	193,151	198,946	204,914	211,062	217,394	223,915	230,633	235,849
Maintenance and leak detection - labour	112,221	115,588	119,055	122,627	126,306	130,095	133,998	138,018	142,159	145,374
Maintenance and leak detection - materials	29,973	30,872	41,798	43,052	56,011	57,691	59,422	61,204	63,040	71,992
Vehicles - fuel & maintenance	11,380	11,722	12,073	12,435	12,808	13,193	13,588	13,996	14,416	14,742
Staff costs	29,103	29,976	34,209	35,235	36,292	37,381	38,502	39,657	40,847	42,919
SWRO Personnel		20,000	30,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000
Repairs & maintenance		371,896	563,291	625,688	660,244	720,516	783,121	848,148	867,800	867,800
Electricity		822,559	1,269,558	1,436,983	1,545,158	1,718,250	1,903,029	2,100,209	2,189,701	2,231,305
Depreciation			238,554	318,072	318,072	318,072	318,072	318,072	318,072	318,072
Total desalination operations	406,023	1,632,659	2,545,486	2,878,149	3,046,269	3,294,117	3,556,419	3,833,992	3,958,963	4,021,530
Kiosk service and distribution operations										
Kiosk attendants		388,800	388,800	388,800	-	-	-	-	-	-
Tank truck operations										
Fuel		34,560	35,217	35,886	-	-	-	-	-	-
Maintenance		13,625	13,625	13,625	-	-	-	-	-	-
Drivers		72,000	72,000	72,000	-	-	-	-	-	-
Depreciation		54,500	54,500	54,500	-	-	-	-	-	-
Total kiosk service and distribution operations		563,485	564,142	564,811	-	-	-	-	-	-
Total Water Supply System Expenses	**1,244,837**	**3,059,913**	**4,025,765**	**4,386,372**	**4,074,456**	**4,351,939**	**4,644,766**	**4,953,779**	**5,111,133**	**5,216,191**

26. Based on these costs and the above estimates of produced water from each source, the following Table 9 scheduling average costs ($/kL) of water supplied by PUB from Bonriki/Buota, the SWRO plants, and distribution activities within the proposed kiosks has been derived.

Table 9: Schedule of Average Costs ($/kL)

	Historical	Period of Operation of Kiosks		
	2012	**2013**	**2014**	**2015**
Average cost of PUB water delivered ($/kL)	2.12	5.82	8.29	8.35
Cost of water produced ($/kL)	2.12	4.61	7.01	7.17
From Bonriki/Buota	2.12	2.35	4.99	5.14
From SWROs	-	5.97	5.92	6.00
Cost of kiosk operations ($/kL)	-	1.67	1.76	1.62
Cost of tank truck delivery ($/kL)	-	1.94	1.95	1.96
Total average cost of kiosks + tank truck delivery	-	3.28	3.01	2.90
	Period of Upgraded Network Operation			
	2016	**2017**	**2018**	**2019**
Average cost of PUB water delivered ($/kL)	4.00	4.11	4.23	4.34
Cost of water produced ($/kL)	4.00	4.11	4.23	4.34
From Bonriki/Buota	1.40	1.44	1.48	1.53
From SWROs	5.64	5.59	5.55	5.53

C. Tariffs, Subsidies, and Affordability Constraints

27. The Political Economy Analysis of Water and Sewerage Services[13] and the “Fees and Charges – Sustainability” section of the Tarawa Water and Sanitation Roadmap 2011-2030, both prepared in conjunction with this PPTA, provide a firm analytical framework for the determination of tariffs and subsidies, based on the costs outlined above. As outlined in the Roadmap, the following principles and criteria are adopted:

- There is overwhelming public dissatisfaction with the quality of the level of the water supply and sanitation services. Domestic customers have some willingness to pay a higher overall tariff for improved water and sewerage services but this support is strongly linked to receiving improved water quality, quantity and service and improved and reliable sanitation services. People may be expected to make spending decisions linked to the relative level of service.
- The poorest 20%-25% of households will have difficulty in paying utility charges provided on credit and billed in arrears. However, as demonstrated in strong pre-paid services markets in South Tarawa (e.g., cell phone, public transportation), it is expected that households with very limited ability to pay can purchase urgently required pre-paid services as needs arise. Therefore, a lifeline block per household per month is proposed, to be charged at a lower rate than non-domestic consumers and households consuming more than the lifeline block in litres per month.
- In the short to medium term a water cost recovery target of 60% for domestic customers is recommended.
- Households consuming more than 5,000 litres/month will pay a higher rate than that charged for the household lifeline block, but will nevertheless be subsidised at a rate below cost (consistent with the above cost recovery target).

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[13] Reference, footnote 2.

- The public good component of projected enhanced water and sewerage services justifies the provision of a partial subsidy for these services on economic efficiency grounds. A higher subsidy is appropriate for sewerage services in view of their greater positive externalities in South Tarawa compared with those applicable to water services.
- Generally there is an acceptance that households should spend no more than 5% of household income on combined water and sewerage services. As shown below, this level of expenditure can largely be managed by choice by the majority of households, with the exception of the 20% to 25% identified as poor.
- Business owners should not be asked to make any cross-subsidy to water and sewerage services provided to domestic customers, but they should nevertheless pay the full cost of their respective services (i.e., a 100% cost recovery target).
- Bad debts on water services billed in arrears are assumed to be 30% of domestic + non-domestic annual revenues (in line with recent historical experience) from 2012-2015, thereafter reducing to 20%[14]. As shown below, before considering subsidies, total revenues rise from about 50 percent of costs in 2012-2013, to about 60 percent by 2020.
- A sustainable management fund (SMF) (combining government and development partner funds) for the water supply sector, linked to a rigorous asset management plan, is recommended (similar in purpose and process to the fund recommended for the sanitation sector (STSISP)). The fund would largely cover network and Bonriki/Buota refurbishment as discussed in Section II above, plus ongoing maintenance and leak detection, and could also cover kiosk operation and maintenance costs during the suspension period (2013-2015). During the suspension period, incorporating network and Bonriki/Buota refurbishment and kiosk operations, the SMF would be funded at approximately $2.5 million/year, dropping to approximately $570,000/year in the period 2016-2020. In the tariff and subsidy calculations discussed in this section, the SMF is not included as a tariff-offsetting source of revenue.

28. Currently in South Tarawa, there is no charge for sewerage services. Under the current PPTA, a sanitation project has been developed and sewerage connections have been estimated. Flat-rate monthly sewerage tariff charges have been proposed for these as illustrated in Table 10.

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[14] If prepayment (and tamper-proof) metering is adopted, bad debts will be far less.

Table 10: Proposed Sewerage Charges

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Sewer Connections										
Domestic	1,505	1,505	1,530	1,580	1,680	1,750	1,750	1,750	1,750	1,750
Non Domestic	495	495	500	500	500	500	500	500	500	500
Total	2,000	2,000	2,030	2,080	2,180	2,250	2,250	2,250	2,250	2,250
Sewer Tariffs										
Domestic ($/month)	-	-	-	5.00	5.00	7.50	7.50	7.50	7.50	7.50
Non-domestic ($/month)	-	-	-	20.00	25.00	30.00	35.00	40.00	50.00	60.00

29. For discussion purposes, and on the basis of the above principles and criteria, a schedule of tariffs has been prepared (Table 11 overleaf) with projected revenues based on the tariffs. Since revenues do not recover full costs, the deficit that is required to be covered by a combination of annual subsidy and the SMF is also indicated.

30. The network suspension period, 2013-2015, is also a transition period for both the supply and the demand components of the water system. As mentioned, on the supply side, the delivery system will be fully refurbished, and new sources of water (SWRO units) will be added. On the demand side, consumers will be disconnected from the dilapidated distribution system, and delivery will be transferred to kiosks. (Only half the network will be down at any one time during the suspension period—since road transport for water delivery by itself could not cope—but all consumers will be affected at one time or another). During this period, consumers will inevitably suffer inconvenience and some hardship, leading to the expectation that, in combination with a demonstration of reliable potable water supply through the kiosk delivery mechanism, a willingness to pay metered charges for water after the refurbished network is pressurised will be general and high.

