EXECUTIVE SUMMARY

1 Background

1.1 Introduction

The Tarawa Water and Sanitation Roadmap 2011-2030 [the Roadmap] prepared under TA 7359-KIR involved an assessment of population growth, land use planning and urban development, and the mapping of the urban groundwater lenses on South Tarawa with the estimation of their sustainable capacity and an assessment of water quality. The existing and potential water sources for Tarawa, especially South Tarawa were investigated.

The findings raised concern for South Tarawa where all natural water sources were found to be either polluted or at risk of pollution which will deny their use as safe water supplies. The population is growing rapidly and largely unchecked and will more than double in the next twenty years. Development is presently unstructured and with a lack of adequate regulation and control, increasing amounts of scarce land are being denied for residential occupation. Large tracts of land under government ownership previously set aside for development will be inundated in the near future through the combined impacts of sea level rise and storm surge, requiring expensive fill and modification for development. Community health is poor and deteriorating.

All tests of the urban groundwater lenses confirmed the unsuitability of the water for human consumption. The well water throughout South Tarawa was found to be saline and was expected to become more saline as abstraction rates increased. While polluted and unfit for human consumption the urban lenses are adequate for secondary uses. Rainwater harvesting provides, and will continue to provide a useful buffer for the shortfall between demand and supply during normal “wet” periods, but will not provide sufficient volumes for the dryer times and periods of drought particularly as household occupancies increase. The existing supplies from Bonriki and Buota are finite and inadequate for even present demands. The overriding conclusion is that a new additional safe water source (supply) is urgently required for potable consumption.

The Roadmap reviewed the findings of the earlier Tarawa Water Master Plan and concluded, like the Master Plan the saltwater reverse osmosis (desalination) offered not only the least costly source, but the only feasible and practical source for South Tarawa’s long-term needs. The Roadmap supported the previous findings of the Tarawa Water Master Plan and confirmed the need for four desalination plants, each comprising three SWRO modules, with each plant capable of producing 528kL of potable water daily for a daily total from all four plants of 2,112kL.

1.2 The Assignment and Tasks

To give improved confidence in a decision to proceed with the desalination option, TA 7359-KIR was extended with support from AusAID, to provide a comprehensive feasibility study of the desalination option and the requirements for the provision and implementation of the desalination plants for South Tarawa. The feasibility study followed Terms of Reference prepared by the ADB with input from the development partners. The Terms of Reference are presented as an appendage to this feasibility study report.

The desalination feasibility study was conducted between February and April 2012 and involved a balance of onsite investigations and planning and office design, analysis and reporting. The draft report was issued in May 2012 and this final report incorporates further analysis and reporting in response to stakeholder comments on the draft report. This executive summary presents an overview of the methodology followed for the study and the technical, environmental, economic and financial assessments carried out. It also summarises the recommendations for procurement, implementation and the subsequent maintenance management of the plants.

The result is a feasibility design, with preliminary design plans, comprehensive bills of quantities and estimations of cost with due diligence assessment and reporting of environmental impacts, economic and financial considerations, and affordability.

2 Prior Experience with Desalination

2.1 Success Experience in Similar Environments

Nauru has successfully run SWRO plants for 10 years, supplying a major proportion of its potable water needs, especially in droughts with maintenance and technical services being contracted out to the manufacturer/supplier. The desalination plant at the Moroni High School operated and maintained by the I-Kiribati maintenance manager and maintenance staff at the school is another successful example where the plant has operated successfully for nine years with the need for membrane replacement only arising after nine years.

2.2 PUB and Other Experience

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 (50kL/day), Otintaai Hotel (50kL/Day) and Betio (110kL/day). All plants failed primarily through a lack of maintenance and inadequate funds for spare parts and repairs. The membranes of a new plant installed on Banaba in 2010 have also failed and enquiries about routine and planned maintenance confirm that the membranes had not been washed or descaled regularly, again through a lack of funds to purchase the chemicals.

The pervading attitude has been to install and operate the plants without maintenance or routine cleaning of the membranes. SWRO units, while not complex, require a rigorous regime for pre-filtering and 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 earlier plants. Poor selection of the plants and technology employed has also been a contributing factor.

3 Desalination Options and Choice of Technology

3.1 Desalination Technology

Three main technologies have been considered in the South Tarawa context:

1. **Multiple -Effect Distillation (MED)** - 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. 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 such as Kiribati and variable quality and security of power supply is a constant unknown.

2. Multi-stage Flash Distillation Process (MSF) - 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 include developments in scale control technologies, heat transfer improvements and the use and development of corrosion resistant materials including titanium and improved design. The technology has similar high technical skill and preventative maintenance requirements to the MED process and is unsuited to the Kiribati situation.

3. Membrane Processes - membranes with controlled pore sizes that allow for the separation of water from saline solution without having to undergo a phase change as in the previously outlined distillation processes. 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).

3.2 Saltwater Reverse Osmosis Processes

A range of membranes is available but the relevant membrane type applicable to desalination is known as reverse osmosis, to be specific for this application seawater reverse osmosis (SWRO). As a guideline 42% of the feed rate is recovered as permeate (product water) and the other 58% is a brine stream discharged to waste, and to the ocean for dilution. SWRO is the preferred technology for desalination plants in at least the southern hemisphere.

Reverse osmosis has lower unit water costs due to lower energy demands, making it the most economical of all the desalination methods. 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 and pre-treating the expected South Tarawa seawater quality has been a key process design consideration during the feasibility study, with the added advantage that the proposed filtration using pre-treatment membranes will also remove harmful pathogens such as Giardia, Cryptosporidium and viruses. Technological advances are also leading to continued reduction in the unit production costs per kL, as are energy recovery systems using the high pressure rejected brine stream

4 Consultation with SWRO Manufacturer/ Supplier

During the feasibility study considerable research was carried out to identify potential suppliers who had the capacity to provide accurate Opex and Capex data on desalination plants, who had the proven capability to supply the Pacific area with robust systems that would operate under tropical conditions and who were also willing to have Opex / Capex data rigorously scrutinised. A leading company with its Australasian and Pacific operations in Australia was willing to supply relevant information and be subject to such scrutiny. The consultants for the feasibility study visited the company's office in Melbourne and remained in contact with the company for the duration of the study. Crucial aspects of the analyses, for example the sizing of the plants and SWRO modules, membrane characteristics, the assessment of energy demand and Opex costs, and the elements of the process and requirements for pre-filtering and pre and post treatment were discussed with the company and referred for comment.

These discussions together with the review of crucial aspects of the study and the costs established were designed to give greater confidence in the study's analyses and the conclusions drawn and recommendations made.

5 Procurement

5.1 Best Technology, SWRO Units and Support

The greatest risk for SWRO desalination will be the ability to effectively maintain and operate the plants for ten years or more. This risk will be minimised by procurement that focuses on a selection process for obtaining the best processes and design involving leading manufacturers/suppliers with proven and extensive operational experience and the ability to back up and support their equipment and processes well into the future. The worst possible outcome would be to install poor equipment from a supplier who is unable to provide a full and extended warranty, is unable to provide technical and parts backup, and who has a high risk of financial and business failure.

