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Ebeye Water Supply and Sanitation Project, Ebeye, Kwajalein Atoll, Marshall Islands

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Summary

Ebeye Water Supply and Sanitation Project comes in response to high levels of waterborne disease on Ebeye. In addition, the project is intended to improve access to safe water and sanitation and promote behavioural change to improve hygiene standards. The master plans for the project comprise infrastructure development and priority interventions for water supply, sewerage and electricity development. In particular, the master plan for the water supply improvements component comprise installing a new reverse osmosis plant along with two new saltwater wells and freshwater pumping station. It also consists of installing a new freshwater tank, constructing a short brine outfall, and upgrading water distribution system. The hygiene awareness component of the project is aimed at improving hygiene behaviour on Ebeye. Safeguard studies have also been prepared including social, poverty and gender assessments, environmental assessments, financial and economic analyses of the interventions and a proposed tariff structure for the power, water and sewerage utility, KAJUR (Kwajalein Atoll Joint Utilities Resources). The project also seeks to make KAJUR self-sustainable financially and administratively through capacity building programmes. The project is estimated to cost USD 19.2 million dollars, and ADB, DFAT Australian Aid and the Compact are the three grantees for the project.

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Acronyms and Abbreviations

ADB	Asian Development Bank
CFA	Compact of Free Association
EWSSP	Ebeye Water Supply and Sanitation Project
KAJUR	Kwajalein Atoll Joint Utilities Resources Inc.
MMF	Multi-Media Filters
MSF	Multi Stage Flash (Distillation)
PPTA	Project Preparation Technical Assistance
RMI	Republic of the Marshall Islands
RO	Reverse Osmosis
SWPS	Saltwater Pumping Station
SWRO	Sea/Salt Water Reverse Osmosis
USD	United States Dollars

1 Introduction

Ebeye is a small low-lying coastal islet located at Latitude: 8°47'33"N and Longitude: 167°44'56" E at the southern end of Kwajalein Atoll, the world's largest atoll. Kwajalein has a total land area of 16 km^2 with about 90 islets surrounding a 1,700 km^2 lagoon. Ebeye alone has an area of approximately 0.31 km^2 and a population of 9, 614 according to 2011 Census. In addition, 1103 of the total 1370 households in Kwajalein Atoll are found in Ebeye with an average household size of 8.7 persons, making it the most crowded area within the Marshall Islands. However, with an estimated growth rate of 0.4% per annum and limited sources of fresh water, Ebeye is vulnerable to water security challenges. In particular, Ebeye has recorded increasingly high cases of water borne diseases because of limited access to safe water, poor hygiene and a dilapidated sanitation system. Kwajalein Atoll Joint Utilities Resources (KAJUR) Inc. is the responsible authority to oversee the water supply and sanitation services in Ebeye. It provides 84% of public fresh water supply in the region; the other sources being rainwater (15%) and bottled water (1%). KAJUR has been operating the Sea Water Reverse Osmosis (SWRO) plant that was commissioned in 2001 with a treatment capacity of 757 m^3/d. The plant was upgraded to a treatment capacity of 1325 m^3/d. However, several factors have led to an inefficient operation of the plant and as such, only 192 m^3/d is produced every day. The situation is further aggravated by a high amount of water losses (about 25%) in Ebeye. These factors have culminated to bring water shortages to an increasing population as projected water demands for the year 2013-2025 have shown for low, medium and high population growth projections of 0% p.a., 0.4% p.a., and 0.8% p.a. respectively. The projections have been shown in Figure 1 which depicts that the water demand may vary from 1450-1490 m^3/d in 2015, 1450-1550 m^3/d in 2020, and 1450-1620 m^3/d in 2025.

Set against this backdrop, the Project Preparation Technical Assistance (PPTA) titled 'Ebeye Water Supply and Sanitation Project (EWSSP)' was planned with an overall objective to reduce the incidence of waterborne disease and improve the sanitary conditions of the place. The specific objectives of the project include:

i. Enhanced awareness of hygiene and water issues and sustained hygiene behaviour
ii. Secure and safe freshwater supplies
iii. Effective, efficient and safe sewerage services
iv. KAJUR is financially and technically sustainable

Table 1 shows the overview of the Ebeye Water Supply and Sanitation Project.