31. During the transition, however, it is not intended that households should also suffer financial hardship in procuring a survival-level volume of water. For this reason, the current flat-rate monthly charge for water ($10) is extended through the transition period, and applied to the procurement by each household of 5,000 litres of water per month. The $10 charge for that quantity is equivalent to $2.00/kL. 5.0 kL is calculated as a very basic survival level of water consumption of approximately 22 litres of water per person per day for an average family of 7.5 members. Better-off households and businesses will consume more than this, as discussed above, and will pay more for it, chiefly through own-transport costs and PUB cartage charges. (In addition, businesses will pay the full cost of water production, much more per kL than households during the transition period: approximately $7/kL, plus cartage. Businesses will pay the full cost recovery rate (exceeding $4.00/kL) once they are connected to the refurbished network. Better-off households will pay the rate $2.00/kL during the transition, but will pay a higher rate, rising to $3.00/kL by 2021, after they are connected to the refurbished network.)

32. PUB cartage service, for all customers who request it during the transition, will be charged at the rate of $2.00/kL.

33. It is assumed that customer meters (perhaps prepayment meters) will cost in the order of $100. Connection charges are thus subsidised for households at $25. Businesses will be charged $100 for a connection to the piped network. Deficit-offsetting subsidies average about $2.0 million per year to 2021 (to cover below-cost tariffs for households).

Table 11: Schedule of Proposed Tariffs (and Revenue Impact)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Water Supply Tariff Schedule										
Non-domestic connections										
Flat monthly rates ($/mo/connection)	10.00	10.00	10.00	10.00						
Metered Supply, all consumption ($/kL)		4.65	6.72	6.87	4.00	4.11	4.23	4.34	4.43	4.52
Cartage Charges ($/kL)		2.00	2.00	2.00						
Domestic connections										
Flat monthly rates ($/mo/poor household)	10.00	10.00	10.00	10.00						
Metered Supply, 0-5.0 kL/mo ($/kL)		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Metered Supply, >5.0 kL/mo ($/kL)		2.00	2.00	2.00	2.17	2.33	2.50	2.67	2.83	3.00
Cartage Charges ($/kL)		2.00	2.00	2.00						
Water Supply Connection Charges ($/connection)										
Non-domestic connections		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Domestic connections		25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Revenues - Water Sales										
Non-domestic connections	59,400	217,992	365,800	512,948	407,446	435,194	464,477	495,378	524,982	556,507
Domestic connections										
Poor Households	172,658	179,340	186,280	193,490	200,978	208,755	216,834	225,226	233,942	242,996
Non-Poor Households	345,316	1,740,506	1,659,345	1,798,731	1,769,021	1,978,827	2,202,223	2,439,945	2,604,001	2,729,828
Total domestic connections	863,291	1,919,846	1,845,626	1,992,220	1,969,999	2,187,583	2,419,057	2,665,171	2,837,943	2,972,823
Less Bad Debts	(276,807)	(641,351)	(663,428)	(751,550)	(475,489)	(524,555)	(576,707)	(632,110)	(672,585)	(705,866)
Total Tariff income	**645,884**	**1,496,487**	**1,547,998**	**1,753,618**	**1,901,956**	**2,098,221**	**2,306,827**	**2,528,439**	**2,690,340**	**2,823,465**
Water Supply Connections ($)										
Non-domestic connections	-	-	-	50,000	-	-	-	-	-	-
Domestic connections	-	-	-	201,552	7,800	8,102	8,415	8,741	9,079	9,431
Total water supply connections	-	-	-	251,552	7,800	8,102	8,415	8,741	9,079	9,431
Total Income	**645,884**	**1,496,487**	**1,547,998**	**2,005,169**	**1,909,756**	**2,106,323**	**2,315,242**	**2,537,180**	**2,699,419**	**2,832,895**
Total Expenses excluding depreciation	**1,244,837**	**3,005,413**	**3,732,711**	**4,013,800**	**3,723,034**	**4,000,517**	**4,293,343**	**4,602,357**	**4,759,711**	**4,864,769**
Deficit, to be offset by government subsidy	**(598,953)**	**(1,508,926)**	**(2,184,713)**	**(2,008,631)**	**(1,813,278)**	**(1,894,193)**	**(1,978,101)**	**(2,065,176)**	**(2,060,292)**	**(2,031,874)**
Income as % of Expenses excl depreciation	0.52	0.50	0.41	0.50	0.51	0.53	0.54	0.55	0.57	0.58

Deficit offset could be a combination of government subsidy and a Sustainable Maintenance Fund with development partner support

34. A further analysis has been prepared (summarised in Table 12 overleaf) of poor and non-poor households' expected expenditures on water supply and on sewerage charges under the tariffs proposed above. For poor households, the projected combination of expenditures during the transition are less than or equal to 5% of income for a household earning $2,400 annually or above in 2013-2014, and $4,100 in 2015 (when sewerage charges are proposed to be introduced). As sewerage charges increase, the minimum household income for a poor family to meet sewerage and water supply costs not exceeding 5% of income rises to about $4,220 from 2017 onwards. According to the Household Income and Expenditure Survey (HIES, 2006), the average income of a poor household in South Tarawa at that time was just over $8,000 per annum. For better-off households, the projected combination of expenditures during the transition are less than or equal to 5% of income for a household earning $5,800 annually or above in 2013-2014, and $7,300 in 2015. As sewerage charges increase, the minimum household income for a better-off family to meet sewerage and water supply costs not exceeding 5% of income rises to a maximum of about $8,600 to 2021. According to the HIES, the average income of a non-poor household in South Tarawa in 2006 was over $12,000 per annum. It is therefore concluded that the proposed combination of water supply and sewerage charges to poor and non-poor households is affordable through 2021.

Table 12: Annual and Monthly Household Expenditures on Water and Sewer based on Proposed Tariffs

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Domestic sector: annual and monthly water supply + sewer costs per household ($)										
***Poor Households**, Water Supply Costs*										
Annual	120	120	120	145	121	121	121	121	121	121
Monthly	10	10	10	12	10	10	10	10	10	10
Poor Households, Sewer Costs										
Annual	-	-	-	60	60	90	90	90	90	90
Monthly	-	-	-	5	5	8	8	8	8	8
Poor Households, Water + Sewer Costs										
Annual	120	120	120	205	181	211	211	211	211	211
Monthly	10	10	10	17	15	18	18	18	18	18
*For affordability (sewer+water costs=5% income), expenditures imply **poor household** income of*										
Annual	2,400	2,400	2,400	4,100	3,619	4,219	4,219	4,219	4,219	4,219
Monthly	200	200	200	342	302	352	352	352	352	352
***Non-Poor Households**, Water Supply Costs*										
Annual	60	291	267	304	265	285	306	326	335	338
Monthly	5	24	22	25	22	24	25	27	28	28
Non-Poor Households, Sewer Costs										
Annual	-	-	-	60	60	90	90	90	90	90
Monthly	-	-	-	5	5	8	8	8	8	8
Non-Poor Households, Water + Sewer Costs										
Annual	60	291	267	364	325	375	396	416	425	428
Monthly	5	24	22	30	27	31	33	35	35	36
*For affordability, water and sewer expenditures imply **non-poor household** income of*										
Annual	1,200	5,823	5,345	7,278	6,500	7,506	7,912	8,319	8,497	8,559
Monthly	100	485	445	606	542	626	659	693	708	713

Water Supply Model

Spread Sheet Printouts

South Tarawa Water Supply System

All dollar amounts = A$

Economic Opportunity Cost of Capital	12.00%	
Import Duty on System Equipment	0.00%	
Tax Rate on Local Labour	20.00%	
Tax Rate on Fuel	0.00%	
Shadow Unskilled Wage Rate Factor (% of Market Wage Rate)	90%	
Number and Cost of Kiosks		
Existing service reservoirs (meter points)	17	
New meter points needed	10	
Number equipped with toilet blocks	10	
Number equipped with shower blocks	27	
Cost of toilet block ($)	30,000	
Cost of shower block ($)	20,000	
Cost of Office/dispensary ($/kiosk)	5,000	
Meter cost per service reservoir ($)	1,000	
Meter cost per new kiosk ($):		
Directly off transmission mains		
Number of connections	5	
Cost per connection	1,000	
From new 22kL reservoirs		
Number of connections	5	
Cost per connection	7,800	
Tank Truck Initial Costs		
Number of tank trucks	5	
Capacity/truck (litres)	5,000	
Cost per truck (A$)	54,500	
Operating costs		
Fuel/mo (litres)	1,500	0%
Fuel cost ($/litre)	1.20	
Cost of electricity ($/kWh)	0.70	
Annual energy cost escalation (real)	1.9%	0%