5.2 Best design, manufacturing and procurement requirements of SWRO units

Procurement for the design, manufacture, implementation and commissioning of the SWRO desalination units should be for RO modules and associated equipment in A-grade (new) or one-use marinised 20 foot containers complete with air conditioning, power boards/switchboards, heavy duty floor finish with coving and lockable personnel access doors, lighting and with other general facilities including appropriate process control systems, all pre-commissioned before transport from the country of origin, and complying with the following requirements:

- SWRO modules to be fully designed and built in their totality by the company supplying, installing and commissioning the modules
- SWRO modules should not be assembled from parts or components from multiple suppliers and manufacturers. 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
- the designer/manufacturer/supplier [the company] should be a world leader in SWRO technology and preeminent in the manufacture and operations of SWRO units
- the company shall have a proven record of supplying package plants in numbers to others with an established history of manufacturing, installing and operating packaged plants and SWRO units on the scale contemplated for South Tarawa, or larger, and should have Pacific experience of installing and operating SWRO units
- the company should 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
- the company should have substantial manufacturing and supply operations in the Australasian and South Pacific regions with the capacity to provide unrestricted

technical, management, maintenance and operations support with globally linkage with in-house or proven R&D capacity
- the company must be able to provide plans, drawings, 3D presentations, technical manuals for the SWRO modules;
- the company must be capable of providing training to MPWU and PUB and assisting with the design and delivery of community education packages and should have the ability to provide proven off-the-shelf education packages and curriculum support; and materials for school and community awareness/education programs suitable for Kiribati
- the company must have the financial capacity and resilience to enter into a five-year extended warranty on the SWRO modules and associated equipment.

6 Feasibility Study and Design

6.1 Introduction

The Roadmap has recommended four desalination plants, each with three SWRO modules and capable of producing 528kL/day from each plant with a combined daily production of 2,112kL and an estimated cost allowing for manufacture, delivery, onsite civil and related works and commissioning of some $9,500,000. The unit production cost was calculated at $4.50/kL allowing for electricity, consumables (RO antiscalant, chemicals and replacement micron filter cartridges), chemicals (for membrane cleaning) and membrane replacement at five years (the Nauru membrane has lasted 10 years), and for an extended manufacturer's service warranty. Provision was also made for spare parts.

6.2 Approach and Methodology

The feasibility study has reviewed the Roadmap recommendations and carried the design and estimation of costs to a higher level of certainty. In the process the sites for the desalination units have been evaluated and fixed, comprehensive feasibility designs and drawings have been produced, electricity demand and supply requirements have been assessed and due diligence assessment of possible environmental impacts, and economic return, tariffs and charges and affordability have been analysed.

6.3 Projected Demand

Nearly 70% of South Tarawa's households rely on water from the PUB piped system. A further nine percent of households rely on rain water tanks, open wells (12%) and protected wells (11%). Twenty-one households (1%) indicate use of bottled water.[1] Importation of bottled water amounted to 325,181 litres in 2008, 285,905 litres in 2009 and 379,275 litres in 2010.[2] The quantity of locally produced bottled water could not be obtained as the information was considered to be commercially sensitive. Bottled water, imported and locally produced is expensive and is unlikely to become a source the households will depend upon.

TA 7359-KIR has confirmed the vulnerability of secondary groundwater lenses in South Tarawa and the poor water quality which makes these groundwater resources unsafe for human consumption. With climate change there is the possibility that these resources could in time be depleted, or become severely limited in their capacity to satisfy secondary demands.[3]

[1] 2010 Census – National Statistics Office
[2] Chief Customs Officer, 23 February 2012
[3] Tarawa Water and Sanitation Roadmap 2011-2030

The recent mapping and quantification of the other freshwater lenses underlying South Tarawa have confirmed their limited capacity and unsuitability as potential source locations. The lenses in Betio, Bairiki and Bikenibeu and along South Tarawa are unsuitable for human consumption and will be hard pressed to meet secondary water requirements.[4]

Rain water harvesting will assist in meeting needs during times of plentiful rainfall, but average and affordable household storage capacity will only sustain a lifeline supply of some 5 litres per person per day for the average household, for a limited drought period of three months, provided the tank is close to full at the outset and managed cautiously throughout the period. For the average household size in South Tarawa, and for average-sized roof catchment areas and rainwater tank storage capacities, rainwater harvesting can only supply water at a modest rate of about 5 L/pers/day, sufficient for drinking and cooking only.[5]

For assessment of demand the feasibility study has adopted the per capita consumption of 50l/c/day from the Tarawa Water Master Plan and the Tarawa Water and Sanitation Road Map. It has also adopted the assumptions of both documents relating to the place of rainwater harvesting in the longer term solution for sustainable potable water supplies where the Master Water Plan in relation to the contribution of rainwater harvesting towards future water needs, makes the following statement:

> *"Estimating the amount of rainwater that is currently harvested in Tarawa is problematic since there is insufficient information on rainwater harvesting and storage systems in Tarawa. In order to make a rough estimate, the 2005 Census results for the number of households in South and North Tarawa harvesting water, together with the average number of people per household and a consumption rate of 5 L/pers/day were used. These indicate that, on average, about 100kL/day of rainwater is harvested in Tarawa currently. If it is assumed that a further 1,750 houses in South Tarawa will have rainwater harvesting and storage systems installed by 2030, then the amount of rainwater water supplied could increase to about 160kL/day. Rainwater harvesting will not meet the projected shortfall in continuous water supply in South Tarawa because of long, severe droughts. It is none-the-less an important source of good quality water and its proper use should be encouraged."*

The desalination study therefore assumes a worst case scenario for water supply planning purposes, i.e. prolonged drought conditions, which essentially eliminate rainwater harvesting as a reliable component of household water supply, and severely constrained urban lenses as secondary sources for washing and bathing.

6.4 Network Modelling

The appropriate location for each desalination plant has been established by first choosing to place the plants closest to the unsatisfied demand, and then refining the locations through network modelling using EPANET. The modelling reflects how the system will be operated, assuming full use of the existing service reservoirs, the replacement of the Tearoraereke to Betio transmission main in 2012 by the Kiribati road improvement project, and a reduction in leaks and wastage to 20% by 2020.

The network has been divided into two zones with an eastern zone from Bonriki to Antemai being supplied from the Bonriki and Bouta water reserves, and a western zone from Antemai

[4] Tarawa Water and Sanitation Road Map 2011-2030 - Section 37.3
[5] Tarawa Water Master Plan - Section 4.1.1 Risk of Failure of Rainwater Storage in Tarawa

to Betio supplied by the proposed desalination plants. The recharge rate of the reservoirs has been set at the average demand for the area which they supply with peak demand supplied from the storage. If, for any reason the Bonriki and Bouta supply is disrupted the desalination plants could deliver 10l/c//day emergency supplies to the eastern zone.

