Improving Drinking Water Supply for Kiritimati Island Project

Babairean Kateimatoan Nakoraoin Butin te Ran - Sustainable Water Management Plan

August 2016

Prepared by GHD Pty Ltd for the Government of Kiribati

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Pacific Community
Communauté du Pacifique

Suva, Fiji
2017

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Executive summary

Overview

Aim

The aim of the Sustainable Water Management Plan (*Babairean Kateimatoan Nakoraoin Butin te Ran*) is to provide a framework which will facilitate the provision of a safe, continuous, reliable and efficient supply of water to households on Kiritimati Island.

Objectives

The objectives of the Sustainable Water Management Plan build on those within the National Water Resources Policy:

1. To create a more ***sustainable management and governance system***, where operation and maintenance is easily facilitated and prevents the system falling into disrepair in the future.
2. To identify how the system can be operated so that the ***supply of water is fair*** to all customers.
3. To ***increase*** *access* to safe and reliable water supplies.
4. Improve ***understanding, monitoring, management and protection*** of water resources.
5. Increase ***customer participation*** in water management and encourage ***water conservation***.
6. ***Decrease*** unaccounted for ***water losses***.
7. Improve ***cost recovery***.

Approach

This Sustainable Water Management Plan was developed as part of the *Improving Drinking Water Supply for Kiritimati Island Project*. The plan was developed in consultation with core stakeholders of the Kiritimati Island Water supply system, including government and residential and commercial customers. Consultation activities included workshops and interviews with key government stakeholders, community consultation forums and a household survey to understand community willingness to pay for an improved water supply and gauge community attitudes, values and preferences to inform future improvements. Data and information was also reviewed to understand the status of the water supply system including the projected water supply-demand balance and the financial status, water pricing and affordability of the system.

Outcomes

Per capita water demand

The analysis of billing and meter data provides no clear reason to reject the reticulated water supply demand assumptions adopted for the 2007 ADB study as these fall within the expected range. However, further refinement resulted in the following recommended assumptions for water demand:

- 60 L/p/d for households with access to well water
- 100 L/p/d for households without access to well water

Note, some refinement to assumptions in the Concept Plan report (Bencke 2015) is also recommended for water balance calculations including most critically that the calculation of demand for reticulated water is based on number of connected households rather than the total population.

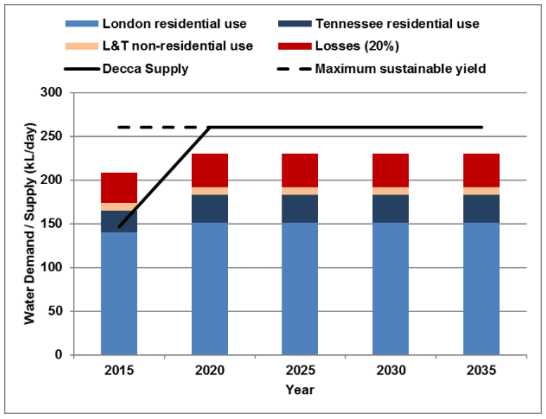
Supply-demand water balance

The figures below show the projected supply-demand water balance for the London-Tennessee and Decca system and the Tabwakea - Four Wells system, with two loss scenarios, 20% and 50%. The projected supply from Decca freshwater lens reflects the increase in production from the proposed additional galleries to be constructed under the Project and the supply from Four Wells reflects an increase in production from the replacement of wind pumps with solar pumps.

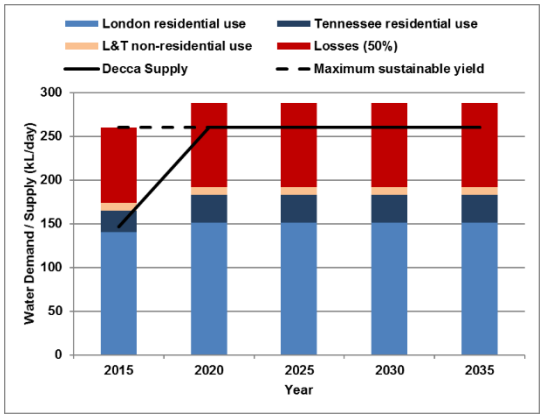
The supply-demand balance highlights the importance of water conservation and efficiency. If system losses remain high (50%) it is projected that even with the increased production at Decca the demands for reticulated water will exceed the available supply for London and Tennessee. However, if losses are minimised (to 20%) supply from Decca can support the population of London and Tennessee, which is expected to remain stable. Conversely, the supply from Four Wells to Tabwakea will continue to exceed demand unless there is an increase in production through the construction of additional galleries at Four Wells. Furthermore, even if production at Four Wells is increased to match the sustainable yield of 300 kL/day the demand is expected to exceed supply by 2030. This highlights:

- The need for long term strategic urban planning and population growth initiatives targeting the Tabwakea village.
- The importance of minimising losses from the system occurring from wastage and leakage through rigorous maintenance and asset management processes and through customer awareness programs on water conservation.

Projected water demand for reticulated supply to London and Tennessee from 2015 to 2035 and supply from Decca freshwater lens.

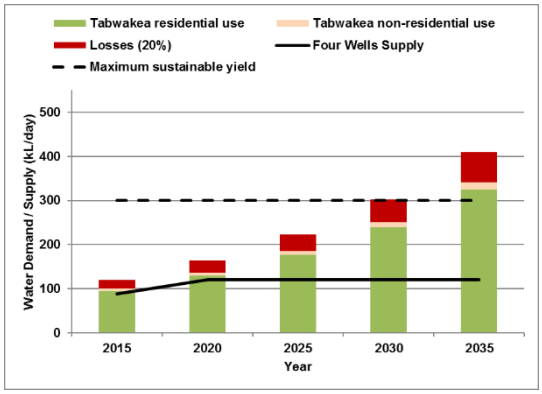


20% losses

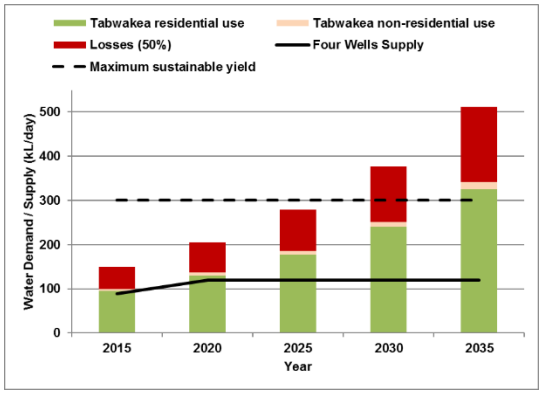


50% losses

Projected water demand for reticulated supply to Tabwakea from 2015 to 2035 and supply from Four Wells freshwater lens.