WITH PROJECT SCENARIO

	2012	2013	2014	2015						
System-wide Costs										
Capital Costs										
Tank trucks	163,500				0%					
Leak repairs	260,000	200,000	200,000	200,000						
Demand management (bulk meters)	58,000									
Reservoir repairs		82,500								
Supply connections (incl consumer meters)			398,084	413,103	76,219	32,408	33,662	34,965	36,318	37,723
Kiosks										
Kiosks equipped with toilets/showers?		1								
with shower blocks only		340,000								
with toilet and shower blocks		500,000								
office/dispensary only		135,000								
Total kiosks		975,000			0%					
O&M Costs										
Staff cost increase (annual)										
Annual cost per person ($)	7,200									
Tanker truck operators	36,000	0%								
RO plant operators	40,000	0%								
Personnel per kiosk (no)	2									
Kiosk attendants	388,800	0%								
Repairs & maintenance, distribution network ($/year)	Assumed to be the same, with project and without project									
Repairs & maintenance, tanker trucks ($/year)	13,625	0%								
Fuel cost, tanker trucks										
Electricity consumption, distribution network (MWh/year)	Assumed to be the same, with project and without project									
Desal-supplied District Costs										
Start year for RO operations	2013									
Useful life of desal plants (years)	30									
Annual output of water (m3)	709,632									

Assumed to be the same, with project and without project

Assume:
Leak repairs and B/B upgrades are on-track with and without the projec
A water system with the present leakage (67%) is unworkable
With-project consists of 4 RO plants vs without-project: bulk water imports

Capital Costs

	2012	2013	2014	2015
4 RO plants (inclusive)	2,385,541	7,156,622		
Asset Replacement Costs				
(per RO plant)				
Pumps, valves, filters, calcite bed	500,000	0%		
replaced every (years)	15			
Chlorination unit	15,000	0%		
replaced every (years)	10			
O&M Costs				
Repairs & maintenance (RO plants)	867,800	0%		
Electricity consumption, RO plants (MWh/year)	2,742	0%		
Cost of RO electricity consumption (2013)	1,919,400			

Bonriki/Buota District Costs

Capital Costs			
Reconnect Buota supply	37,000		
Supply protection (Bonriki/Buota)	80,000	60,000	60,000
Bonriki improvements			
Clearing of palms	272,000		
Infilling old borrow pits		2,500,000	
Gallery management	98,500		
Water treatment plant improvements	141,000		
O&M Costs			
Repairs & maintenance (B/B galleries and WTP)	Assumed to be the same, with project and without project		
Electricity consumption, B/B galleries and WTP (MWh/year)	Assumed to be the same, with project and without project		

Assumed to be the same, with project and without project

WITHOUT PROJECT SCENARIO

Useful life of bulk storage facilities (years)	30			
Start date for bulk importation	2013			
Capital Costs	2012	2013	2014	2015
Tanker trucks		735,000		
Metering points		317,000		
O&M Costs ($/year from start date)				
Purchase of bulk water	1,064,448			
International shipping costs	4,200,000	Note: ship departs Fiji with 60,000 m3 of water on the ~22nd of each month, arrives in Tarawa on the 1st		
Port charges	180,000			
In-port "floating storage" costs	5,400,000	Ship remains in port as floating storage for 30 days at $15,000/day; departs empty when 2nd ship (full) arrives from Fiji		
Tanker truck O&M costs	145,200			

	With-Project Scenario									Without-Project Scenario (avoided costs)							
	Initial Costs			Asset Replacements		O&M Costs				Initial Costs		O&M Costs					
Year	RO Plants	Kiosks	Tanker Trucks	Pumps, valves, etc	Chlor units	RO Plants	Kiosks	Tanker Trucks	Total With-Project Costs	Tanker Trucks	Metering Points	Bulk Water Purchase	Shipping & Port Charges	Storage Charges	Tanker Trucks	Total Avoided Costs	Net Benefits
2012	2,385,541	-	163,500	-	-	-	-	-	2,549,041	-	-	-	-	-	-	-	(2,549,041)
2013	7,156,622	975,000	-	-	-	1,211,597	388,800	71,225	9,803,244	735,000	317,000	456,169	1,979,911	2,314,171	145,200	5,947,451	(3,855,793)
2014	-	-	-	-	-	1,858,813	388,800	71,635	2,319,248	-	-	690,935	2,958,026	3,505,150	146,021	7,300,132	4,980,884
2015	-	-	-	-	-	2,091,511	388,800	72,054	2,552,365	-	-	767,472	3,324,384	3,893,424	146,857	8,132,137	5,579,772
2016	-	-	-	-	-	2,235,835	388,800	-	2,624,635	-	-	809,859	3,561,090	4,108,456	147,709	8,627,114	6,002,479
2017	-	-	-	-	-	2,471,977	388,800	-	2,860,777	-	-	883,789	3,939,846	4,483,506	148,578	9,455,719	6,594,942
2018	-	-	-	-	-	2,722,246	388,800	-	3,111,046	-	-	960,580	4,344,177	4,873,071	149,463	10,327,291	7,216,244
2019	-	-	-	-	-	2,987,451	388,800	-	3,376,251	-	-	1,040,343	4,775,643	5,277,712	150,365	11,244,062	7,867,811
2020	-	-	-	-	-	3,097,501	388,800	-	3,486,301	-	-	1,064,448	4,971,468	5,400,000	151,284	11,587,200	8,100,899
2021	-	-	-	-	-	3,139,105	388,800	-	3,527,905	-	-	1,064,448	5,062,506	5,400,000	152,220	11,679,174	8,151,269
2022	-	-	-	-	-	3,181,500	388,800	-	3,570,300	-	-	1,064,448	5,155,273	5,400,000	153,174	11,772,896	8,202,596
2023	-	-	-	-	60,000	3,224,700	388,800	-	3,673,500	-	-	1,064,448	5,249,804	5,400,000	154,147	11,868,398	8,194,898
2024	-	-	-	-	-	3,268,721	388,800	-	3,657,521	-	-	1,064,448	5,346,130	5,400,000	155,137	11,965,715	8,308,194
2025	-	-	-	-	-	3,313,579	388,800	-	3,702,379	-	-	1,064,448	5,444,286	5,400,000	156,147	12,064,881	8,362,502
2026	-	-	-	-	-	3,359,289	388,800	-	3,748,089	-	-	1,064,448	5,544,308	5,400,000	157,176	12,165,931	8,417,843
2027	-	-	-	-	-	3,405,867	388,800	-	3,794,667	-	-	1,064,448	5,646,230	5,400,000	158,224	12,268,902	8,474,235
2028	-	-	-	2,000,000	-	3,453,330	388,800	-	5,842,130	-	-	1,064,448	5,750,088	5,400,000	159,292	12,373,828	6,531,698
2029	-	-	-	-	-	3,501,695	388,800	-	3,890,495	-	-	1,064,448	5,855,920	5,400,000	160,381	12,480,748	8,590,253
2030	-	-	-	-	-	3,550,979	388,800	-	3,939,779	-	-	1,064,448	5,963,762	5,400,000	161,490	12,589,700	8,649,921
2031	-	-	-	-	-	3,601,200	388,800	-	3,990,000	-	-	1,064,448	6,073,654	5,400,000	162,620	12,700,722	8,710,722
2032	-	-	-	-	-	3,652,374	388,800	-	4,041,174	-	-	1,064,448	6,185,633	5,400,000	163,772	12,813,853	8,772,679
2033	-	-	-	-	60,000	3,704,521	388,800	-	4,153,321	-	-	1,064,448	6,299,740	5,400,000	164,946	12,929,134	8,775,813
2034	-	-	-	-	-	3,757,659	388,800	-	4,146,459	-	-	1,064,448	6,416,015	5,400,000	166,142	13,046,605	8,900,146

2035	-	-	-	-	-	3,811,806	388,800	-	4,200,606	-	-	1,064,448	6,534,499	5,400,000	167,361	13,166,308	8,965,702	
2036	-	-	-	-	-	3,866,982	388,800	-	4,255,782	-	-	1,064,448	6,655,235	5,400,000	168,602	13,288,285	9,032,503	
2037	-	-	-	-	-	3,923,207	388,800	-	4,312,007	-	-	1,064,448	6,778,264	5,400,000	169,868	13,412,580	9,100,573	
2038	-	-	-	-	-	3,980,500	388,800	-	4,369,300	-	-	1,064,448	6,903,631	5,400,000	171,157	13,539,237	9,169,937	
2039	-	-	-	-	-	4,038,881	388,800	-	4,427,681	-	-	1,064,448	7,031,380	5,400,000	172,471	13,668,300	9,240,619	
2040	-	-	-	-	-	4,098,371	388,800	-	4,487,171	-	-	1,064,448	7,161,557	5,400,000	173,810	13,799,815	9,312,643	
2041	-	-	-	-	-	4,158,992	388,800	-	4,547,792	-	-	1,064,448	7,294,206	5,400,000	175,175	13,933,829	9,386,037	
2042	-	-	-	-	-	4,220,765	388,800	-	4,609,565	-	-	1,064,448	7,429,376	5,400,000	176,565	14,070,389	9,460,824	
2043	-	-	-	2,000,000	60,000	4,283,711	388,800	-	6,732,511	-	-	1,064,448	7,567,114	5,400,000	177,982	14,209,544	7,477,033	
ENPVs	8,775,382	870,536	163,500	385,847	24,590	21,594,990	3,143,442	171,987	35,130,275	656,250	283,036	7,225,963	35,224,282	36,657,685	1,229,546	81,276,762	46,146,487	70.0%
EIRR																	70.0%	