For 2015, the network modelling shows that 2,500kL from the Bonriki/Bouta supply at 20 to 30m head would give a minimum residual head of 8m at Banraeba. For the western zone a 13m static head at the desalination plants would retain a 12m minimum residual head at Antemai. If the systems were operated as an integrated network and the Bonriki treatment discharge is pumped at 20 to 25m head a minimum residual head would be retained at Taborio/Eita

6.5 Site Selection

The sites for the desalination plants were first located generally by the network modelling, then selected after site visits and assessment. Government owned or leased land was chosen to avoid land resettlement and compensation issues. Other criteria were choice of a location to suit the network operations, availability and access, area, shape and contours, and suitability for saltwater extraction to feed the plants, and brine disposal as a waste product. Discussion occurred with the Lands division of MELAD and agreement for the use of the four sites was obtained. The locations are displayed by Figures E1 to E4 respectively.

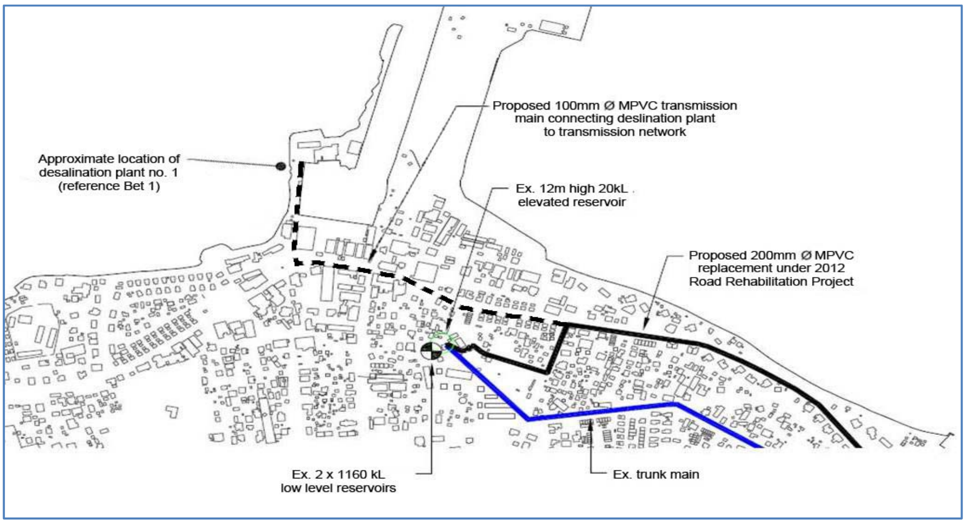

Figure E1: Desalination Plant No. 1

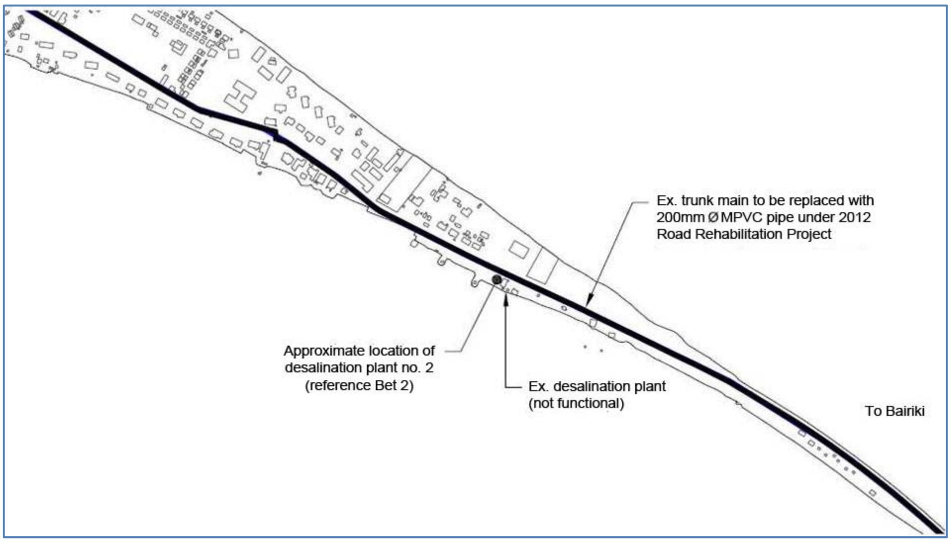

Figure E2: Desalination Plant No. 2

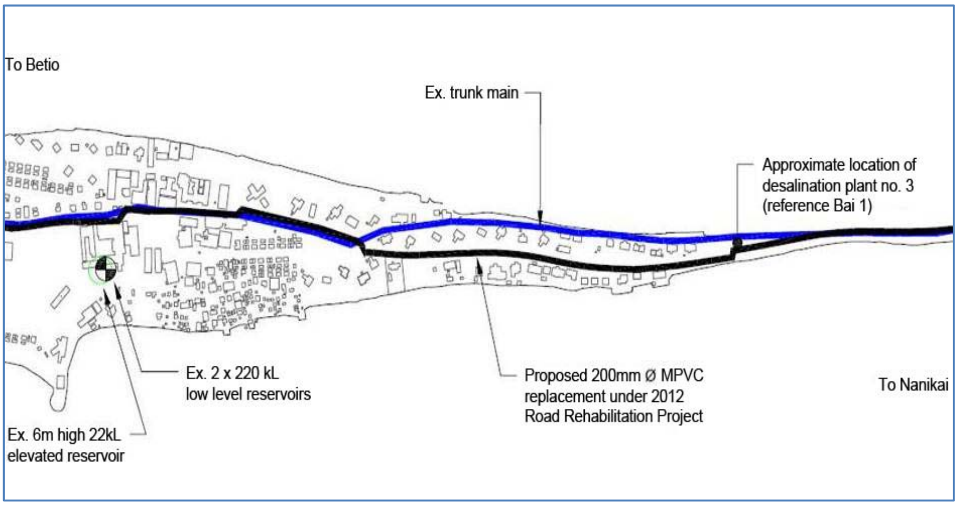

Figure E3: Desalination Plant No. 3

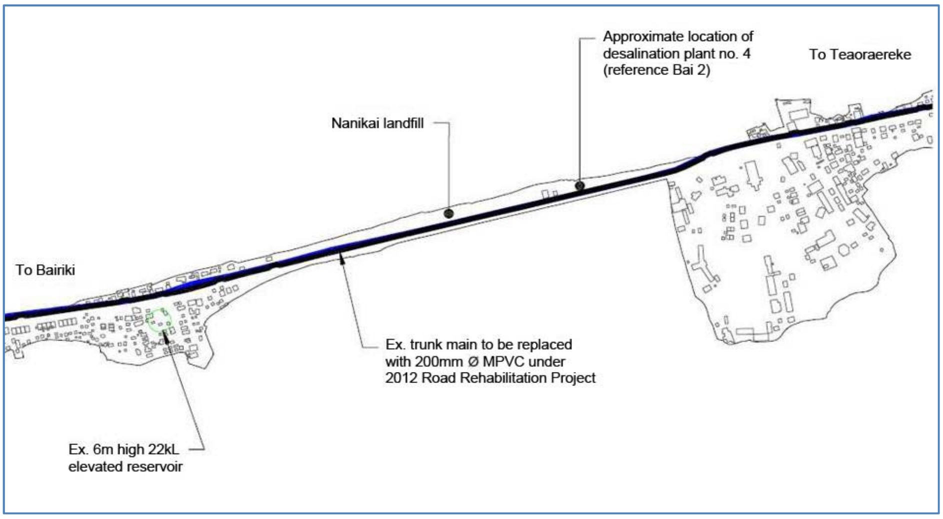

Figure E4: Desalination Plant No. 4

6.6 The Desalination Process

The design allows for saltwater (seawater) feed from three boreholes or from a shallow gallery under the ocean side inner reef platform if delivery from the bores proves to be inadequate. Feed water then goes to raw water storage tanks then filtering at 57kL/hr to remove contaminants, before entering the SWRO modules giving 24kL/hr of treated water with a waste stream (brine) of 33kL/hr per plant. The treated water is then run over a calcite bed within a filter vessel to restore natural ions and the pH level before storage in low and high level treated water tanks. The high level tank on a 12m elevated tower establishes the operating head for the eastern zone fed by the desalination plants. The brine stream passes to a 22kl tank which balances the outfall discharge to dilution in the outer ocean tidal zone. The process in plan form and profile is displayed in Figures E5 and E6 below.

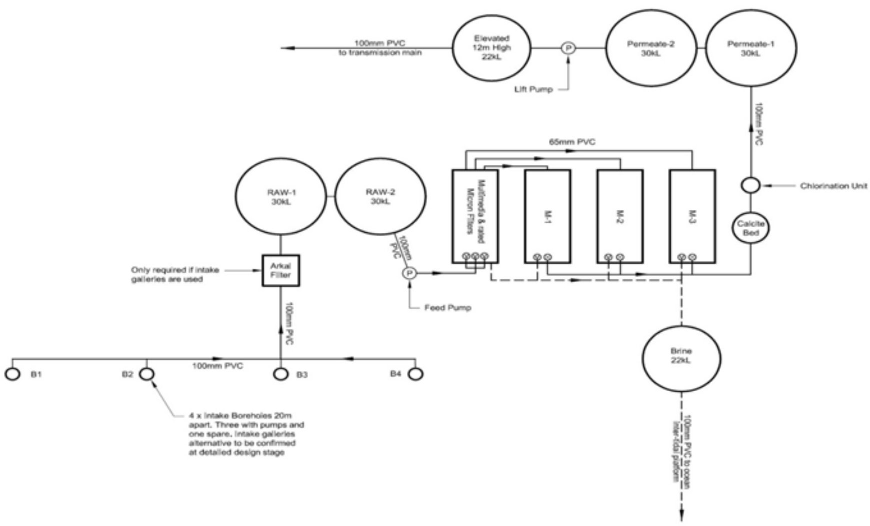

Figure E5: Desalination Plant Layout Plan

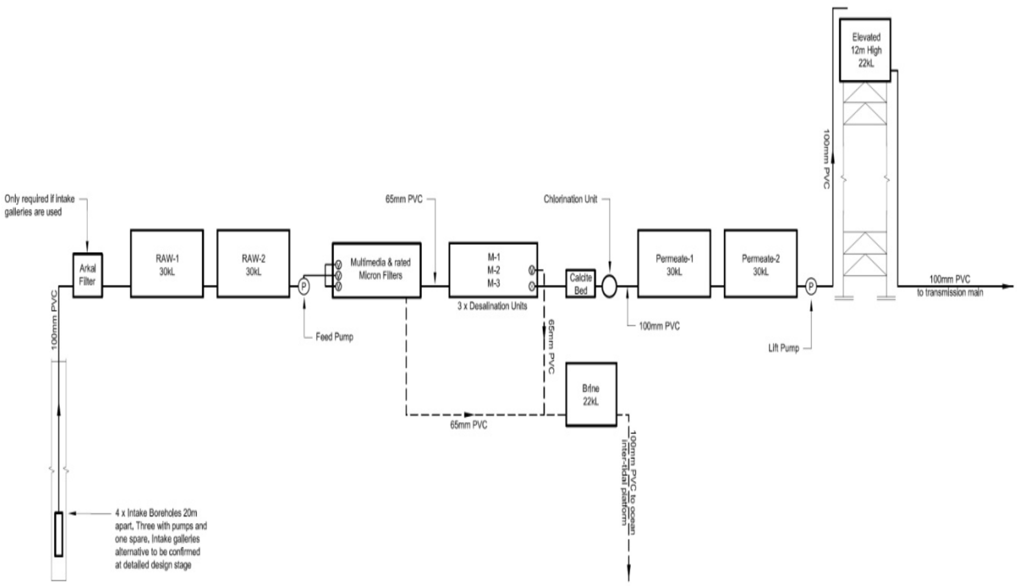

Figure E6: Desalination Plant Typical Profile

6.7 Plant Components

In summary the components of each desalination plant comprise the following:

- three deep bores for saltwater intake (or shallow gallery)
- raw water storage, 2 x 30kL reservoirs
- pre-filtration of a multi-media and a rated micron filter for each SWRO module
- an Arkal mechanical filter for removal of sand and coral fragments if the shallow intake gallery is used