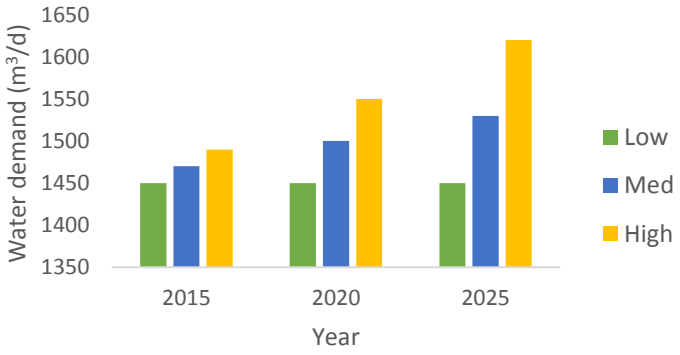

Figure 1: (Projected) Water demand of Ebeye (GHD, 2015)

Table 1: Overview of Ebeye Water Supply and Sanitation Project (GHD, 2015)

Items		Description
Project Name	:	Ebeye Water Supply and Sanitation Project
Type	:	Water Supply and Sanitation
Donor Name	:	i. Asian Development Bank ii. Government of Australia iii. Compact of Free Association Agreement (US-RMI)
Project components	:	i. Component A: Water Supply Improvements ii. Component B: Wastewater System and Sanitation Improvements iii. Component C: Electrical System Improvements iv. Component D: Hygiene promotion and awareness v. Component E: Project implementation assistance, institutional strengthening and capacity building of KAJUR
Project Fund	:	Total: USD 19, 214, 050 Component A: USD 6, 639, 000 Component B: USD 3, 505, 000 Component C: USD 1, 073, 000 Component D: USD 250, 000 Component E: USD 2,870,050 Contingencies: USD 3, 013, 320 Taxes and duties: USD 1, 863, 680
Project Duration	:	From September 2015 to June 2022

In this report, only component A, water supply improvements, has been described. The components B to E are beyond the scope of this report (except in cases of occasional mentions in association with the water supply component).

2 Technical and technological brief

Component A (Water Supply Improvements) of EWSSP comprises of Sea Water Reverse Osmosis (SWRO) plant with saltwater abstracted from two wellfields located on either of North and South end of the island as shown in Figure 2. A master plan prepared for the period 2013-2025 addressed the immediate needs, medium term needs (2015-2020) and longer term needs (beyond 2020) for water supply in Ebeye. The master plan was based on the medium term population growth rate projection of 0.4% per annum which indicates that the population in Ebeye in 2025 will be 10, 617. The estimated average water demand for Ebeye by 2025 is 1600 m^3/d, assuming 25% losses can be achieved by the end of the water supply master plan period. This is based on a per capita water demand of 0.105 m^3/capita/day and excludes toilet flushing water which is sourced from salt water. On the whole, the contents of the master plan for water supply in Ebeye can be summarised in the following headings:

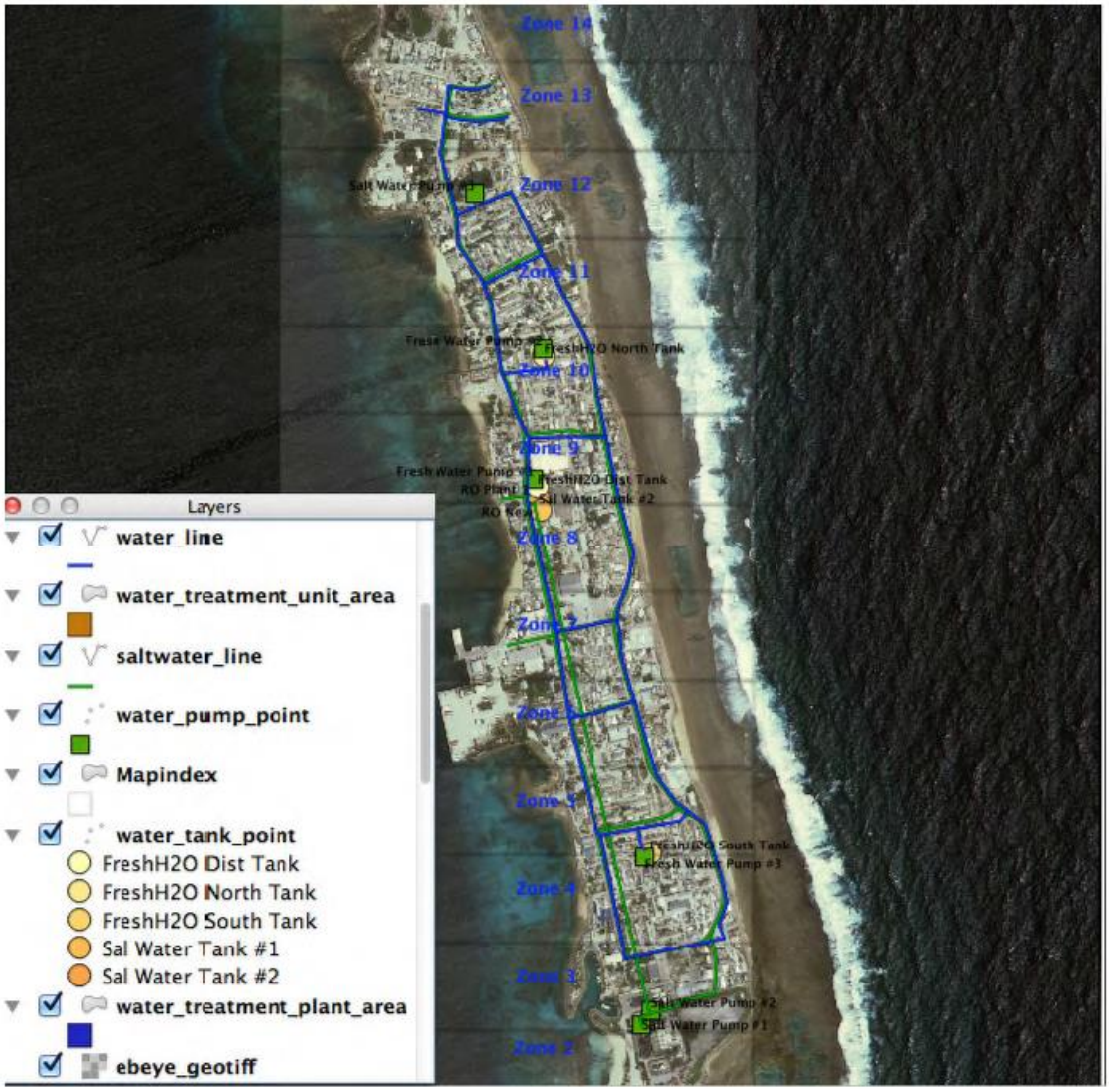

Figure 2: Overview of Ebeye Water Supply System (GHD, 2014)

2.1 Raw water production and transmission

Sea water (saltwater) is currently abstracted from three wells located at two wellfields at the North and South ends of the island. Southern wellfields contain two operating wells and pumping installations. One of the pump stations supplies Salt Water Reverse Osmosis (SWRO) plant while the other is involved in saltwater sewerage flushing system. Likewise, Northern wellfield has a single well with a motive to supply Northern portion of saltwater sewerage flushing system and supply excess saltwater to RO plant. A groundwater study revealed that the required water demand for 2025 could be supplied from the two boreholes at the south and north ends of the island. However, the transmission pipelines from the boreholes to SWRO plant needed upgradation. Further analysis showed that it would be economic to construct two new boreholes at the SWRO plant site and use the existing borehole as standby or as a continued supply of saltwater for toilet flushing. Technically, all the three wells are equipped with centrifugal pumps to abstract water. The abstracted water from pump station is channelled through 6”/4” (15 cm/10 cm) diameter PVC pipelines to SWRO plant. The capacity of dedicated pipeline limits to 1037 m^3/d. In order to balance flow from salt water wells, two 946 m^3 storage reservoirs with

the corrugated iron roof are built near water treatment plant. The quantity of saltwater currently being used for feed water to transmit to the 568 m^3/d SWRO Unit 3 and the 114 m^3/d containerized RO Unit 4 are shown below in Table 2 whereas the capacities of the pumps used for transmission have been tabulated as shown in Table 3 and Figure 3. The overview of the water supply infrastructures has been shown in Figure 4.