Sensitivity Analysis

Test Case	Test Variation (+/- %)	ENPV	EIRR	Sensitivity Indicator	Basecase Parameter	Switching Value (SV)	Switching Value (+/-%)
Base (reference case)		46,146,487	70.0%				
Increases in Costs							
Capital Cost	20%	44,184,604	57.1%	0.21	9,542,163	54,431,402	470.4%
O&M and Asset Replacement Costs	20%	41,082,316	63.2%	0.55	2,319,248	6,546,006	182.2%
Decrease in Benefits							
Fuel Price Escalation Rate	-20%	45,502,897	69.8%	0.07	1.9%	N/A	No SV
Decrease in Avoided Costs	-20%	29,891,135	48.3%	1.76	7,300,132	3,155,338	-56.8%
Initial Costs Increased (+) and Benefits Decreased (-)	20%	22,562,876	34.9%				

Capital Cost	0%
O&M and Asset Replacement Costs	0%
Fuel Price Escalation Rate	0%
Decrease in Avoided Costs	0%

Projected PUB Water Supply Production and Delivery Costs

Assumptions

Flat rates are phased out in 2016, when metered piped connections become universal

Water system is refurbished over the period 2013-2015 inclusive, when the network is repaired, meters installed for all customers wanting a connection, the RO plants are installed, and the Bonriki/Buota reserve is optimised

The 'lifeline' tariff block for households is 3.4 kL/household/mo, equivalent to 15 litres/capita/day for an average family of 7.5 members

Household consumption exceeding 3.4 kL and all business/social/government consumption is charged full cost recovery rate (+ cartage costs, as applicable)

Poor households (% domestic category)	20%
Business demand for water (% total demand)	10%
Long term population growth rate	3.87%

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Provision for Bad Debt	30.0%	30.0%	30.0%	30.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%
Sewer Connections										
Domestic	1,505	1,505	1,530	1,580	1,680	1,750	1,750	1,750	1,750	1,750
Non Domestic	495	495	500	500	500	500	500	500	500	500
Total	2,000	2,000	2,030	2,080	2,180	2,250	2,250	2,250	2,250	2,250
Sewer Tariffs										
Domestic ($/month)	-	-	-	5.00	5.00	7.50	7.50	7.50	7.50	7.50
Non-domestic ($/month)	-	-	-	20.00	25.00	30.00	35.00	40.00	50.00	60.00

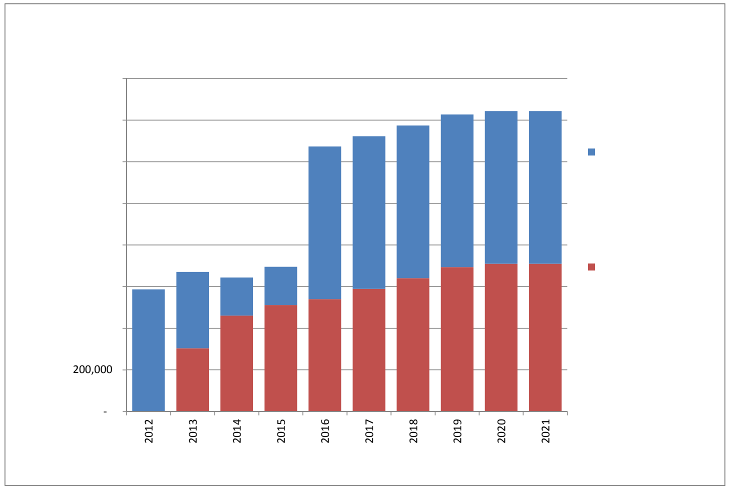
Water Supply Analysis

	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Water Demand, Unconstrained by Water System or Transport Capacity (kL)										
Population served	53,956	56,044	58,213	60,465	62,805	65,236	67,761	70,383	73,107	75,936
Number of Households	7,194	7,473	7,762	8,062	8,374	8,698	9,035	9,384	9,748	10,125
Domestic demand (kL)	787,753	818,239	849,905	882,796	916,960	952,447	989,306	1,027,592	1,067,360	1,108,667
Number of business/social connections	495	495	500	500	500	500	500	500	500	500
Commercial/social demand (kL)	87,528	90,915	94,434	98,088	101,884	105,827	109,923	114,177	118,596	123,185
Total unconstrained demand (kL)	**875,281**	**909,154**	**944,339**	**980,884**	**1,018,845**	**1,058,274**	**1,099,229**	**1,141,769**	**1,185,956**	**1,231,852**
Water Consumption (partly constrained), PUB sourced (kL)										
Non-domestic consumers	58,692	56,621	53,648	57,812	101,884	105,827	109,923	114,177	118,596	123,185
Domestic consumers										
Poor households (consume up to 5.0 kL/mo)	86,329	45,003	46,745	48,554	100,489	104,378	108,417	112,613	116,971	121,498
Non-poor households (consume >5.0 kL/mo)	441,899	435,127	414,836	449,683	816,471	848,069	880,889	914,980	919,059	909,943
Total water consumption from PUB sources (kL)	**586,920**	**536,750**	**515,229**	**556,048**	**1,018,845**	**1,058,274**	**1,099,229**	**1,141,769**	**1,154,626**	**1,154,626**
Total water required from PUB sources including 20% losses (kL)	**733,650**	**670,938**	**644,036**	**695,060**	**1,273,556**	**1,322,842**	**1,374,036**	**1,427,212**	**1,443,282**	**1,443,282**
Water sourced from Bonriki/Buota	586,920	366,825	183,413	183,413	733,650	733,650	733,650	733,650	733,650	733,650
Water sourced from SWROs		304,113	460,623	511,648	539,906	589,192	640,386	693,562	709,632	709,632

Subsidise non-poor households during suspension?	Yes

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Water Supply Tariff Schedule										
Non-domestic connections										
Flat monthly rates ($/mo/connection)	10.00	10.00	10.00	10.00						
Metered Supply, all consumption ($/kL)		4.65	6.72	6.87	4.00	4.11	4.23	4.34	4.43	4.52
Cartage Charges ($/kL)		2.00	2.00	2.00						
Domestic connections										
Flat monthly rates ($/mo/poor household)	10.00	10.00	10.00	10.00						
Metered Supply, 0-5.0 kL/mo ($/kL)		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Metered Supply, >5.0 kL/mo ($/kL)		2.00	2.00	2.00	2.17	2.33	2.50	2.67	2.83	3.00
Cartage Charges ($/kL)		2.00	2.00	2.00						
Water Supply Connection Charges ($/connection)										
Non-domestic connections		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Domestic connections		25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Revenues - Water Sales										
Non-domestic connections	59,400	217,992	365,800	512,948	407,446	435,194	464,477	495,378	524,982	556,507
Domestic connections										
Poor Households	172,658	179,340	186,280	193,490	200,978	208,755	216,834	225,226	233,942	242,996
Non-Poor Households	345,316	1,740,506	1,659,345	1,798,731	1,769,021	1,978,827	2,202,223	2,439,945	2,604,001	2,729,828
Total domestic connections	863,291	1,919,846	1,845,626	1,992,220	1,969,999	2,187,583	2,419,057	2,665,171	2,837,943	2,972,823
Less Bad Debts	(276,807)	(641,351)	(663,428)	(751,550)	(475,489)	(524,555)	(576,707)	(632,110)	(672,585)	(705,866)
Total Tariff income	**645,884**	**1,496,487**	**1,547,998**	**1,753,618**	**1,901,956**	**2,098,221**	**2,306,827**	**2,528,439**	**2,690,340**	**2,823,465**
Water Supply Connections ($)										
Non-domestic connections	-	-	-	50,000	-	-	-	-	-	-
Domestic connections	-	-	-	201,552	7,800	8,102	8,415	8,741	9,079	9,431
Total water supply connections	-	-	-	251,552	7,800	8,102	8,415	8,741	9,079	9,431
Total Income	**645,884**	**1,496,487**	**1,547,998**	**2,005,169**	**1,909,756**	**2,106,323**	**2,315,242**	**2,537,180**	**2,699,419**	**2,832,895**
Total Expenses excluding depreciation	**1,244,837**	**3,005,413**	**3,732,711**	**4,013,800**	**3,723,034**	**4,000,517**	**4,293,343**	**4,602,357**	**4,759,711**	**4,864,769**
Deficit, to be offset by government subsidy	**(598,953)**	**(1,508,926)**	**(2,184,713)**	**(2,008,631)**	**(1,813,278)**	**(1,894,193)**	**(1,978,101)**	**(2,065,176)**	**(2,060,292)**	**(2,031,874)**
Income as % of Expenses excl depreciation	0.52	0.50	0.41	0.50	0.51	0.53	0.54	0.55	0.57	0.58