- three SWRO modules for each plant
- Calcite bed for adjustment of treated water
- chlorination disinfection unit
- treated water storage, 2x 30kl ground tanks and a12m elevated tower and 22kL tank
- one 22KL brine storage tank
- the brine disposal outfall and dispersal system.

1. Intake boreholes and water quality

Desalination plant permeate (final treated water) recovery rate is dependent on sea water quality. A rate of 42% is qualified in the information received from the manufacturer/supplier consulted during the feasibility study. Water quality data from two samples taken during the feasibility study suggest that a rate greater than 42 % is potentially achievable.

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.

Falkland[6] 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. Falkland[7] provided advice (pers comm) that indicated 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 located approximately 20-30m apart.

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.

The final design of the bore field will depend on the test results for bore yield and seawater quality. This work should be conducted in advance of the preparation of final documents for procurement and design as both considerations will have an impact on the plant design and process. One borehole will be sunk initially as a test borehole at each site and will be tested to confirm the sustainable abstraction rate with the other boreholes only being constructed if the tests indicate satisfactory flows. There would be advantages in handling the exploratory

[6] Falkland referred to Marshall and Jacobson, 1985 Holocene Growth of a mid-Pacific atoll: Tarawa, Kiribati, Coral reefs 4; 11-17.
[7] Pers comm. detailed in an email referring to Home Islands in the Cocos Islands (Keeling) Islands.

drilling, the sinking and capping of the boreholes and the water testing as a preliminary stage when drilling equipment associated with other project activities is on-site in South Tarawa.

2. Infiltration galleries

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.

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.

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 used. If this is the case, the filter will be installed on a concrete pad just prior to the raw water storage tanks.

3. Chemicals, handling, transport, storage and use (approach and risks)

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 example the membranes in the Veolia Water SWRO units would be continuously dosed with the Veolia proprietary antiscalant chemical (Hydrex 4101) at a rate of 0.4g/m^3 (estimated usage 150 litres per annum). The toxicological data and exo-toxicological data indicates no environmental issues so discharge with the reject brine stream is an acceptable low cost option.

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.