20% losses



50% losses

Water pricing and affordability

The average willingness to pay (WTP) for improved water supply as stated in the household survey is $43/mth. Based on this, with the current tariff structure, houses where no alternative water supply is available (i.e. where no well water is used and demand is 100 L/p/d) could support approximately up to 6 people. This highlights the question of equity for larger households, with the average household size being 6.5 people, and illustrates that the current tariff structure is potentially unaffordable for many households.

In addition, the average WTP is approximately 10% of the median income which is significantly higher than commonly accepted international benchmarks for affordability of 2 to 4% of household income (Hutton, 2012).

Recommendations for sustainable water management

Stakeholder consultations and analysis have revealed a number of issues with the current water management systems and resources. The following provides a summary of opportunities for sustainable water management initiatives to address these issues. These have been integrated into the draft Water and Sanitation Division (WSD) Ministry Operational Plan (MOP) developed with the WSD Water Foreperson and Meter Reader during the in-country trip in February (Appendix A) and align with the seven objectives of the Sustainable Water Management Plan.

Water and Sanitation Division restructure

A need for additional posts has been identified to support WSD operations including:

- A Water Engineer
- A Customer Service/Water Awareness Officer
- A Water Sustainability/Quality Officer

There is also a need to review the current leadership of the WSD and consider the appointment of a divisional head with skills and experience in managing budgets, people, strategic planning and communication ï rather than focused purely on technical skills. Alternatively, strong focus on capacity building in this area is essential.

Tariff structures, rates and affordability

There is a need to review the current tariff structure and rates, with the following issues identified:

- The current two-tiered structure results in inequity and unaffordable charges for large households and leases with multiple households sharing a single meter.
- The current rate for smaller households using lower per capita consumption is relatively cheap. However, there is inequity for those customers without alternative water sources that have a higher per capita consumption, which results in unaffordable water charges.
- The existing tariff rates and structure are not understood in relation to the actual operational costs. Analysis of the long-term marginal costs of the water supply system is required to understand the cost recovery potential through tariffs.
- Arrears should be audited in detail to understand the specific circumstances for each customer. It is expected in some cases that arrears may result from faulty meter readings or due to high charges from large household or lease populations sharing a single meter where the second tier tariff was charged although the per capita consumption may not be excessive.

Budget management and links to revenue collection

Revenue collected for water and sanitation services should be linked to operational budgets to increase accountability and incentives for billing and revenue collection. Substantial support in the form of skills and capacity development and review and revision of the existing administrative, accounting and financial systems is necessary to strengthen the billing system.

Review of governance arrangement

The current governance arrangement provides limited authority for the WSD and Ministry of Line and Phoenix Island Development (MLPID) Executive to make decisions regarding water services. This limited autonomy was identified by stakeholders as a constraint to the sustainable management of the water system.

Revised governance options discussed during consultation included:

- Strengthening MLPID as the lead agency with greater autonomy to manage operational and financial aspects of the water system.
- Creating a water utility similar to or linked to the Public Utilities Board in South Tarawa.

Community roles in sustainable water management

The community plays a key role in the management of the water system and a culture of customer service and community engagement needs to be created as part of water management. Communication with customers is critical and opportunities and ideas raised during consultation for improved community engagement included:

- Working with the Kiritimati Urban Council (KUC) village wardens to report issues with the water supply system at a community level and WSD to respond to issues promptly.
- Creation of a dedicated customer relations and awareness officer post within the WSD.
- Improved systems for customer service including making it easier for people to pay bills and report problems or processes for complaints resolution.
- Integrating water awareness specifically tailored to Kiritimati Island into the new curriculum and engaging.
- Each WSD tradesman to be allocated a set number of houses for monthly inspections where they can identify issues and discuss water issues with householders.
- Penalties for those damaging the water system, stealing property or wasting water.

Capacity building, training and resources

The capacity of the WSD and its resources require strengthening, including training and support to improve skills in:

- Technical areas required to undertake daily activities such as plumbing, pump mechanics, GIS, computer skills, water quality testing and gallery and borehole monitoring. Although the Project is proposing on-the-job training through placement of an international consultant plumber this has been delayed due to difficulties identifying a suitable candidate. It is encouraged that the WSD also seek support from the MPWU staff, who have more recent formal training in plumbing.
- The use of electronic billing and revenue management system (in Microsoft Access or Excel) and general computing skills of the Meter Reader and Accounts Staff.
- Training on budget management for Head of Department, Foreperson, Store Manager and meter reader/revenue collector.
- Training and support on team leadership and management for the WSD Head of Department.

Transport and private sector involvement

A key constraint in the WSD operations is the access to reliable transport to perform core duties including maintenance and monitoring. The current arrangement involves the sharing of vehicles between the water and sanitation units, the use of the Project truck to assist with water cartage and the loan of vehicles from the Government run Plant and Vehicle Unit (PVU). A more sustainable solution which would have lower long term costs than loaning vehicles from the PVU is to purchase a second truck.

In addition, a significant proportion of the activities undertaken by the WSD is taken up with managing orders and delivery of tankered water. There is potential for this service to be delivered by the private sector, thereby enabling WSD staff to focus on their core activities of maintenance and operation of the water supply system and freeing up vehicles for other use. If this system is to be introduced, WSD would play a regulatory role, managing contractors and would need to enforce stringent water safety and quality processes to protect public health.

Improving knowledge and monitoring

The proposed new Water Sustainability/ Quality Officer should be responsible for monitoring and water resource management activities. This should include monitoring of the galleries and groundwater boreholes at Decca and Four Wells, the weather station at Decca, chlorine residual tests at selected locations in the distribution system, and collection of samples from selected sites for bacteriological testing by Ministry of Health (MOH) staff at the hospital laboratory.

Improving water quality

There is a high demand from the community for chlorinated reticulated water which has the advantage of reducing the burden of household treatment on customers. The project will install a new chlorination facility at Decca. There is also opportunity to involve WSD and the MOH staff in water quality monitoring and the Project should support capacity development in this area including supporting the recommencing meetings of the technical water quality committee which should meet regularly to review water quality results.