Table 2: Freshwater production and concentrate flows in March 2014 from RO units (GHD, 2015)

	RO unit		
	RO Unit No. 3 (nominal 568 m^3/d)	**RO Unit No. 4 (nominal 114 m^3/d)**	**Combined 3 & 4**
Permeate (or product) water (m^3/d)	553	78	631
Concentrate (or brine or reject) water (m^3/d)	1305	147	1452
Total (permeate + concentrate) (m^3/d)	1858	225	2083
Ratio (permeate/total)	0.30	0.34	

Table 3: Average saltwater production flows in March 2014 (GHD, 2015)

Pump	**Average flow (m^3/d)**
1 (eastern pump 1B only)	1037
2	1988
3	1988
Total	**5013**

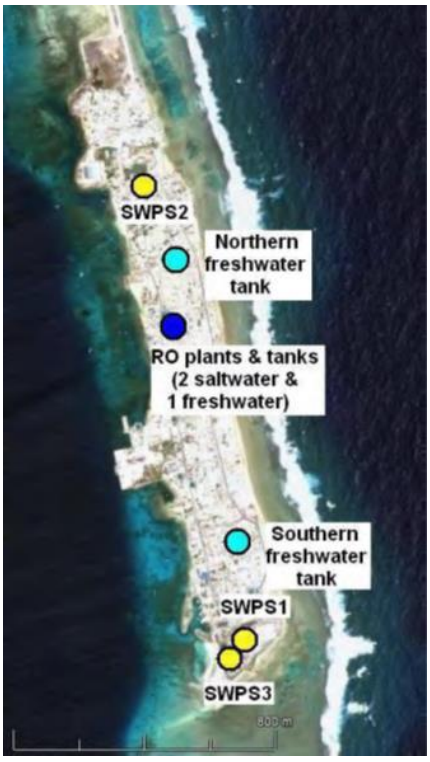

Figure 3: Seawater pump station locations (GHD, 2014)

Figure 4: Southern Ebeye location showing locations of water supply infrastructures (GHD, 2014)

2.2 Water treatment plant

The water treatment plant contains three RO units; two of which are of capacities 379 m^3/d while the other with 568 m^3/d. The schematic of the prevalent water treatment system in Ebeye has been shown in Figures 5 and 6. However, only the unit with capacity 568 m^3/d is functional but the procurement time for membranes is considerable. The membrane holders require some retrofitting to accept newly procured membranes, which may contribute to some loss in water quality. The range of water quality produced by the RO plant fluctuates in the order of 450 – 500 mg/L TDS which is still an acceptable drinking water supply. KAJUR is concerned that RO3 will not remain in workable order for the time required before a replacement could be provided under the investment project resulting in a water crisis and has considered procuring a 757 m^3/d unit under funding from the CFA infrastructure fund. A containerized plant with capacity 114 m^3/d was provided by USAID which was commissioned and is used to supply residents at a standpipe located adjacent to the SWRO plant. The treatment plant comprises low pressure and high-pressure pumps, media and cartridge pre-filtration, RO membranes, antiscalant dosing and disinfection unit with appropriately dosed liquid chlorine. Likewise, the brine rejects water is discharged at foreshore via pipeline.

Because of the inefficient operation of the plant, it was proposed to provide a new treatment system to provide for 2025 needs. The Master Plan proposes early replacement of the existing RO plant with a new facility with capacity 1628 m^3/d. The existing unit RO3 may be retained as a standby and the 114 m^3/d containerised plant could continue to deliver water to the public standpipe or augment to supply to the distribution system. The layout of this proposed development has been shown in Figure 7.