4. Engineering feasibility design activities

Topographical survey – all sites have been surveyed and the dimensions and contours have been established.

Preliminary design drawings – have been prepared and are presented in volume 2 of the desalination feasibility study report

South Tarawa Road Improvements – the impacts on the road improvements have been assessed and provided for in the preliminary designs. Conduits for services to each site and the brine discharge outfall have been located for placement during the road works. Potential savings can be achieved using surplus excavated material from the road works for site formation. Sea walls could also be constructed.

Feasibility designs for each site – have been developed for network location and implementation details, the typical plant process and profile, and for each site; (i) location, contour and site plans; (ii) services, drainage and landscaping plans; and (iii) cross sections and site development. Other designs and plans have been prepared for construction details, including boreholes, intake gallery, brine disposal system, elevated tower and tank and storage tank mounting details. Sample drawings follow as Figures E7 and E8 on the next page.

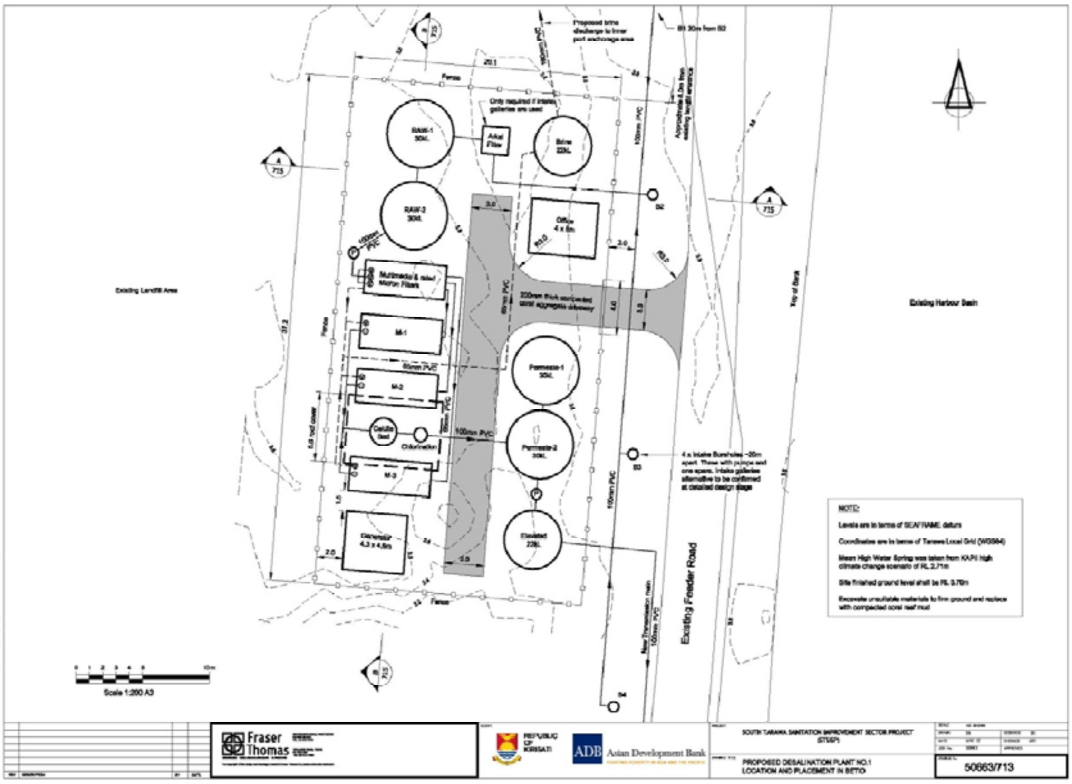

Figure E7: Desalination Plant No. 1 - Site and Contour Plan

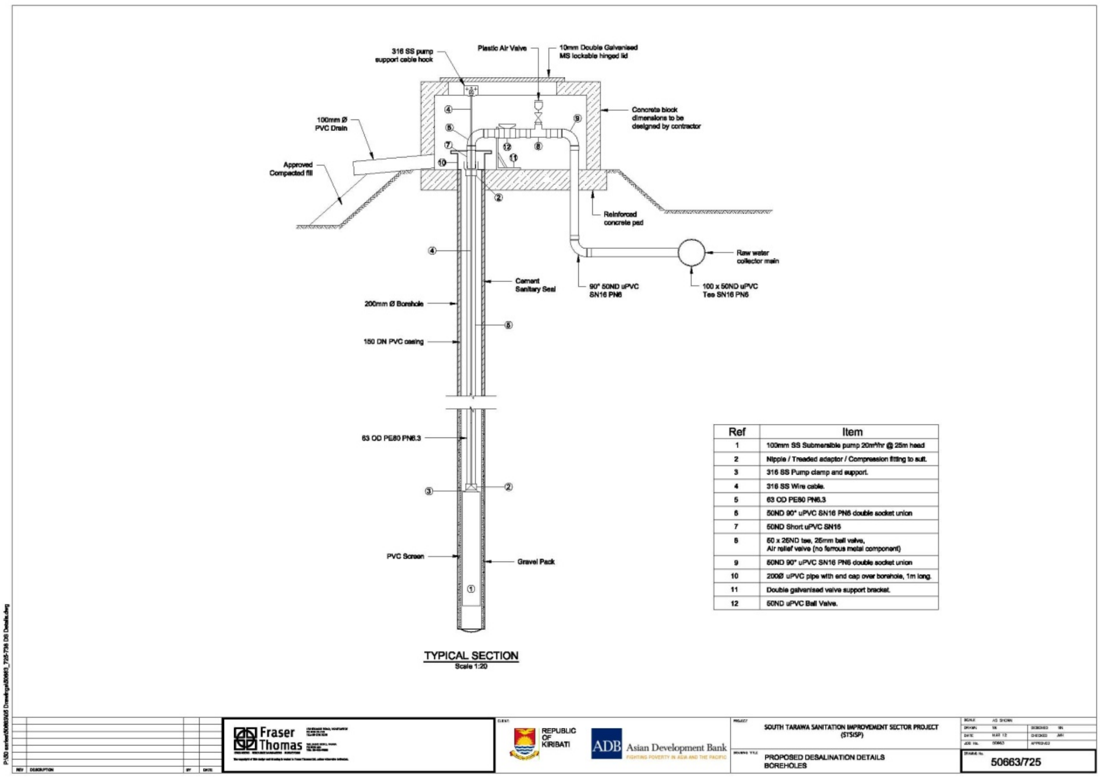

Figure E8: Borehole – Typical Detail

7 Electrical Demand and Related Considerations

7.1 Energy Demand and Annual Costs

An analysis of the energy requirements of the SWRO modules of the size considered by feasibility study has been developed in conjunction with the manufacturer/supplier of the units. The operating costs of power consumption allow for a 40 percent energy saving in the RO modules through the energy recovery processes installed in the SWRO modules. All additional electricity requirements for the bore pumps, line and lift pumps and ancillary power requirements have been calculated. Overall cost has been calculated on the basis of the present PUB charge of $0.70/kWh for government consumers. Production costs and quantities reflect the Opex calculations were also developed in conjunction with the manufacturer/supplier.