One immediate example of where this committee could be used it to investigate claims by householders in Tabwakea that water from õTekarimiõs wellõrequires no treatment. It is highly unlikely that this source is not contaminated, and hence it is recommended that the WSD and MOH undertake further testing and awareness on water safety risks.

Improving access to all

An objective of this Sustainable Water Management Plan is *"to increase access to safe and reliable water supplies"*, recognising that access to water is of critical importance to the health and development of the Kiritimati Island community. As such, MLPID should consider opportunities to enable easier access to the reticulated water supply for additional households within the sustainable limits of the freshwater lenses. This includes:

- Improving the processes and affordability for new residential connections, particularly in new lease areas where local groundwater quality is not suitable for use.
- Prioritising supply to core community services including schools and the hospital.

Performance monitoring, accountability and operational efficiency

Performance monitoring should be incorporated into MLPID procedures to improve the effectiveness and efficiency of WSD operations and in turn improve the efficiency of the water supply system. Areas of WSD operations where more efficient and effective processes can be implemented include:

- Stock management and ordering, which involves seven steps from the initial ordering to the collection of stock. This system is inefficient and causes delays in accessing important spares.
- Meter reading and billing process.
- Staff management, including allocation of targets and work planning and more stringent management and accountability for overtime.
- Linking the WSD operational budget to water bill revenue.

There is also opportunity to learn from and share procedures and information being used or in development at the PUB in South Tarawa to improve the operational efficiencies on Kiritimati.

Water use efficiency

Water conservation and efficiency should be a high priority for the MLPID. If losses can be controlled in the London-Tennessee system (to 20%) the supply from Decca lens is projected to be sufficient to meet demands, provided that the population remains stable and other assumptions regarding per capita demand are accurate. However, for the Four Wells ï Tabwakea system, even if reduced losses are achieved and production is increased to match the sustainable yield, the demands for reticulated water is expected to exceed supply by 2030.

There is a range of water use efficiency opportunities that should be considered to help manage the finite water resource and many of these overlap with those described previously. These include:

- Supply efficiency initiatives including improved maintenance, monitoring, governance and accountability mechanisms, skills and capacity development and increased resources.
- User efficiency initiatives including behaviour change campaigns, enforcing penalties for tampering of the water system, tariffs that influence water consumption whilst remaining equitable and water stewardship for large non-residential water users.
- Water recycling and reuse including encouraging fit-for-purpose water use and remediation of local groundwater lenses through improved land use practices and sanitation.
- Review of allocated water to key services and sectors, considering the contributions of each to sustainable development and economic productivity of water supply allocations.

Limitations

This report was undertaken by the consultant, GHD Pty Ltd, on behalf of the Geoscience Division of the Pacific Community (SPC) for the Government of Kiribati and may only be used and relied on by SPC for the purpose agreed between GHD and the SPC as set out in section 1.3 of this report.

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Acronyms and abbreviations

ADB	Asian Development Bank
BEIA	Basic Environmental Impact Assessment
CSO	Community Service Obligation
CVM	Contingent valuation method
hh	Household
GoK	Government of Kiribati
KDP	Kiribati Development Plan
kL	kilolitre
KNSO	Kiribati National Statistics Office
KUC	Kiritimati Urban Council
KWASP	Kiritimati Water and Sanitation Project
LIPIDS	Line and Phoenix Islands Development Strategy
MFED	Ministry for Finance and Economic Development
MLPID	Ministry of Line and Phoenix Island Development
MOH	Ministry of Health
MOP	Ministry Operational Plan
MPWU	Ministry of Public Works and Utilities
MS	Microsoft
mth	month
PS	Permanent Secretary
SD	Standard deviation
SDA	Seventh Day Adventist
SPC	Pacific Community
TOR	Terms of Reference
WHO	World Health Organisation
WSD	Water and Sanitation Division, MLPID
WTP	Willingness to Pay
WUE	Water use efficiency

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Appendices

1. Introduction

1.1 Purpose of this report

The purpose of this report is to document the activities and outcomes from the GHD consultancy undertaken as part of the *Improving Drinking Water Supply for Kiritimati Island Project* (the Project). The report includes a summary of the activities undertaken during the two week in-country mission and analysis of data and information regarding management of water services and resources on Kiritimati Island. As an annex (Appendix A) and separate to this report is the draft Ministry Operational Plan (MOP) which presents key objectives and actions to be implemented by the Water and Sanitation Division (WSD) of the Ministry of Line and Phoenix Island Development (MLPID) to advance towards more sustainable management of the water system.

1.2 Purpose of the consultancy

The objective of this consultancy is to develop a 'Water Use Efficiency Plan'. Water use efficiency (WUE) is described in the United Nations *Guideline to Preparing Urban Water Use Efficiency Plans* (UN ESCAP, 2003) as action taken to reduce water use by a utility or consumer. Whilst water use efficiency, demand management and conservation are important aspects of water management for Kiritimati Island these components are part of a broader picture which considers how the system is operated and managed into the future. Following consultation with government, project and community stakeholders in Kiritimati Island, it was agreed that the Plan should be renamed the 'Sustainable Water Management Plan'. Translated to I-Kiribati the Plan is: *Babairean Kateimatoan Nakoraoin Butin te Ran.* This reflects the broader scope and objectives of the Plan which extend beyond efficiency as outlined in Section 2.

1.3 Consultancy scope and activities

The *Improving Drinking Water Supply for Kiritimati Island Project* focuses on the pumping of groundwater from Decca to supply London and Tennessee. Whilst not the main focus of the project, there will also be some improvements to the Tabwakea supply including through rehabilitation and installation of pumps at Four Wells lens and lowering of the Tabwakea tank stand. As such, data analysis, stakeholder consultation and water balance estimates undertaken as part of this consultancy have focused on these villages. However, this Sustainable Water Management Plan also covers aspects of water management applicable to the whole island.

The following activities were undertaken as part of this consultancy to develop this Sustainable Water Management Plan:

- A two week in-country trip conducted from 10 ï 24 Feb 2016 which included:
  - ï Community forums on the Project and discussion of ideas for future sustainable management of the water system
  - ï One-on-one meetings with key government representatives
  - ï A multi-stakeholder workshop including key government and Kiritimati Urban Council staff, unimaneês and representatives from hotels
  - ï A workshop with WSD staff
  - ï Household surveys on willingness to pay (WTP) and perceptions of the existing water services
  - ï Household water consumption surveys (limited).
- Visit to Poland village to discuss the water supply situation and consider any lessons that could be applied in London, Tennessee and Tabwakea.
- Review of data collected during in-country trip and review of background materials
- Meetings with key government officials in Tarawa in May 2016 to discuss the Project and potential initiatives for Sustainable Water Management.