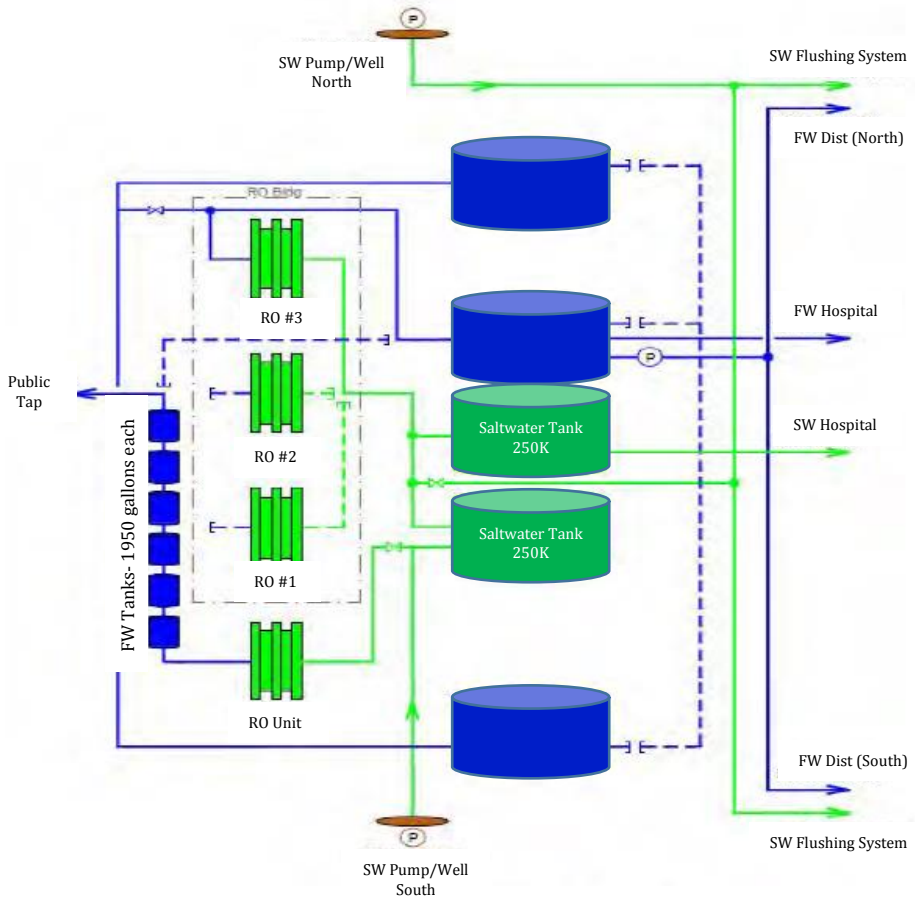

Figure 5: Schematic of water treatment system in Ebeye (GHD , 2014)

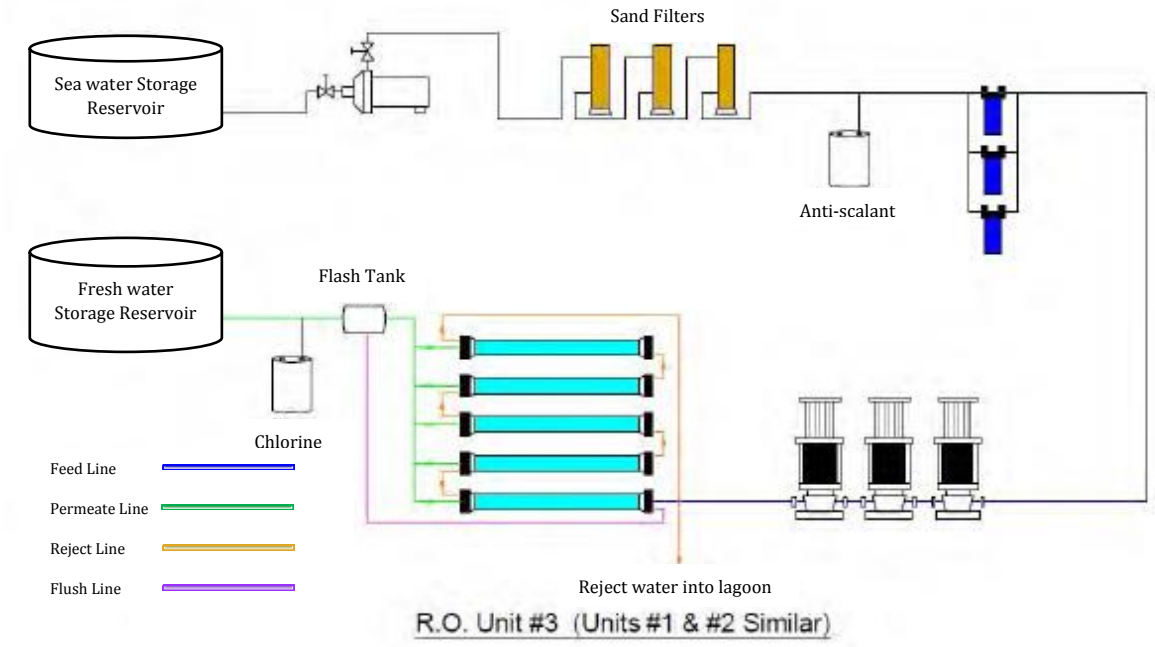

Figure 6: Reverse Osmosis Flow Diagram (GHD , 2014)