The required energy demand and costs are illustrated in Table E1 Below:

Table E1: Energy Demand and Annual Cost

Each site 3 x DX190 SWRO modules

Feed rate 57kL/hr   Treated water production 24kL/hr   Daily production 528kL

Assume 22 hrs per day for 48 weeks per year

No.	Item	kW	No.	kW	Running Hours	kWh	Unit Cost[6]	Daily Cost	Annual Days	Annual Power Cost (A$)
1	Bore pumps[1]	5	3	15	22	330	0.7	231	350	80,850
2	Arkal filter (possible)[2]	0	0	0	-	-	-	-	-	-
3	Low lift pump to filters	2	3	6	22	132	0.7	92	350	32,340
4	SWRO module, HP filter[3]	16	3	48	22	1,056	0.7	739	350	258,720
5	Air conditioning	5	3	15	24	360	0.7	252	350	88,200
6	Miscellaneous on site[4]	0.5	1	0.5	24	12	0.7	8	350	2,940
7	High lift pump to reservoir[5]	7.5	1	7.5	20	150	0.7	105	350	36,750
8	Contingency for larger pumps and other equipment	10	1	10	20	200	0.7	140	350	49,000
	Totals	46	15	**102**	154	**2,240**		1,568		**548,800**
	Allow, generator start-up			**120**						

Power requirements for one site/ hour   **102 kW** per hour   2240 kW/day

Generator allowing for start-up   **120 kVA**

Notes:

1 Three bores each at 20kL/hr – 5.6l/sec

2 Mechanical filter, no electricity required

3 SWRO has energy recovery (40%) process

4 Site office, security lighting and other

5 Lift pump to elevated treated water reservoir

6 Electricity tariff at PUB rate for Government activities

Total energy consumption, 4 sites (rounded)	408 kW/hour	8,960 kW/day
Annual power cost for plant (3 SWRO modules)	$548,800	
Annual power cost, 4 plants (3 modules/plant)	$2,195,200	
Annual water production	528kL x 350 = 184,800kL/annum	

7.2 Network Capacity

1. Feasibility study assessment

Enquiries to PUB during the study, and information made available at the time indicated sufficient network capacity for the plants. Comments on the draft feasibility study report and advice that has since come to hand estimates the future demands from growth and associated development on South Tarawa and presents a case for additional generation capacity. This is a requirement that was bound to occur in the normal event through the present largely uncurbed population growth and as a consequence of the increasing urbanisation. On their own and as an essential priority service there is capacity which could be dedicated to the desalination plants, but all demands are considered equal additional generating capacity will be necessary in the immediate future.

An example of competing demand is the new fish processing plant near Betio port. The EIA submitted for the venture indicated an energy demand of 500kW, for which the company intended installing its own generator. For water supply the EIA stated the company would install a dedicated desalination plant and operate this using the installed generating capacity within the plant without placing a demand on the PUB water supplies. The feasibility study has experienced difficulty in establishing the actual demand with PUB reports indicating a requirement for 800 kW from their network (against the originally stated 500 kW). Other statements refer to the possibility that a generator may be in the process of being installed but this is still to be confirmed. The preferred desalination operating scenario depends to a large extent on how power is supplied to the fish factory and this needs clarification as the outcome has an impact on Opex.

Earlier information provided placed the peak demand for 2012 at 4,550 kW with a generating capacity of 5,450 giving a surplus of 950 kW, sufficient for the short duration peak loadings of the desalination plants. The World Bank solar generation project was forecast to add an additional capacity of between 300 and 800 kW depending upon climatic conditions and the impact of inclement weather and cloud cover on energy production.

2. Updated assessment

Updated information now provided by PUB indicates the probability of a 2016 peak loading of 5,830 kW (allowing an annual 4% growth in demand) and a immediate future demand of 1,350 kW for the fish processing plant (800 kW), the Temaiku subdivision (300 kW) and a backlog of new connections (250kW), in addition to the desalination plants (408kW). PUB identifies a requirement for additional generating capacity estimated as 2,183 kW and raises the need for an additional 3.6 MW of generating capacity.

In the short term there would appear to be capacity to operate the desalination plants, with the option over time of managing production by either ceasing or scaling down production during periods of peak hour demand with reliance on stored supplies for water supply distribution, or by operating during these periods by automatic switch-over and use of the stand-by generators installed at each plant.

7.3 Solar Power versus Diesel Generation

The terms of reference required consideration of solar power for the energy to run the desalination plants. The requirements for solar energy and its suitability for powering the desalination plants were analysed. For reasons of the sheer size of the photovoltaic panels (4,200m2 for each desalination plant), the large banks of batteries required to store energy for operations during poor and cloudy weather, and during night hours, and the additional need to house the batteries in stable conditions with air conditioning to maintain temperatures for peak operating efficiency, the solar option was found to be both expensive and impractical.

Providing a continuous water supply over a 24 hour period and at times of low insolation also meant that power for desalination would have to be sourced from an alternative, back-up source as well as sunlight, if satisfactory levels of service are to be met. The use of a backup power source was found to entail considerable sophistication in terms of the complexity of control systems and operator competence. The technology to do this is also not well developed at present. The conclusion was that solar power cannot be used conveniently to power the desalination units.

8 Estimates of Cost

8.1 Bills of Quantities

Comprehensive bills of quantities scheduling the anticipated items of work have been developed for the four desalination plants and are incorporated in the feasibility study report.

8.2 Estimates of Cost

Estimates of cost have been developed from 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 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.

As a further cross check the unit rates and costs for the construction of protective sea walls have been used to define the costs for similar work associated with the desalination plants. Contingencies appropriate to project risk and detailed design and supervision costs have been allowed for.

Tables E2 and E3 below 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 E2: 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 E3: 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**

9 Due Diligence Considerations

9.1 Resettlement

The four proposed sites are located on government owned and controlled land. No resettlement or land and crop compensation issues are anticipated.

9.2 Environmental Assessment

An Environmental Assessment and Review Framework (EARF) has been prepared bt TA 7359-KIR for the South Tarawa Sanitation Improvement Sector Project (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 (IEE) for the supply, installation and operation of SWRO plants has been prepared and contained as an appendage to the report. 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.

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 Environmental Management Plan (EMP) for the project. No further environmental assessment is therefore required.

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 at less frequent, half yearly intervals

9.3 Economic Assessment

1. Without project scenario

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)[8]. 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 rehabilitation and improvements to the Bonriki/Buota supply is illustrated in the figures E9 and E10, 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.