1.3.1 Variation from Terms of Reference

The following limitations are acknowledged and variation from the original Terms of Reference (TOR) for this consultancy:

- As described in section 1.2, following stakeholder discussions the scope of this consultancy has been broadened to consider the multi-faceted aspects of sustainable water management, going beyond the concept of WUE which focuses primarily on water conservation and demand management.
- The original TOR for this consultancy required that analysis of the cost of WUE measures and budget requirements be undertaken. However, insufficient cost information was made available to GHD by the Project or MLPID. Instead, some analysis of operational costs has been undertaken using the limited data available (section 3.6) and some estimates of costs were made with the WSD staff whilst developing the draft WSD MOP ï refer to Appendix A.
- The TOR required an evaluation of the concepts proposed in the *Concept Plan for Upgraded Water Supply to London-Tennessee and Tabwakea* (Bencke 2015) with respect to WUE. The three concepts in the Bencke (2015) report were discussed with the Project team, and it was indicated that the only option being considered was to provide continuous (24 hour) supply, sufficient water pressure to enable showering and individual metering for each household in London and Tennessee. Hence, there was no need to consider alternative options in the Concept Report during community consultations.

  Since the completion of the in-country trip and community consultations the water supply rehabilitation design has been refined and this includes provision for an underground storage and pump system adjacent to the London overhead tank. This design allows for continued operation under high leakage and wastage conditions (above the 20% design). This operational mode will provide an intermittent supply to customers at low pressure. It should be noted that this operational condition was not described to the community during the household surveys.

1.4 Report overview

This report is structured such that:

- **Section 2** provides an overview of the aim and objectives of the Sustainable Water Management Plan and a summary of the strategic framework and stakeholders to provide important context to the Plan.
- **Section 3** summarises key background information including an overview of the population and the existing water supply and management situation in the study area.
- **Section 4** provides analysis of a range of data sources to determine an estimate of per capita water demands for the study area.
- **Section 5** presents the current and projected (2035) supply-demand water balance for the study area, considering the proposed system changes under the Project and the projected population growth and per capita water demands.
- **Section 6** provides a summary of the outcomes from stakeholder consultation undertaken in Kiritimati Island and South Tarawa.
- **Section 7** presents the results of the household survey undertaken to assess willingness to pay and the beliefs and perceptions of the survey respondents on the existing water services.
- **Section 8** presents analysis of the cost of water supply and discusses the need to consider government policies on water tariffs, subsidies and cost recovery to ensure affordability, equity and sustainability.
- **Section 9** provides a summary of opportunities for sustainable water management initiatives including a feasibility assessment of these opportunities and alignment with the MOP which was developed with the WSD during the in-country trip.

2. Babairean Kateimatoan Nakoraoin Butin te Ran – *the Sustainable Water Management Plan*

2.1 Aim

The aim of the Sustainable Water Management Plan (*Babairean Kateimatoan Nakoraoin Butin te Ran*) is to provide a framework which will facilitate the provision of a safe, continuous, reliable and efficient supply of water to households on Kiritimati Island.

2.2 Objectives

The objectives of the Sustainable Water Management Plan build on those within the National Water Resources Policy (GoK 2008a):

1. To create a more ***sustainable management and governance system***, where operation and maintenance is easily facilitated and prevents the system falling into disrepair in the future.
2. To identify how the system can be operated so that the ***supply of water is fair*** to all customers
3. To ***increase access*** to safe and reliable water supplies
4. Improve ***understanding, monitoring, management and protection*** of water resources
5. Increase ***customer participation*** in water management and encourage ***water conservation***
6. ***Decrease*** unaccounted for ***water losses***
7. Improve ***cost recovery.***

2.3 Strategic Framework

2.3.1 Overview

Figure 1 illustrates the strategic framework influencing development and water management in Kiritimati Island. The following section provides an overview of the key strategies and mechanisms that can be used to promote sustainable water management in Kiritimati Island.

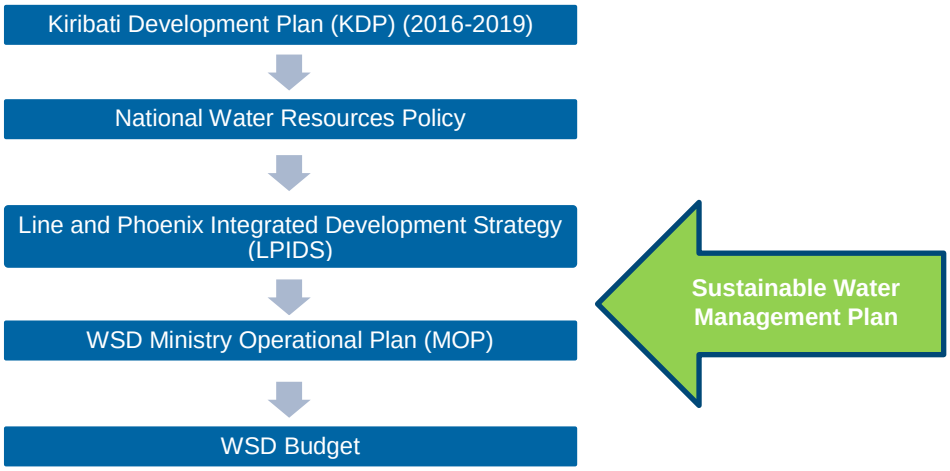

Figure 1 Strategic plans and links to budgets

2.3.2 Kiribati Development Plan

The Kiribati Development Plan (KDP) is a four-yearly national strategic plan which is currently being updated. In meetings with the acting Permanent Secretary (PS) for MLPID, in February, it was commented that the current KDP provides limited autonomy to MLPID and they are seen to play only a supporting role to other ministries in the implementation of the KDP. The PS has highlighted the limitations of this supporting role and proposed to central government, for the next KDP (2016-2019), that the MLPID is given greater authority for coordinating other Ministries. In addition, in discussions in May 2016 with the new Minister for LPID, Mikarite Temari, he indicated that cabinet (during the May 2016 sitting of Parliament) approved a plan for better integration of Ministry activities on Kiritimati Island. This proposal is that MLPID will take on a supervisory position (as opposed to the current supporting role) of all other Ministry activities in Kiritimati. This includes oversight of Ministries such as Fisheries, Tourism, Commerce, Environment, Tax, Customs and Immigration, which currently all operate independently of MLPID. The need to review governance structures has also been considered in the Line and Phoenix Integrated Development Strategy (LPIDS), as discussed below.