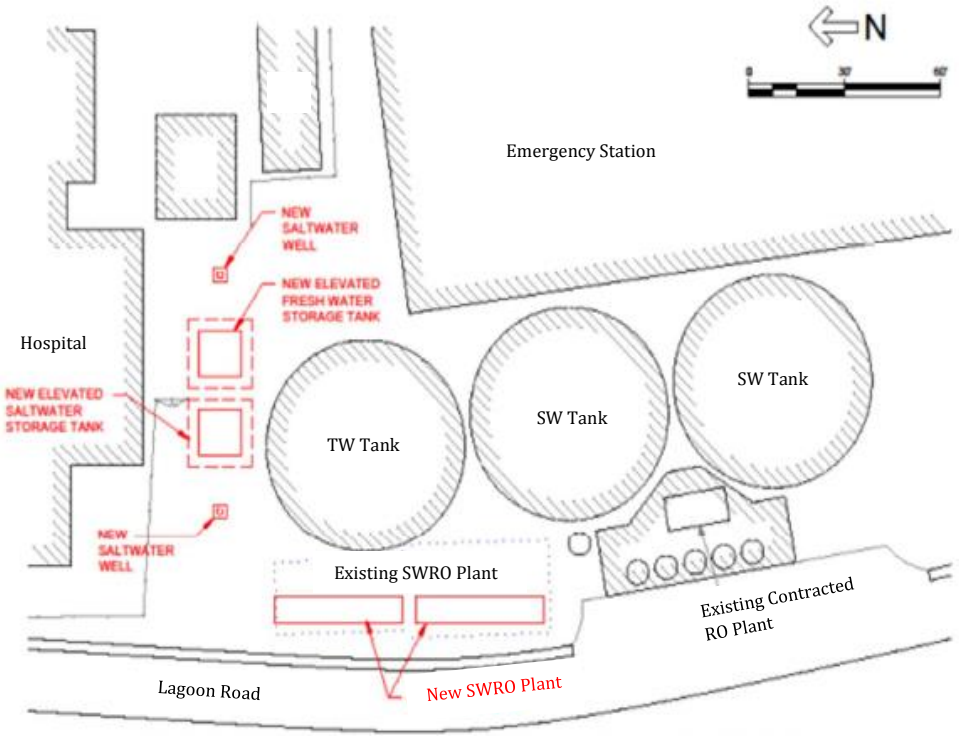

Figure 7: Layout for SWRO plant development (GHD, 2015)

2.3 Freshwater storage reservoirs, pumping stations and transmission

With the same design as that of salt water storage reservoirs, the water distribution system has three units, each of 947 m^3 capacity. However, only the central reservoir and pumping station are operational. Currently, KAJUR is involved in rehabilitating North and South zones with intents to maintain pressure at zones. Central pumping station contains two pumps; one pumping into the main distribution system and North camp water system while the other to the public standpipe. Finally, the distribution is made through 4.5 km of 6" (15 mm) diameter PVC pipe over most of the island. Out of total 1100 households, 857 are benefited by the water connections using 92 distribution gate valves with diameters 4" (10 mm) and 6" (15mm).

3 Financial brief

EWSSP was initially estimated to cost USD 15.2 million. However, an additional fund worth USD 4 million was negotiated in 2015 between the RMI and ADB; thus the revised estimated cost of the project is USD 19.2 million. As shown in Figure 8, component A, i.e. the water supply improvement, has been allotted 34.55% of the budget share, amounting to USD 6.639 million. Similarly, components B and C, i.e. wastewater system and sanitation improvements, and electrical system improvements have each received 18.24% (USD 3,505,000) and 5.58% (USD 1, 073, 000) of the total budget share. The remaining budget has been allotted for the hygiene awareness and education programme (1.30%), project implementation assistance (including taxes, duties and contingencies) (37.71%), and institutional strengthening and capacity building of KAJUR (2.60%). ADB, DFAT Australian Aid and the Compact are the three grantees for the project with 26% (USD 5 million), 21% (USD 4 million) and 53% (USD 10.2 million) contributions to the total budget.