[8] 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)

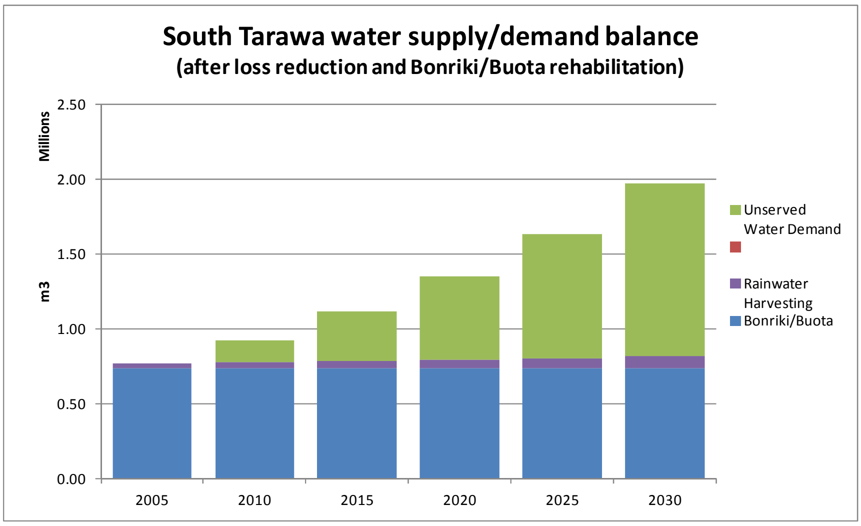

Figure E9: Water Supply Balance after Leak Detection and Bonriki and Bouta Improvements

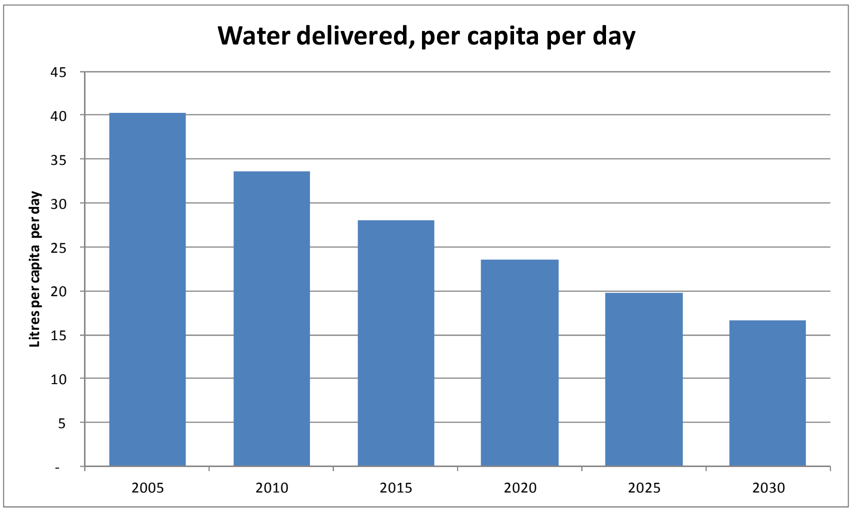

Figure E10: Water Delivered per Capita per Day

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 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 have been estimated. 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 are the basis for quantifying the benefits of the with project scenario.

2. With project scenario

The SWRO project operating period is 30 years following full commissioning of the desalination investments in 2014. All benefits and costs have been 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[9]. 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.

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.

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 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 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.

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

3. EIRR and ENPV

Given the very high 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.

4. Sensitivity analysis

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).

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.

10 Strategies for implementing Desalination

1. Reduction of leakage and wastage

Before desalination proceeds urgent measures will be to be taken to ensure the required investments in desalination are sustainable. Foremost amongst these will be steps to significantly reduce leakage and wastage and to recover actual costs. The proposed measures 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.

The production of water by desalination, while more practicable and cheaper than the other options available, has a relatively high cost. It is therefore desirable for the water produced to be distributed 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 an SOE the minimum requirement again is recovery of the cost of supplying water. Failure to achieve this will mean certain economic failure for PUB. Community Service Obligation (CSO) allocations towards general operations also need to be based on justified requirements with monitoring and reporting to ensure application towards the declared purpose.

2. Isolation and suspension of parts of the distribution network

The approach to implementation follows that recommended by the Tarawa Water Master Plan providing for the isolation and suspension of the distribution network which is the excessively leaking parts of the system, with water being supplied from fixed points such as existing village head tanks, or installed standpipes and temporary water kiosks throughout villages, or by tanker from main storage points.

While the suspension of parts of the reticulation system may be viewed as a backward step for South Tarawa's urban water supply, it was promoted by the Water Master Plan and now supported by this feasibility study as an approach that would dramatically cut waste and the cost of supplying water and a method of ensuring that all water produced is 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 approach adopted therefore conforms to that outlined as appropriate in the Tarawa Water Master Plan (Section 6.2 Leakage Reduction). The Tarawa Water and Sanitation Roadmap 2011-2030 favoured delaying the implementation of the desalination plants until closer to 2015 when the leak detection programme was well in hand with substantial progress in the reduction of the leaks and wastage. The rationale was the inappropriateness of producing high quality potable water, to lose significant volumes without generating the level of income necessary to sustain the desalination operations.

Development partners have raised the possibility of earlier implementation resulting in a reassessment of the approach to be taken for the managed suspension of sections of the network, in the manner foreshadowed by the Tarawa Water Master Plan. The key requirement for the division of the network into "blocks" for partial suspension while the leak detection programs proceed is the balance that will need to be maintained between the 24 hour production of the desalination plants and available reservoir capacity. There is, in practical terms, no ideal match between production and the reservoir capacity required to absorb the production rate of the newly installed desalination plants, especially the production overnight when consumption is minimal.

3. Location of desalination plants

Two desalination plants are required to serve the needs of Betio, and two further plants are required for the needs of the balance of the western zone (Bairiki, Teaoraereke, Antemai). The smallest service division then becomes that where the available reservoir capacity, plus the storage at the desalination plant site balances with production. For Betio, where the main reservoir capacity is in a central location, fed directly through transmission mains from the desalination plants the smallest division is the whole of Betio. For the remaining section of the western zone the location of the available reservoirs together with the storage at the proposed water kiosks would allow for division of the area into two sub-zones, one centred on Bairiki, and the other incorporating Nanikai, Teaoraereke and Antemai.

For the eastern zone fed from the Bonriki and Bouta water reserves the losses are somewhat historical and can possibly be tolerated for during the transition period. Here division could occur on a village by village basis, provided PUB and the Government accept the costs of the unaccounted for water loss.

4. Desalination plant operation and distribution zone suspension

Comments have been received on the draft desalination study report suggesting the smallest possible areas for the suspension of supplies. In the light of the comments received three options could be considered: (i) to install and operate the desalination plants with the acceptance of large volumes of the production water being lost through leakage and wastage; (ii) to install and commission the plants but refrain from connecting these to the system until the leak detection is well advanced; or (iii) to base the suspension on the minimal division indicated above which is the approach favoured by the desalination feasibility study.

5. Community "buy-in"

An important consideration also is the time needed for 'buy-in' of the community for paying for piped water. All customers must be metered, must refrain from tampering with their connections, and must drastically reduce wastage. The Master Plan has concluded, appropriately, that acceptance of the need to pay a higher tariff for piped water and reduction in wastage will only come after clear demonstration that the level of service has significantly increased. For this to happen, it is crucial that the transition period is well carried out, with high-quality water continuously supplied under the terms offered. Thereafter, it is essential that PUB exercise high standards of customer service, detecting leaks, meter tampering, and illegal connection; with provisions to enforces payment through disconnections as necessary.