2.3.3 National Water Resources Policy

The National Water Resources Policy (GoK 2008a) and the Implementation Plan (GoK 2008b) provide a framework for leadership and coordinated action in the provision of water services across Kiribati. The goals of the National Water Resources Policy are to:

1. Provide safe, socially equitable, financially, technically and environmentally sustainable water supplies to enhance the welfare and livelihood of Kiritimati Island.
2. Protect and conserve freshwater sources for public water supplies.
3. Deliver freshwater efficiently and effectively.

As summarised in the National Water Resources Policy Implementation Plan, these goals contain some very important policy directives which have been adopted in the development of this Kiritimati Island Sustainable Water Management Plan. The policy directives are that:

- Water supplied to communities has to be ***safe and equitable;***
- The water supply systems have to be ***environmentally, technically and financially sustainable;***
- Sources of water will be ***protected*** and water resources ***conserved***;
- These services will be ***delivered well.***

2.3.4 Line and Phoenix Integrated Development Strategy

As part of a commitment by the European Union to provide development funding to Kiritimati Island, a strategic plan is being developed. The LPIDS (COWI Consortium & Prospect Consulting and Services 2015), is hoped to provide a new strategic direction for MLPID and specifically includes initiatives linked to water supply planning.

The draft LPIDS was provided for review and a summary of key aspects of the strategy as they relate to water management are as follows:

- The strategy identifies freshwater availability as the ódefining development factorô The strategy acknowledges that with the current geographical population distribution, population growth and pressures cannot be sustained (namely in the Tabwakea area). As such, the strategy recommends that future development be concentrated outside the New Zealand Airfield freshwater lens area, at the south west side of the island in the C®cile Peninsular and Poland areas.

- Access to good water services is recognised as a key limitation to tourism development. Actions proposed to address this include:
  - Purchase one water truck to meet the increasing water demand from guesthouses
  - Purchase more water pumps for water trucks
  - Establish a water reservoir at each village for better and faster distribution of water to households
  - Build the capacity of water staff of WSD of MLPID in maintenance and repair
  - Organize active awareness programs and groups to educate people of the impact of vandalising the water system.
- The strategy advocates a dramatically new governance structure for MLPID of complete decentralisation from Tarawa. Whilst decentralisation of services is a policy objective of the new government of Kiribati, the extent of decentralisation and re-structure proposed within the LPIDS is highly unlikely and may not be appropriate given the low capacity of government in Kiritimati and the need for technical and financial support from external parties (and central government). The structure proposed in the LPIDS is a "Unity Authoritative Structure" which proposes that Government Ministries and the KUC be merged into four departments, each with a Policy Board. Each Policy Board is proposed to have a selection of elected, community, technical and business or NGO representatives, and the four proposed departments are:
  - Policy coordination and economic development
  - Infrastructure and service coordination
  - Land and environmental management
  - Social development and administrative support
- A "Phase II Water Project" is proposed, with a one to five year timeframe and indicative cost of AUD 6.5 million. The scope of this proposed project is not detailed, but it is proposed to be an extension of the existing project being implemented by SPC.

2.3.5 Ministry Operational Plans

The Ministry Operational Plans (MOPs) are the core mechanism used by MLPID at a departmental level to outline specific objectives, activities and projected costs in 4 year cycles linked to the KDP. The MOPs are reviewed annually. This presents a key mechanism for the WSD to implement the Sustainable Water Management Plan. As such, the 2016-2019 WSD MOP which was due to be updated in February 2016, was drafted during the in-country trip activities. This was undertaken with the WSD Water Foreperson and Meter Reader following stakeholder consultations and incorporated ideas and initiatives proposed during these consultations. A draft of the proposed 2016-2019 WSD MOP is provided in Appendix A.

2.4 Stakeholders

Implementation of this Sustainable Water Management Plan requires key stakeholders to accept responsibility for actions within the Plan and understand their roles. Stakeholders important to the sustainable management of the water system can be categorised into three core groups:

1. Governance and administrators
2. Operators
3. Customers.

As an exercise to understand the interactions and role of key stakeholders, analysis of the óimportanceôand óinfluenceôof each core stakeholder group for the Kiritimati Island water supply is presented in Figure 2. This is a subjective analysis and in reality the position is not static. As reflected in the objectives of the Sustainable Water Management Plan (section 2.2), the customer group, who currently have high importance but limited influence in the management of the system, are to be encouraged to be more actively engaged with water management. It could also be argued that customers already have a high level of influence on the sustainability of the water system, since their actions can result in the degeneration of the water system or increased loss of water. However, the control and enforcement of consumer behaviours remains with the Government.

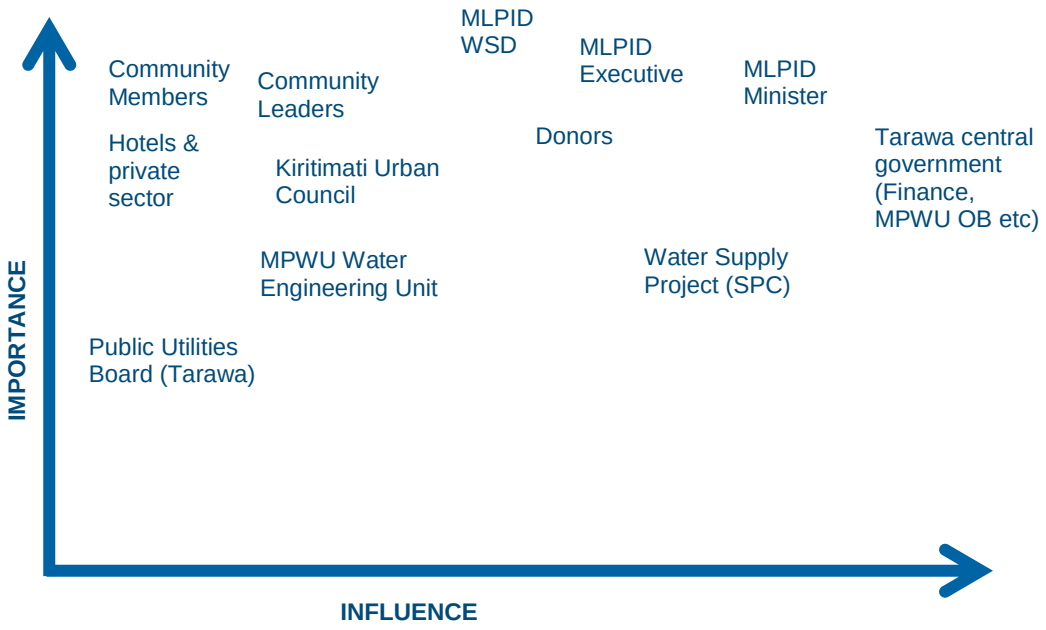

Figure 2 Stakeholder analysis, importance and influence levels for sustainable water management in Kiritimati Island