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Domestic sector: annual and monthly water supply + sewer costs per household ($)										
***Poor Households** , Water Supply Costs*										
Annual	120	120	120	145	121	121	121	121	121	121
Monthly	10	10	10	12	10	10	10	10	10	10
Poor Households, Sewer Costs										
Annual	-	-	-	60	60	90	90	90	90	90
Monthly	-	-	-	5	5	8	8	8	8	8
Poor Households, Water + Sewer Costs										
Annual	120	120	120	205	181	211	211	211	211	211
Monthly	10	10	10	17	15	18	18	18	18	18



For affordability (sewer+water costs=5% income), expenditures imply ***poor household*** *income of*											Average poor household income, 2006 HIES
Annual	2,400	2,400	2,400	4,100	3,619	4,219	4,219	4,219	4,219	4,219	8,048
Monthly	200	200	200	342	302	352	352	352	352	352	
Non-Poor Households *, Water Supply Costs*											
Annual	60	291	267	304	265	285	306	326	335	338	
Monthly	5	24	22	25	22	24	25	27	28	28	
Non-Poor Households, Sewer Costs											
Annual	-	-	-	60	60	90	90	90	90	90	
Monthly	-	-	-	5	5	8	8	8	8	8	
Non-Poor Households, Water + Sewer Costs											
Annual	60	291	267	364	325	375	396	416	425	428	
Monthly	5	24	22	30	27	31	33	35	35	36	
For affordability, water and sewer expenditures imply ***non-poor household*** *income of*											Average non-poor household income, 2006 HIES
Annual	1,200	5,823	5,345	7,278	6,500	7,506	7,912	8,319	8,497	8,559	12,190
Monthly	100	485	445	606	542	626	659	693	708	713	

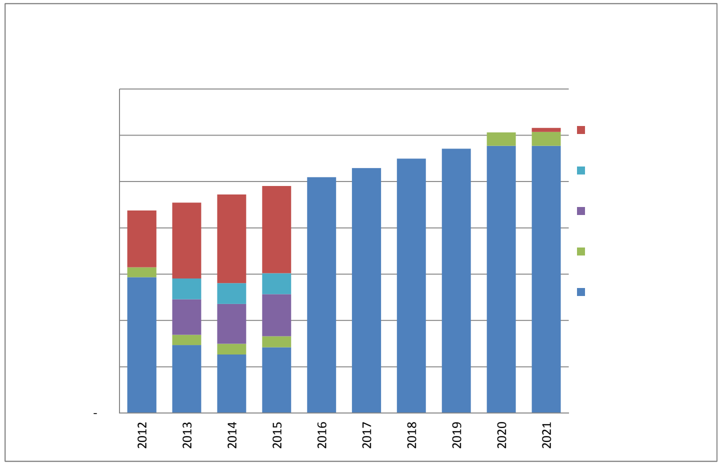
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Water Supply Expenses										
Bonfiki/Buota ("east") district operations										
Administration and Overheads	82,565	85,042	87,593	90,221	92,927	95,715	98,587	101,544	104,591	106,956
Groundwater production, transmission and distribution	371,127	382,051	393,303	404,892	416,829	429,123	441,787	454,831	468,266	478,698
Maintenance and leak detection - labour	198,693	204,653	210,793	217,117	223,630	230,339	237,249	244,367	251,698	257,390
Maintenance and leak detection - materials	105,463	108,627	131,886	135,842	163,250	168,148	173,192	178,389	183,740	202,947
Vehicles - fuel & maintenance	22,760	23,443	24,147	24,871	25,617	26,385	27,177	27,992	28,832	29,484
Staff costs	58,206	59,952	68,417	70,470	72,584	74,761	77,005	79,315	81,694	85,837
Depreciation					33,350	33,350	33,350	33,350	33,350	33,350
Total Bonriki/Buota operations	838,814	863,769	916,138	943,412	1,028,187	1,057,822	1,088,347	1,119,787	1,152,170	1,194,661
Desalination ("west") district operations										
Administration and Overheads	41,282	42,521	43,796	45,110	46,464	47,858	49,293	50,772	52,295	53,478
Groundwater production, transmission and distribution	182,064	187,526	193,151	198,946	204,914	211,062	217,394	223,915	230,633	235,849
Maintenance and leak detection - labour	112,221	115,588	119,055	122,627	126,306	130,095	133,998	138,018	142,159	145,374
Maintenance and leak detection - materials	29,973	30,872	41,798	43,052	56,011	57,691	59,422	61,204	63,040	71,992
Vehicles - fuel & maintenance	11,380	11,722	12,073	12,435	12,808	13,193	13,588	13,996	14,416	14,742
Staff costs	29,103	29,976	34,209	35,235	36,292	37,381	38,502	39,657	40,847	42,919
SWRO Personnel		20,000	30,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000
Repairs & maintenance		371,896	563,291	625,688	660,244	720,516	783,121	848,148	867,800	867,800
Electricity		822,559	1,269,558	1,436,983	1,545,158	1,718,250	1,903,029	2,100,209	2,189,701	2,231,305
Depreciation			238,554	318,072	318,072	318,072	318,072	318,072	318,072	318,072
Total desalination operations	406,023	1,632,659	2,545,486	2,878,149	3,046,269	3,294,117	3,556,419	3,833,992	3,958,963	4,021,530
Kiosk service and distribution operations										
Kiosk attendants		388,800	388,800	388,800	-	-	-	-	-	-
Tank truck operations										
Fuel		34,560	35,217	35,886	-	-	-	-	-	-
Maintenance		13,625	13,625	13,625	-	-	-	-	-	-
Drivers		72,000	72,000	72,000	-	-	-	-	-	-
Depreciation		54,500	54,500	54,500	-	-	-	-	-	-
Total kiosk service and distribution operations		563,485	564,142	564,811	-	-	-	-	-	-
Total Water Supply System Expenses	**1,244,837**	**3,059,913**	**4,025,765**	**4,386,372**	**4,074,456**	**4,351,939**	**4,644,766**	**4,953,779**	**5,111,133**	**5,216,191**
Average cost of PUB water delivered ($/kL)	2.12	5.70	7.81	7.89	4.00	4.11	4.23	4.34	4.43	4.52
Cost of water produced ($/kL)	2.12	4.65	6.72	6.87	4.00	4.11	4.23	4.34	4.43	4.52
From Bonriki/Buota	2.12	2.35	4.99	5.14	1.40	1.44	1.48	1.53	1.57	1.63
From ROs	-	5.37	5.53	5.63	5.64	5.59	5.55	5.53	5.58	5.67
Cost of kiosk operations ($/kL)	-	1.45	1.51	1.40	-	-	-	-	-	-
Cost of tank truck delivery ($/kL)	-	1.94	1.95	1.96	-	-	-	-	-	-
Total average cost of kiosks + tank truck delivery	-	2.32	2.15	2.08	-	-	-	-	-	-

Water Demand, Available Supply, and Delivery

Period of piped network suspension (mos)				
West district (supplied by ROs)	18	2013 to mid-2014		
East district (supplied by Bonriki/Buota	18	mid 2014 to end 2015		
Population (and no of households), West (%)	50%			
Population (and no of households), East (%)	50%			
'Lifeline' per capita consumption (l/c/d)	22			
Design per capita demand (l/c/d)	40			
Household size (persons/household)	7.5			
'Lifeline' monthly consumption, average household (kL)	5.0			
Poor households (%)	20%			
PUB tank truck (cartage) costs				
Number of PUB tank trucks	5			
Capacity per truck (litres)	5,000			
Average speed (dleivering water, full load), kph	40			
Max driving time per day (hrs)	4			
Distance travelled per truck per day (km)	160			
Max no of loads per day per truck	10			
Fuel efficiency per truck (litres per 100 km)	10			
Max deliveries per day (by all trucks, kL)	250			
Driver's wages ($/year)	7,200			
Number of drivers (including relief)	10			
Days per year worked	360			
Number of days worked per year per driver	183			
Population growth rate (%/year)	High	Low	Population growth flag =	High
	3.9%	3.0%		
Business/social demand (% of total demand)	10%			
SWRO flag =	1			