11 Maintenance and Operations

The Water and Sanitation Roadmap identified the importance of a procurement process that delivered the "best" desalination plants to guarantee at least 10 years or longer operating life. The Roadmap also identified four options for the subsequent management/maintenance of the plants; (i) Design, Build, Own and Transfer (DBOT); (ii) Design, Build, Operate and Maintain (DBOM); (iii) Contracted management; and, (iv) Contracted maintenance.

1. Possible management, maintenance and operations options

DBOT would involve proposals from qualified companies to design, build, own and operate the plants under a franchise granted by government for a period normally aligned to amortisation of the original investment. After the period the plants would transfer to PUB, with the option of a continuing management contract with the company concerned. There are variations on the DBOT concept.

DBOM provides for selection of a company to design, supply, operate, manage and maintain the plants, with PUB purchasing the water on a "take or pay" basis. This removes operational and maintenance risks and could provide for further company investment to extend production. While reducing PUB risks it has implications of a higher cost of water and the obligation to take and pay for the production of the plants.

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.

Contracted maintenance contemplates a contract with the manufacturer/supplier for an agreed period with an agreed program for routine and planned maintenance. PUB would retain ownership and management/operation of the system.

2. Analysis of options

These options together with possible privatisation and a public/private/partnership have been analysed by the study and the advantages, disadvantages and the risks for each party (Government, PUB and the private company) have been assessed.

The option favoured by both the SWRO manufacturer/supplier consulted and PUB maintenance contract for a period of up to five years, renewable beyond the initial period.

Options for privatization, public/private partnership, build/operate and transfer and design/build and lease and all variations of this concept carry high risks for the private sector partner that would normally be recognized through a higher return on investment, and as a consequence higher tariffs and charges. More significantly the condition of the PUB's water assets and their inflated book value together with the present debt ridden and undercapitalized operations raises some doubt as to whether any potential investor would investing in the system, wholly or in part especially given the investments required to rehabilitate and improve the system and still achieve a commercial return on the investment.

The option of the maintenance contract presents an acceptable and manageable risk for private sector involvement. The approach also has the added advantage of maintaining ownership and management of the system with the Government and PUB together with the associated policy and regulatory functions.

12 Operating Requirements, Tariffs and Affordability

12.1 Operating Requirements and Tariffs

The Political Economy Analysis of Water and Sewerage Services[10] and the "Fees and Charges – Sustainability" section of the Tarawa Water and Sanitation Roadmap 2011-2030, both prepared in conjunction with TA 7359-KIR, provide a firm analytical framework for the determination of tariffs and CSO allocations, based on the costs of providing water in the medium to longer term from the parallel supplies of the desalination plants and Bonriki/Bouta. The following key principles and criteria have been adopted

- Recognition that the poorest 20% of households (25% of the population) will have difficulty in paying utility charges provided on credit and billed in arrears. As demonstrated in strong pre-paid services markets in South Tarawa (e.g., cell phone, public transportation), households with very limited ability to pay can purchase urgently required pre-paid services as needs arise.
- A lifeline block per household per month is proposed, to be charged at a lower rate than non-domestic consumers and better-off households consuming more than the lifeline block in litres per month. The modality of the payment will be purchase when the water is supplied, or pre-paid.
- In the short to medium term a water cost recovery target of 80% (by 2016) for domestic customers is recommended, rising to 90% by 2020.
- Acceptance that households should spend no more than 5% of household income on combined water and sewerage services. This level of expenditure can largely be managed by choice by the majority of households.
- Business owners should not cross-subsidise to water and sewerage services provided to domestic customers. 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, reducing to 20% in 2016 and thence gradually reducing to 10% by 2020. This degree of bad debt reduction is considered feasible given the introduction, under the project, of rigorous revenue collection and arrears reduction efforts by the PUB, assisted by the widespread implementation of prepayment meters as the distribution system is

[10] TA 7359-KIR, The Political Economy Analysis of Water and Sewerage Services, 2012.

upgraded. The analysis contained in the report shows total revenues rising from about 50 percent of costs in 2012-2013, to about 90 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 (STSISP)). The SMF would largely cover network and Bonriki/Buota refurbishment as discussed earlier, 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. The SMF is intended only to assist the PUB to meet the costs (and thus aggressively implement) leak detection and other network upgrade operations for a period of time – it is not related to the PUB's needs for operating revenue. Thus in the tariff and broader community service obligations (CSO) calculations discussed in report, the SMF is not included as a tariff-offsetting source of revenue.
- The tariff-offsetting CSO allocation (subsidy) from government, as shown in Table 17 of the feasibility report, does not include any allowance for the SMF. During the network suspension period (2013-2015), the need for government support to keep PUB afloat financially reaches $1.5 million, $2.2 million, and 2.0 million in 2013, 2014, and 2015 respectively. Once the upgraded network is pressurised, however, under the proposed tariff schedule, operating support from the government begins to fall significantly, from about $0.8 million in 2016 to about $0.3 million by 2021.

During the transition, however, it is not intended that households should also suffer financial hardship in procuring a survival-level volume of water. 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 with 5.0kL representing a 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, and will pay more for it, through own-transport costs and PUB cartage charges. Better-off households will pay the rate of $2.00/kL during the transition, but will pay a higher rate of $3.6/kL from 2016, rising to the full cost recovery level of about $4.50/kL by 2021, after they are connected to the refurbished network).

The level of the tariff for consumption in excess of the lifeline volume should be sufficient deterrent to high consumption and wastage. Other block tariffs could be considered, but increased tariffs will impact upon affordability and the ability to keep water and sanitation tariffs close to the normally accepted guideline of 5% of household revenue.

12.2 Affordability

Table E4 presents an 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 $5,420 from 2017 onwards. The Household Income and Expenditure Survey (HIES, 2006), reported the average income of a poor household in South Tarawa at that time as 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 $12,000 to 2021. According to the HIES, the average income of a non-poor household in South Tarawa in 2006 exceeded $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 to 2021.

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 E4: Annual and Monthly Household Expenditures on Water and Sewer based on Proposed Tariffs

Domestic sector: annual and monthly water supply + sewer costs per household ($)										
***Poor Households**, Water Supply Costs*										
Annual	120	120	120	145	181	181	181	181	181	181
Monthly	10	10	10	12	15	15	15	15	15	15
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	241	271	271	271	271	271
Monthly	10	10	10	17	20	23	23	23	23	23
*For affordability (sewer+water costs=5% income), expenditures imply **poor household** income of*										
Annual	2,400	2,400	2,400	4,100	4,819	5,419	5,419	5,419	5,419	5,419
Monthly	200	200	200	342	402	452	452	452	452	452
***Non-Poor Households**, Water Supply Costs*										
Annual	60	291	267	304	440	458	488	488	502	508
Monthly	5	24	22	25	37	38	41	41	42	42
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	500	548	578	578	592	598
Monthly	5	24	22	30	42	46	48	48	49	50
*For affordability, water and sewer expenditures imply **non-poor household** income of*										
Annual	1,200	5,823	5,345	7,278	9,994	10,959	11,569	11,569	11,837	11,969
Monthly	100	485	445	606	833	913	964	964	986	997