3. Background

3.1 Population

3.1.1 Population and Housing Census

A five-yearly national population and housing census is conducted by the Kiribati National Statistics Office (KNSO). The Kiritimati Island population by village from 2000 to 2015 is illustrated in Figure 3 and summarised in Table 1. This includes preliminary results from the 2015 census, conducted in November 2015.

Table 2 provides analysis of the annual population growth rate, between a range of intercensal periods between 2000 and 2015. The annual growth rate was calculated using the natural logarithmic method[1], consistent with the KNSO approach.

The following population trends are observed:

- The population of London and Tennessee remains relatively constant, particularly in the last 10 years. The most recent intercensal period (2010-2015) recorded negative growth of -0.5%.
- The largest proportion of the population is located in Tabwakea village, which also has the highest growth rate, with a long term (2000 ï 2015) annual growth rate of 7.4% and a recent annual growth rate of 5% for 2010 to 2015.
- The largest growth for all villages occurred between 2000 and 2005.
- Negative growth was recorded for London and Tennessee and Poland between 2010 and 2015.

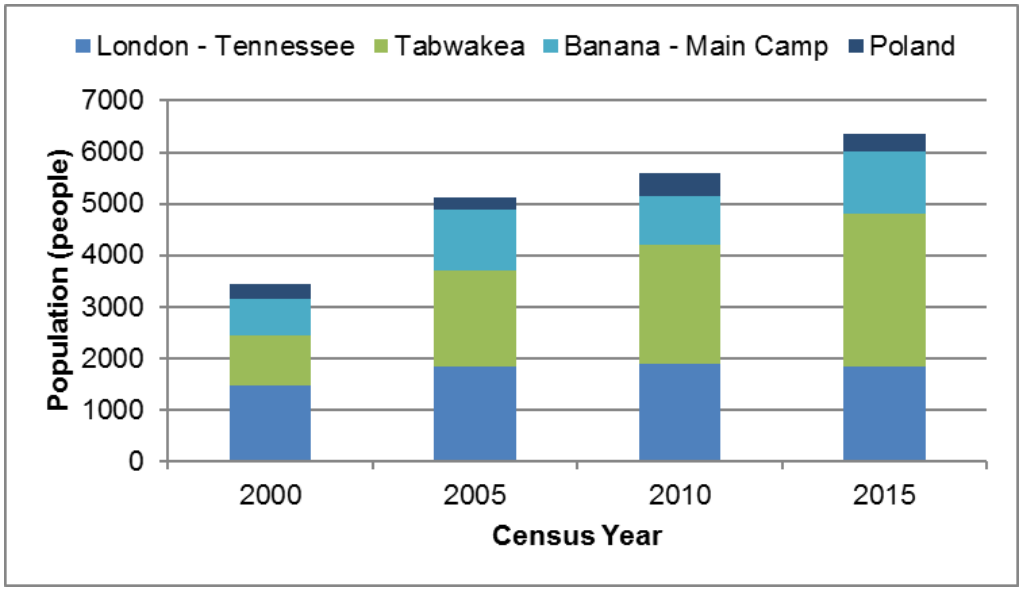

Figure 3 Kiritimati Island population by village from 2000 - 2015

[1] $Rate = \frac{\ln(Pop.new) - \ln(Pop.previous)}{Time\ interval}$

Table 1 Kiritimati Island population by village in 2000, 2005, 2010 and 2015

	2000	2005	2010	2015
London - Tennessee	1465	1829	1879	1837
Tabwakea	976	1881	2311	2972
Banana - Main Camp	707	1170	955	1208
Poland	283	235	441	339
Total	**3431**	**5115**	**5586**	**6356**

Table 2 Annual population growth rate, for range of analysis periods between 2000 and 2015

Period of analysis	Tabwakea	London - Tennessee	Banana - Main Camp	Poland	Kiritimati (total)
2000-2005	13.1%	4.4%	10.1%	-3.7%	8.0%
2005-2010	4.1%	0.5%	-4.1%	12.6%	1.8%
2010-2015	***5.0%***	-0.5%	4.7%	-5.3%	2.6%
2000-2010	8.6%	2.5%	3.0%	4.4%	4.9%
2005-2015	4.6%	***0.0%***	0.3%	3.7%	2.2%
2000-2015	7.4%	1.5%	3.6%	1.2%	4.1%

3.1.1 SPC Population survey

In June 2015, SPC conducted a comprehensive survey of all dwellings within the villages of London, Tennessee and Tabwakea. The survey focused on these three villages as whilst London and Tennessee are the primary focus, Tabwakea will also benefit from some of the increased supply and infrastructure improvements under the Kiritimati Island Water Supply Improvement Project. The purpose of this survey was to record the population, basic demographic data and information on the type of water supply used at each dwelling.

A comparison of the 2015 SPC survey and the 2015 census data is provided in Table 3 below. This shows some discrepancy between the results, with the SPC survey producing higher population counts, with the largest difference for London and Tennessee (6.5% higher).

Table 3 Comparison of SPC household survey results with 2015 preliminary census data

	2015 Census	SPC 2015 survey
London - Tennessee	1837	1957
Tabwakea	2972	3037
Total population - Project study area	4809	4994
Tabwakea growth rate 2010-2015	5.0%	5.5%
Tabwakea growth rate 2005-2015	4.6%	4.8%

3.1.2 Population growth projections

The Kiritimati Island Water Supply Improvement Project is focussing on water supply to the villages of London and Tennessee and there will also be some benefits provided to Tabwakea. As such, population growth projections for these villages are required to estimate future water demand.