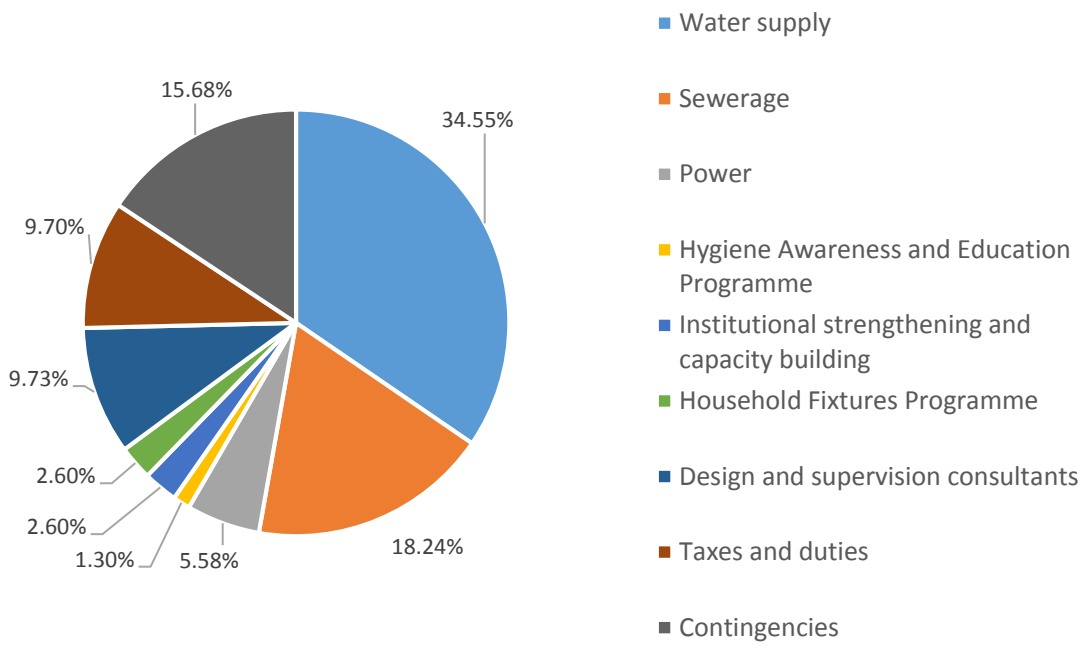

Figure 8: Proposed budget allocation for various components of the project (GHD, 2015)

4 Project features

4.1 Technical and technological features

The master plan for water supply presumed to achieve an average water demand in Ebeye by 2025 as 1601 m^3/d with a loss of 25%. With the required water demand on mind, the project offered water supplies from two boreholes at south and north ends of the island. Also, it suggested for construction of two new boreholes at SWRO plant site and use the existing ones as standby. Among the three RO units, only one is functional with a capacity of 379 m^3/d. The power consumption of at the RO plant is 10.72 kWh/m^3 resulting in water production cost of USD 5.36/m^3. The conductivity of water produced is measured to be 450ppm. The supply of RO water is made by standpipes to water tankers. In addition, the SWRO plant will also have the following key components:

- 2 sets of Multi- Media Filters (MMF) each designed for 803 m^3/d;
- Pre-treatment dosing equipment including antiscalant dosing;
- 2 Reverse Osmosis units each designed for 803 m^3/d;
- Post-treatment equipment to make portable the RO permeate including hypochlorite dosing and possible a calcite filter;
- Clean in place system including tank, heater and distribution pump;
- Programmable logic controller (PLC) for the above equipment;
- Operating manuals, documentation etc.