RO production, when installed	-	283,853	425,779	567,706	567,706	567,706	567,706	567,706	567,706	567,706
Water Demand	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Population served	53,956	56,044	58,213	60,465	62,805	65,236	67,761	70,383	73,107	75,936
Number of households	7,194	7,473	7,762	8,062	8,374	8,698	9,035	9,384	9,748	10,125
Domestic demand (kL)	787,753	818,239	849,905	882,796	916,960	952,447	989,306	1,027,592	1,067,360	1,108,667
Commercial/social demand (kL)	87,528	90,915	94,434	98,088	101,884	105,827	109,923	114,177	118,596	123,185
Total end-use demand (kL)	875,281	909,154	944,339	980,884	1,018,845	1,058,274	1,099,229	1,141,769	1,185,956	1,231,852
Losses (20%)	218,820	227,289	236,085	245,221	254,711	264,568	274,807	285,442	296,489	307,963
Total Volume required (kL)	1,094,101	1,136,443	1,180,423	1,226,106	1,273,556	1,322,842	1,374,036	1,427,212	1,482,445	1,539,815
Available Supply after losses (kL)										
Bonriki/Buota	586,920	586,920	586,920	586,920	586,920	586,920	586,920	586,920	586,920	586,920
Rainwater Harvesting	42,705	44,410	46,115	47,820	49,826	51,832	53,839	55,845	57,852	59,858
SWRO Plants	-	283,853	425,779	567,706	567,706	567,706	567,706	567,706	567,706	567,706
Total Available Supply at End-use	629,625	915,183	1,058,814	1,202,445	1,204,452	1,206,458	1,208,464	1,210,471	1,212,477	1,214,484
Water Delivered, all sources (kL)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
By PUB Piped Network	586,920	293,460	253,175	283,853	1,018,845	1,058,274	1,099,229	1,141,769	1,154,626	1,154,626
By Rainwater Harvesting	42,705	44,410	46,115	47,820	-	-	-	-	57,852	59,858
By Self-Delivery from PUB Kiosk										
Poor Households (small personal containers)	-	45,003	46,745	48,554	-	-	-	-	-	-
Non Poor Households (private tank trucks)	-	90,013	105,979	113,215	-	-	-	-	-	-
Businesses (private tank trucks)	-	18,275	19,330	20,427	-	-	-	-	-	-
Total Self-Delivered	-	153,290	172,054	182,195	-	-	-	-	-	-
By PUB Tank Truck from PUB Kiosks										
Non Poor Households	-	81,000	81,000	81,000	-	-	-	-	-	-
Businesses	-	9,000	9,000	9,000	-	-	-	-	-	-
Maximum Total Delivered by PUB Tank Truck	-	90,000	90,000	90,000	-	-	-	-	-	-
Total Water Delivered, all sources	629,625	581,160	561,343	603,868	1,018,845	1,058,274	1,099,229	1,141,769	1,212,477	1,214,484
Total Water Delivered, PUB sources	586,920	536,750	515,229	556,048	1,018,845	1,058,274	1,099,229	1,141,769	1,154,626	1,154,626
Unserved Water Demand	245,656	327,994	382,995	377,017	-	-	-	-	-	17,369
Domestic water delivered per capita per day, all sources	28.77	25.57	23.78	24.63	40.00	40.00	40.00	40.00	40.89	39.44

Use this graph after discussion of the Suspension period



DESALINATION PLANTS COST - SUMMARY

ITEM	DESCRIPTION	ESTIMATED COST				TOTAL	
		BET1	BET2	BAI1	BAI2		
100	PRELIMINARY AND GENERAL	43,875	43,875	43,875	43,875	175,500	
200	DESALINATION PLANT	1,362,290	1,362,290	1,362,290	1,370,690	5,457,560	
300	CIVIL AND ANCILLIARY	90,680	82,780	87,000	97,200	357,660	
400	GENERATORS	52,500	52,500	52,500	52,500	210,000	
500	INTAKE BOREHOLES AND PUMPS	176,625	176,625	176,625	176,625	706,500	
600	PIPES AND FITTINGS	93,940	24,340	21,940	18,595	158,815	
700	STORAGE TANKS AND PUMPS	248,400	248,400	248,400	248,400	993,600	
800	ELECTRICAL	46,679	64,007	63,606	63,606	237,898	
	Subtotal	**2,114,989**	**2,054,817**	**2,056,236**	**2,071,491**	**8,297,533**	
	Contingencies 12%	253,799	246,578	246,748	248,579	995,704	
	Engineering, design and supervision 3%	63,450	61,645	61,687	62,145	248,926	
	TOTAL ESTIMATE A$	**2,432,237**	**2,363,040**	**2,364,671**	**2,382,215**	**9,542,163**	0%

Shipping and Distribution of Bulk Water Supplies

	Item	Unit	Rate	Quantity	Amount	Rationale and Comment
Monthly Water Purchase, Freighting and Distribution						
1	Purchase of water - say Fiji	m3	$ 1.50	59,136	88,704	
2	Shipping of Bulk Supplies	per load	$ 350,000	1	350,000	Volume to meet water deficit
3	Port handling & clearance costs	per load	$ 15,000	1	15,000	Based on cost of pumping to tanks at 2% of freight costs
4	Drivers for tankers	mth	$ 600	10	6,000	Based on $9,000 annual salary/wages per driver and 10 tankers
5	Vehicle maintenance	unit	$ 250	10	2,500	Estimated at 5% of capital cost annually
6	Monthly fuel cost for tankers	litres	$ 1.20	3,000	3,600	Based on average mileage of 100 km a day (5 loads and 10 litres per 100 km
	Subtotal Monthly				465,804	
	Cost per m3				7.76	
Capital Costs						
7	Preparation of area for tanks	m3	40	10,500	420,000	Development of filled Betio landfill area - based on 60,000 m3 storage and 0.5m consolidated depth of fill
8	!50mm Pipeline from port to storage tanks	m	150	1,000	150,000	Excavation, supply of pipe, installation and reinstatement. Based on costs for desalination and systems improvements
9	Purchase and installation of storage tanks	No.	15,000	2,000	30,000,000	Purchase of tanks plus shipping and freighting and installation at costs obtained for desalination plant costs
10	65mm and 100mm connection pipes	m	90	600	54,000	At costs presented for desalination plants
11	Discharge pumps at port	No.	10,000	2	20,000	As above
12	Meters at discharge to tanks	No.	5,000	2	10,000	Priced as for water supply improvements
13	Lift pumps at storage tank discharge points	No.	4,000	4	16,000	At costs presented for desalination plants
14	Meters at tank discharge points	No.	5,000	2	10,000	At costs presented for desalination plants
15	Tanker parking and filling points	Item	10,000	1	10,000	
16	Security fence around tank farm	m	200	600	120,000	Priced as for desalination plants
17	Entrance gates	No.	2	400	800	Priced as for desalination plants
18	Site office and amenities	m2	30	2,000	60,000	
19	Metering points at existing service reservoirs	No.	1,000	17	17,000	At costs presented for desalination plants
20	Construction of additional temporary water points	No.	15,000	20	300,000	Comprising 22 m3 tank, connection pipe and meter manifolds
21	Purchase, freighting and commissioning of 10m3 tankers	No.	73,500	10	735,000	Stainless steel milk tankers converted for water delivery. Cost US$ 60,000 FOB China. Provision for freight and port handling at $A10,000 per unit. Allow 5% for tools and spares

Total	**31,922,800**	Cost to be amortised over five years of temporary supplie**s**
Cost per annum - five year write down	6,384,560	amortised over five years
Cost per annum - ten year write down	3,192,280	amortised over ten years
	720,000	Volume supplied per annum
Cost per m3 for five year period	9	
Cost per m3 for ten year period	4	
Total cost per m3 - five year period	17	
Total cost per m3 - ten year period	12	

Water Demand Forecast (m3/day)