For the purpose of the water balance analysis, the most recent (2010 ï 2015) population growth rates will be adopted for Tabwakea, and for London-Tennessee where negative growth (-0.5%) was observed in the most recent intercensal period, a 0% growth rate will be adopted (equating to the annual growth rate between 2005-2015, which excludes the uncharacteristically higher growth between 2000 and 2005). The projected population for the next 30 years, if no constraints to growth occurred in Tabwakea and growth continued at 5% per year is 8,100 as illustrated in Figure 4. The sustainability of this growth with respect to available water supplies is considered in Section 5. It should be noted that the projections illustrated in Figure 4 represent uncapped growth, continuing at 5% per year. However, in reality growth may be constrained if not by policy factors, at least by physical and resource constraints including land availability and water resource availability.

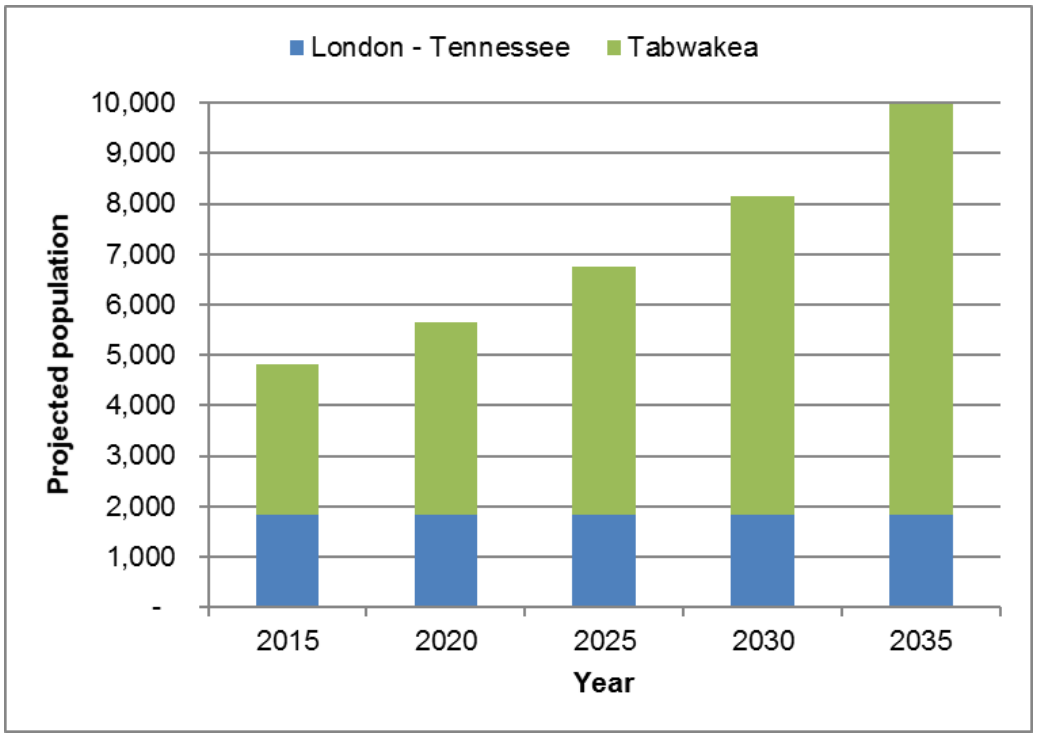

Figure 4 Projected population for London, Tennessee and Tabwakea to 2055

3.2 Current water supply situation

3.2.1 Water sources

Water sources relied on in Kiritimati Island include:

- Reticulated groundwater sourced from the following major freshwater lenses:
  - ï Decca and Four Wells lenses supplying London, Tennessee and parts of Tabwakea
  - ï New Zealand Airfield lens supplying government and community buildings in Poland (and two private households)
  - ï Banana lens supplying Banana Village and Main Camp.
- Water delivery via tanker, sourced from the Decca lens
- Harvested rainwater at some individual households and community buildings
- Local wells at some households
- Desalination supplying water to the hospital in London

Whilst harvested rainwater is a good option in high rainfall conditions associated with El Ni¶o episodes, this is an unreliable supply due to regular prolonged dry periods. Household wells also vary in quality. In areas of London the groundwater lens is known to be contaminated with oil and other areas are too saline for use. The availability of freshwater from a local lens in Tabwakea and northern Tennessee varies and in all areas contamination from septic tanks, pigs and other land uses is a significant concern. The quality of local groundwater is reflected in the proportion of houses with wells across the three villages surveyed in 2015, as shown in Table 4.

Table 4 Coverage of rainwater and wells in London, Tennessee and Tabwakea (SPC 2015 survey)

	Proportion of houses with wells	Proportion of houses with rain tanks
London	16%	51%
Tennessee	22%	24%
Tabwakea	63%	36%

3.2.2 Reticulated water supply

The current reticulated water supplies to London, Tennessee and Tabwakea are in poor condition. The Banana system was not inspected as it was outside the scope of the project. However, it is understood that water supply to Main Camp and Banana is comparatively reliable. The system in Poland is in good working order, with the exception of the chlorination system which is not working. Historically, chlorination systems were located at Banana, Decca and New Zealand Airfield, but these are no longer functioning and all hence all supply is delivered untreated.

Table 5 shows the coverage of reticulation connections and use of tankered delivery in London, Tennessee and Tabwakea from the SPC survey undertaken in June 2015. This highlights the poor water supply services at the time of survey, and in particular for London a high reliance on tanker delivered water (68% of households in London). This also shows that whilst the majority of households in London and Tennessee have connections to the reticulated water system (notwithstanding the inadequate service) only 40% of properties in Tabwakea have connections. This is because new leases have been allocated in Tabwakea since the installation of the water supply network under the Kiritimati Water and Sanitation Project (KWASP) and there has been a low number of new connections initiated by leaseholders of these properties. In consultation

undertaken with some households without connections the cost to connect was raised as a constraint and understanding of the process involved to access the reticulated water system also seemed to be poor. Further discussion on access and provision of new connections is provided in section 9.10.