4.2 Economic and financial features

Existing parameters and indications of the projected signal to a strong performance both economically and financially. The project addresses the precarious situation of increasing water

borne diseases on the island by providing safe water in adequate quantities. It is also expected to contribute to minimizing onshore and marine pollution by strengthening the sewerage system. In addition, improving KAJUR's financial stability will lead to an expansion of its revenue base and recovery of the costs expended for the upgradation, operation and maintenance of the water supply system. The project internal rate of return (IRR) is 14.8%, with an economic net present value of USD 3.1 million. The project financial internal rate of return is 19.1% with a financial net present value USD 43.0 million. Project performance is 'robust' to adverse changes in key cost and benefit parameters, both economically and financially (GHD, 2014).

4.3 Social and environmental features

Ebeye water supply and sanitation project focuses to mitigate the alarming statistics of incidences of debilitating and life-threatening diseases in public. The reduction in trends of non-infectious diseases like gastritis, gastroenteritis, amoebiasis, giardiasis, cholera, diarrhoea and various forms of hepatitis that are presumably caused by unsafe drinking water and unhygienic behaviours have been targeted by this project. The project also impacts on the socio-economic status of the inhabitants in Ebeye when the tariff scenarios are adjusted based on household survey.

Similarly, as all the consumers of drinking water would be metered, there will be less probability of losses in water sales thereby eliminating potential arrears. Likewise, the increment in fresh water production from sea water and proper delivery would supplement the commercial and governmental consumers by over 230%, while pipeline losses would reduce to 25% from initial 50%. In addition, proper drainage installations due to the maintenance of toilets would reduce salt water from flushing thereby causing land and marine environment greatly improved. However, construction works might have some adverse environmental impacts and hence will have to be minimized to an acceptable level by environmental management plan (EMP) component. Also, the civil works on land will cause temporary resettlements since several fences have to be removed in the expansion of water supply and sewerage system. The project does not have any impacts on any groups of indigenous people.

5 Project benefits

With expectations to bring various positive impacts, the project has direct benefits to local people. The inhabitants will have better access to safe drinkable water and help in promoting sanitation and hygiene standards. In addition, the project aims for secure and safe freshwater supplies as well as provide effective and efficient sewerage services. The health benefits of the project can be discerned to the facts of lesser water borne diseases which were once averaging 1182 cases per year resulting from limited access to safe water, ineffective hygiene behaviours and a ruined sanitation management system. With improved conditions, the Ebeye RO plant produces 379 m^3 with an average of 0.04 m^3 per person. The improved sanitation system is consistent with RMI's strategic development strategy, Vision 2018, for improved hygiene and sanitation, and reliable and affordable water and sanitation infrastructure. This vision is also aligned with ADB's strategy 2020 would contribute to improved public health under water and sanitation investments; ADB's Approach to Assisting the Pacific (2010-14) in improving supply and delivery of water and sanitation services; and ADB's Water Policy and Water Operational Plan (2011-20) in increasing the efficiency and productivity for channeling of water services with focus on sanitation and wastewater management.

6 Implementation status of the project

After the concept clearance of the project on 20 December 2012, one week of the time period was allocated for fact finding. Finally, the Ebeye Water Supply and Sanitation project was approved on 28 September 2015 and is expected to finish by 30 June 2022. After the signing made on 13 October 2015 by ADB, the project effectively began on 03 December 2015 and has been active ever since.

Among the five primary components of the project, each of them has progressed well to date. For secure and safe freshwater supplies, two new salt water wells had been constructed and commissioned by KAJUR at the end of December 2015. Similarly, SWRO plant having a capacity of 1.6 million litres per day have been commissioned on July 2016 while management by the supplier seems to be carried out till June 2021. Similarly, milestones for rehabilitation of water supply system and its expansion to unserved areas are projected to reach by October 2018. In addition to this, contracts for project outputs with project implementation assistance consultants have been made by 21 October 2015. Also, contracts on SWRO supply, installment and managements were carried out by the same date. Likewise, for effective, efficient and safe sewerage services, the new sewage treatment facilities and effluent outfall have been commissioned by October 2017.

7 References

GHD (2014). *Appendix D: Interim report for Ebeye Water Supply and Sanitation Project.* Canberra: GHD Pty Ltd.

GHD (2015). *Marshall Islands: Ebeye Water Supply and Sanitation Project (Final report).* Canberra: Asian Development Bank.