Production normal wet conditions

Year	2005	2010	2015	2020	2025	2030	
Population--High Growth Scenario	41,684	50,402	60,936	73,720	89,131	107,719	
Demand m3 at 40 l/cap/day	1,667	2,016	2,437	2,949	3,565	4,309	
Domestic Demand	1,501	1,814	2,194	2,654	3,209	3,878	
Commercial/Institutional Demand	167	202	244	295	357	431	
Required production 50% loss	3,335	4,032	4,875	5,898	7,130	8,618	
Required production 20% loss	2,084	2,520	3,047	3,686	4,457	5,386	
Product Bonriki with improvements	1,660	1,660	1,535	1,410	1,285	1,328	20% reduction climate related
Production Buota	350	350	333	315	298	280	20% reduction climate related
Production Bonriki and Buota	2,010	2,010	1,868	1,725	1,583	1,608	
Deliver primary sources allowing 20% losses	36	30	23	18	13	11	
Rainwater normal conditions	823	823	823	823	995	902	2040 mm, 5254 households 2007 - assume 43% with tanks
Total - Normal	2,833	2,833	2,691	2,548	2,578	2,510	Average h/h occupance increases from 7.5 to 20 in 2030
Delivery capacity l/cap day	68	56	44	35	29	23	
Production prolonged drought	2010	2010	1868	1725	1583	1608	
RWH - 50m3 catchment 0.85 runoff coef	90	108	131	158	192	232	Prolonged drought 5l/cap/day for 43% of population
Total availability	2100	2118	1999	1883	1774	1840	
Availability l/cap day - prolonged drought	50	42	33	26	20	17	
		117.05924					

Growth rates						
2005-2010	2010-2015	2015-2020	2020-2025	2025-2030	2005-2030	2010-2020
3.87	3.87	3.88	3.87	3.86	3.87	3.88

Lower Growth with reduction after 2010

	2005	2010	2015	2020	2025	2030	
Population--Lower Growth Scenario	41,684	50,402	60,936	68,131	75,440	82,058	
Demand m3 at 50 l/cap	2,084	2,520	3,047	3,407	3,772	4,103	
Domestic Demand	1,876	2,268	2,742	3,066	3,395	3,693	
Commercial/Institutional Demand	208	252	305	341	377	410	
Required production 50% loss	4,168	5,040	6,094	6,813	7,544	8,206	
Required production 25% loss	3,126	3,780	4,570	5,110	5,658	6,154	
Production Bonriki with improvements	1,660	1,660	1,535	1,410	1,285	1,328	20% reduction climate related
Production Buota	350	350	333	315	298	280	
Production Bonriki and Buota	2,010	2,010	1,868	1,725	1,583	1,608	
Deliver primary sources allowing 25% losses	48	40	31	25	21	20	
Rainwater normal conditions	880	880	1,021	1,141	1,264	1,375	
Total - Normal	2,890	2,890	2,888	2,866	2,846	2,983	
Delivery capacity l/cap day	69	57	47	42	38	36	
Production prolonged drought	2,010	2,010	1,868	1,725	1,583	1,608	
RWH - 50m3 catchment 0.85 runoff coef	208	252	305	341	377	410	Prolonged drought
Total availability	2,218	2,262	2,172	2,066	1,960	2,018	
Availability l/cap day - prolonged drought	53	45	36	30	26	25	
RWH at 5l/Cap day	208	252	305	341	377	410	
Calculated deficit		3,509	1,831	2,352	3,611	4,489	
Net deficit		3,257	1,526	2,011	3,234	4,079	
RO Plants (4)			709,632	709,632	709,632	709,632	

Growth rates						
2005-2010	2010-2015	2015-2020	2020-2025	2025-2030	2005-2030	2010-2020
3.87	3.87	2.26	2.06	1.70	2.75	3.06

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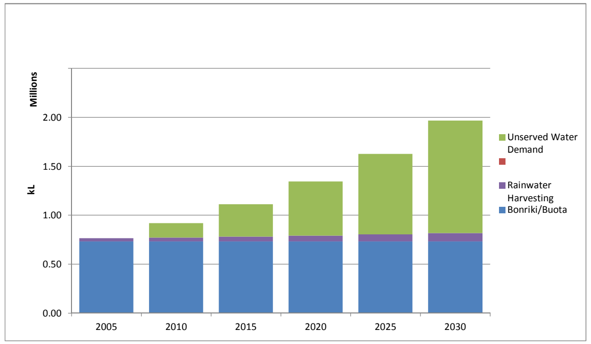


Water Supply Forecast (m3/year) -- Prolonged Drought

High Population Growth Scenario	2005	2010	2015	2020	2025	2030
Production, Bonriki/Buota	733,650	733,650	733,650	733,650	733,650	733,650
Rain Water Harvesting (prolonged drought)	32,712	39,553	47,820	57,852	69,946	84,532
Total Supply	766,362	773,203	781,470	791,502	803,596	818,182
Required production, 20% loss, 40 l/c/d	760,733	919,837	1,112,082	1,345,390	1,626,641	1,965,872
Deficit	-	146,634	330,612	553,888	823,045	1,147,689
Water delivered per capita (l/day)	40	34	28	24	20	17
Lower Population Growth Scenario						
Production, Bonriki/Buota	733,650	733,650	681,638	629,625	577,613	586,920
Rain Water Harvesting	300,529	300,529	300,529	300,529	363,354	329,347
RO Plants (4)			709,632	709,632	709,632	709,632
Total Supply	1,034,179	1,034,179	1,691,798	1,639,786	1,650,598	1,625,899
Required production, 25% loss, 50 l/c/d	1,141,100	1,379,755	1,668,123	1,865,086	2,065,170	2,246,338
Surplus/(deficit)	106,921	345,576	-	225,300	414,572	620,438
Water delivered per capita (l/day)	51	42	57	49	45	41

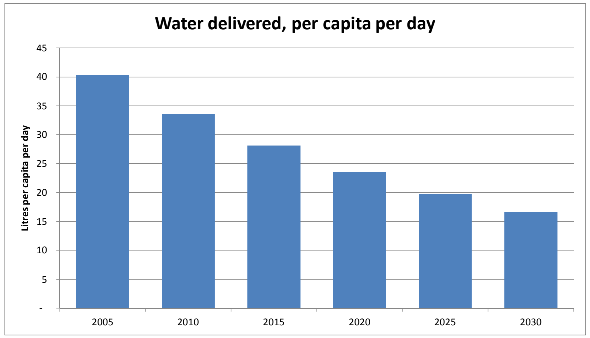
Water Supply Forecast (m3/year) -- Prolonged Drought Conditions

High Population Growth Scenario

Production, Bonriki/Buota
Rain Water Harvesting
RO Plants (4)
Total Supply
Required production, 25% loss, 50 l/c/d
Deficit
Water delivered per capita (l/day)

Lower Population Growth Scenario

Production, Bonriki/Buota
Rain Water Harvesting
RO Plants (4)
Total Supply
Required production, 25% loss, 50 l/c/d
Surplus/(deficit)
Water delivered per capita (l/day)



PUB Water Supply Activities – Extracted from Draft Asset Management Plan prepared by TA 7359-KIR, 2011

ITEM	DESCRIPTION	YEAR 2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	**REVENUE**[1]										
1	Water sales - domestic	337,668	347,798	358,232	368,979	380,048	391,450	403,193	415,289	427,748	440,580
2	Water sales - commercial/industrial	175,223	180,480	185,894	191,471	197,215	203,131	209,225	215,502	221,967	228,626
3	Connection fee - water	3,132	3,226	3,323	3,422	3,525	3,631	3,740	3,852	3,968	4,087
4	Reconnection fee - water	84	87	89	92	95	97	100	103	106	110
5	Sale of stores - water	3,320	3,420	3,522	3,628	3,737	3,849	3,964	4,083	4,206	4,332
6	Sale of works - water	6,110	6,293	6,482	6,677	6,877	7,083	7,296	7,515	7,740	7,972
7	Sundry revenues - water delivery sales	17,000	17,510	18,035	18,576	19,134	19,708	20,299	20,908	21,535	22,181
	Impact of tariff increase to $20 per month						457,222	484,644	513,574	544,091	576,279
	Government subsidy[2]	666,247	686,024	706,395	767,377	790,188	391,461	389,290	386,369	382,640	378,044
	Total Revenue	**1,208,784**	**1,244,837**	**1,281,973**	**1,360,222**	**1,400,818**	**1,477,632**	**1,521,752**	**1,567,195**	**1,614,000**	**1,662,210**
	EXPENDITURE										
	Management and Administration										
1	Administrative Overheads 20%[3]	51,136	52,670	54,250	55,878	57,554	59,281	61,059	62,891	64,778	66,721
2	Supervisory and Clerical 20%	69,104	71,177	73,312	75,512	77,777	80,110	82,514	84,989	87,539	90,165
	Sub-total	120,240	123,847	127,563	131,389	135,331	139,391	143,573	147,880	152,316	156,886
	Operating Costs										
	Pumping and Electrical[4]										
1	Water production, transportation and treatment	476,783	491,086	505,819	520,993	536,623	552,722	569,304	586,383	603,974	622,093
2	Water distribution to reticulation/ households	53,500	55,105	56,758	58,461	60,215	62,021	63,882	65,798	67,772	69,805
	Sub-total	530,283	546,191	562,577	579,454	596,838	614,743	633,185	652,181	671,746	691,899
	Operations and Maintenance										
	Staff and Labour										
1	Direct labour[5]	182,908	188,395	194,047	199,869	205,865	212,041	218,402	224,954	231,702	238,653
2	Overtime	25,000	25,750	26,523	27,318	28,138	28,982	29,851	30,747	31,669	32,619
3	System maintenance	35,142	36,196	37,282	38,401	39,553	40,739	41,961	43,220	44,517	45,852
4	Leak detection and demand management[5]	50,000	51,500	53,045	54,636	56,275	57,964	59,703	61,494	63,339	65,239
5	Temporary assistance	8,808	9,072	9,344	9,625	9,913	10,211	10,517	10,833	11,158	11,492
	Sub-total	301,858	310,914	320,241	329,848	339,744	349,936	360,434	371,247	382,385	393,856
	Staff, Social and Related Costs										
1	KPF contribution	10,000	10,300	10,609	10,927	11,255	11,593	11,941	12,299	12,668	13,048
2	Bonus and allowances[6]	47,662	49,092	50,565	52,082	53,644	55,253	56,911	58,618	60,377	62,188
3	Leave passages	7,200	7,416	7,638	7,868	8,104	8,347	8,597	8,855	9,121	9,394
4	Leave commutation	0	0	0	0	0	0	0	0	0	0
5	Staff subsidised rent	8,856	9,122	9,395	9,677	9,968	10,267	10,575	10,892	11,219	11,555
6	Travelling and transport	5,000	5,150	5,305	5,464	5,628	5,796	5,970	6,149	6,334	6,524
7	Telephone and fax	6,048	6,229	6,416	6,609	6,807	7,011	7,222	7,438	7,661	7,891
8	Training[7]	0	0	0	10,000	10,300	10,609	10,927	11,255	11,593	11,941

Split between east (B/B) and west (ROs) districts

🟨	67%	B/B
	33%	ROs
🟦	50%	B/B
	50%	ROs
▨	100%	B/B
	0%	ROs

	Sub-total	84,766	87,309	89,928	102,626	105,705	108,876	112,142	115,507	118,972	122,541
	Repairs and Maintenance, etc										
1	Chlorine and laboratory[8]	44,191	45,517	46,882	48,289	49,737	51,229	52,766	54,349	55,980	57,659
1	New connections - water	14,000	14,420	14,853	15,298	15,757	16,230	16,717	17,218	17,735	18,267
2	Buildings	12,500	12,875	13,261	13,659	14,069	14,491	14,926	15,373	15,835	16,310
3	Furniture and equipment	800	824	849	874	900	927	955	984	1,013	1,044
4	Plant and machinery	25,000	25,750	26,523	27,318	28,138	63,982	65,901	67,878	69,915	72,012
5	Pipes[9]	18,500	19,055	19,627	50,215	51,722	53,274	54,872	56,518	58,213	59,960
6	Operating supplies	16,500	16,995	17,505	18,030	18,571	19,128	19,702	20,293	20,902	21,529
	Sub-total	131,491	135,436	139,499	173,684	178,894	219,261	225,839	232,614	239,593	246,780
	Plant and Equipment										
1	Fuel - Vehicles	23,146	23,840	24,556	25,292	26,051	26,833	27,638	28,467	29,321	30,200
2	Repairs & maintenance - motor vehicles	10,000	10,300	10,609	10,927	11,255	11,593	11,941	12,299	12,668	13,048
3	Vehicle hire	0	0	0	0	0	0	0	0	0	0
	Sub-total	33,146	34,140	35,165	36,220	37,306	38,425	39,578	40,765	41,988	43,248
	Land rentals	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000
	Total Expenditure	1,208,784	1,244,837	1,281,972	1,360,222	1,400,818	1,477,633	1,521,752	1,567,194	1,614,000	1,662,210
	Operating Surplus (Deficit)	0	0	0	0	0	0	0	0	0	0
	Capital Expenditure										
	Vehicles and Equipment										
1	Pickup vehicle (1)[10]	30,000	51,500	54,075	56,779	59,618	89,427	93,898	98,593	103,522	108,699
2	Mobile tanker truck (1)	120,000	0	0	0	0	0	0	0	0	0
3	Motorcycle (3)	7,500	0	0	0	0	0	0	0	0	0
4	Workshop tools - press machine, bench drill, welding machine	10,000	0	0	0	0	0	0	0	0	0
5	Construction of new plumbing workshop	30,000	0	0	0	0	0	0	0	0	0
	Office Equipment										
1	Laptop computer (1)[11]	2,500	4,625	4,856	5,099	5,354	8,031	8,433	8,854	9,297	9,762
2	Desktop computers (2)	5,000	0	0	0	0	0	0	0	0	0
	Sub-total	175,000	56,125	58,931	61,878	64,972	97,458	102,330	107,447	112,819	118,460
	Total Expenditure - All	1,383,784	1,300,962	1,340,904	1,422,099	1,465,790	1,575,090	1,624,082	1,674,641	1,726,819	1,780,670
	Total Deficit	-175,000	-56,125	-58,931	-61,877	-64,972	-97,458	-102,331	-107,446	-112,819	-118,460

Notes on provisions in spread sheet:

1 Provides for continuation of business tariff assuming 20% allowance for arrears. Introduces a $20 fixed charge for Households from 2016 with 40% allowance for arrears

2 Government subsidy peaks at $790,188 in 2015 and decreases to $378,044 in 2020

3 Administrative overheads and supervisory and clerical costs have been apportioned from the aggregate in PUB's accounts

4 Consultant has estimated the electrical consumption and costs associated with the water supply system

5 Transfers a proportion of direct labour costs to a new item for leak detection and demand management. TA 7359 (KIR) institutional assessment

6 Needs review and linkage to improvement in services and operations. Should be based on achievement

7 Allows provision for staff training

8 If new chlorination process recommended is introduced, costs will reduce for the process, but increase due to recommissioning of Betio

9 Allows for increase in pipe and fittings from 2014 following KAP III support for leak detection

10 Makes a general allowance from 2012 for new vehicles and equipment

11 Makes a general allowance from 2012 for computers and office equipment

Appendix G

South Tarawa Desalination Plants OPEX

SOUTH TARAWA DESALINATION OPEX

Based on 22hr/day , 50 weeks per year and 528m^3/ production per day **Each site - 3 modules**

Annual Output : 184,800m^3/ annum

		1 site Annual Cost AUD	**4 sites Annual cost AUD**		**4 sites Annual cost AUD**	
1	Power	490,000	1,960,000		1,960,000	
2	Chemicals - antiscalants	1200	4,800		4,800	
3	Chemicals - cleaning in place	1000	4,000		4,000	
4	3 micron cartridges	14,000	56,000		56,000	
5	Freight ' landing charges for items 1-4	5,000	10,000		10,000	
6	Membranes : est min 5 yr life	15,000	60,000	8yr life	48,000	10yr life
7	Media top up multimedia filter incl frgt	250	1,000		1,000	
8	Media top up calcite filter incl frgt	500	2,000		2,000	
9	Chlorination- 1g/m3	3,000	12,000		12,000	
10	Services contract	125,000	200,000		200,000	
11	Client labour/operating costs	30,000	40,000		40,000	
12	Spares etc based on 5% capital costs	65,000	260,000		260,000	
13	Contingency 10%	75,000	258,000		258,000	
		824,950	2,867,800		2,855,800	

Based on 184,800m^3/annum		739200m^3/annum	739200m^3/anum
Opex per m^3 produced	$4.65 per m^3	$3.88 per m^3	$3.86per m^3
Opex per litre produced	4.7 c/litre	4.0c/litre	4.0c/litre

594,950 184,800 3.219426407 without service contract

Notes

Item 3 - rounded up

Item 5 - assumes economies of scale in bulk

Item 6- worst case scenario that takes into account freight, and cost increases (normally higher than $ inc)

Item 10- assumes economies of scale

Item 11- Includes vehicle , tools etc included - dedicated person.

Item 12- impotant component of asset management

Item 13 - will include random costs of generator operation.

General - asumes 50 weeks/annum operation to allow for maintenance time