Table 5 Coverage of reticulation connections and use of tankered delivery in London, Tennessee and Tabwakea (SPC 2015 survey)

	Proportion of buildings with reticulation connection	Proportion of connected buildings receiving water	Proportion of customers using tanker delivery
London	79%	8%	68%
Tennessee	74%	47%	33%
Tabwakea	42%	27%	5%

The government has discontinued water supply to Tabwakea, with the aim of improving pressure and supply to Tennessee and London. This was justified by the availability of a freshwater lens in most areas of Tabwakea compared with London and Tennessee. Also, the recent El Nino conditions produced recent significant rainfall. The resulting increased thickness of the local freshwater lens and availability of harvested rainwater assisted the governmentôs decision about the acceptability of this interim disconnection of the Tabwakea supply. However, it is not a viable or equitable long-term solution and, in consultation with residents, it appeared that knowledge of this decision was low, with customers presuming that the lack of supply was due to faults with the system and not a government decision.

Despite the prioritisation of water supply to London and Tennessee, the water pressure delivered to these villages has remained low. During the February trip, only one house in Tennessee was found to be receiving water with sufficient pressure to reach the 500 L household header tank. Some houses in London were observed to have developed make-shift solutions to the low water pressure through:

1. Accessing pipes below or at ground level;
2. Connection of low capacity pumps directly on the reticulation pipe to draw water into house or to the header tanks.

Whilst access to water is vital and the need for such modifications to the system is understood, these modifications contribute to wastage of water as many pipes are left open or closed with make-shift means (such as blocking pipes with sticks). Examples of modifications to the system are provided in Appendix B.

The spiral of decline experienced following the construction of the water supply system under the KWASP is illustrated in Figure 5. From discussions with key stakeholders, including managers of the water system and customers, it is understood that the original decline in services was caused by failure of pumps which were due to a combination of factors including poor design and installation of gallery pump wells, ingress of sand causing problems to wind pumps, lack of spare parts and theft of solar panels. However, there are multiple factors which have caused the current major state of disrepair. Some factors were identified during stakeholder consultation and include:

- Lack of funding for necessary equipment, spare parts and transport to support essential maintenance.
- Poor design of the system, which meant the required water pressure to fill 500 L household header tanks was never achieved in some areas. This has led customers to divert pipes and modify the system in order to access water.
- Theft and lack of enforcement to prevent vandalism and misuse of the water system.
- Increasing population in Tabwakea, with illegal connections that contribute to high non-revenue water.

- Limited skills and resources within the WSD to manage the system.
- Lack of accountability mechanisms for delivery of good water services.
- Limited autonomy of MLPID for strategic decision making.

Other factors also identified by the Project team include:

- Breakdown of the water billing system following tampering of water meters.
- Inability to fill the London head tank due to low pressure.
- Major problem with leakage and wastage going unattended.
- Failure of water meters with no replacement.
- Cessation of a proper billing and revenue collection process.
- Lack of funds to support water supply operations and maintenance.

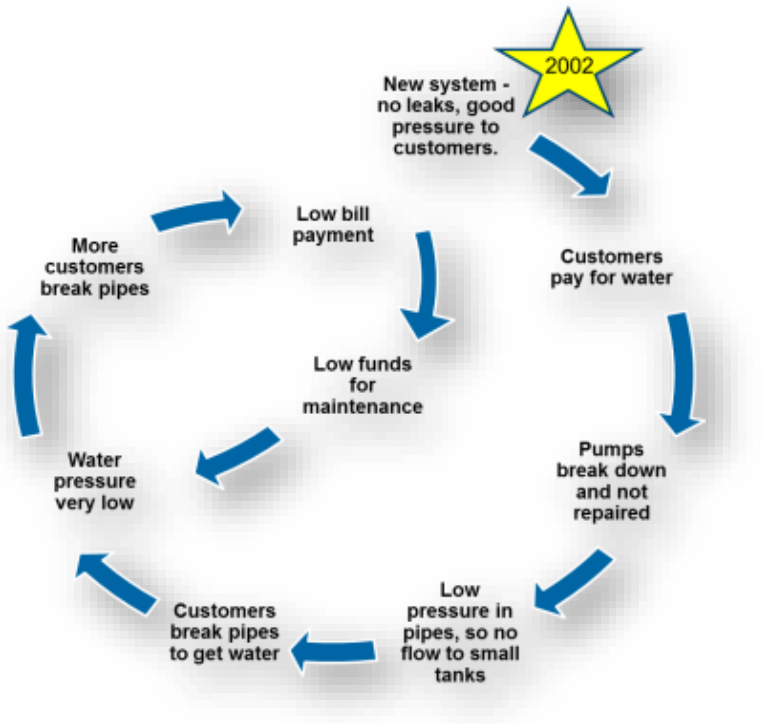

Figure 5 Water system history

3.3 Proposed water supply upgrade

The Project primarily aims to increase the production of water at Decca and improve connections supplying London and Tennessee. Where funding permits some improvement of production from Four Wells and connections in Tabwakea are also proposed.

Some works have already commenced to improve production at the Decca and Four Wells lenses. These works include rehabilitation of wind pumps and installation of new solar pumps at Decca and Four Wells. Proposed future works include the construction of additional galleries at Decca and installation of new solar pumping systems at all gallery pump wells to achieve pumping rates at each pump well of 20 kL/day so as to achieve a design total flow rate of 240 kL/day. The existing solar and wind pumps can be removed for use primarily at Four Wells to enable a more consistent supply of water from the existing galleries and via the existing pipeline to Tabwakea.

Table 6 shows the number of gallery pumps and the range of pump yields recorded for the three pump types at Decca and Four Wells freshwater lenses. This current arrangement is considered transitional with the recent installation of additional solar pumps at two gallery wells in Decca which have been co-located with existing windmills.

Table 7 summarises the proposed changes in water production under the Project and the target pump yield. It is proposed that under the project, all windmills will be replaced with a new solar pump arrangement, including an increased number of solar panels to provide an average pumping capacity of 20 kL per day at Decca and Four Wells. In addition, there will be three new gallery pumps added at Decca. The diesel pump at Decca will also remain, but this will be used as back-up only. This provides a significant increase in production, with an increase to 260 kL/day at Decca and increase to 120 kL/day at Four Wells. The estimated maximum sustainable yield for Decca and Four Wells lenses is 260 kL/day and 300 kL/day, respectively (Douglas Partners 2002). Hence, the proposed works will result in pumping at the maximum sustainable yield that can be achieved at Decca, but there is still significant opportunity to increase the production at Four Wells if additional galleries are constructed ï up to 4 additional galleries. This could be undertaken as part of a future project.

Table 6 Total and average pumping rates for current Decca and Four Wells gallery pump wells, March - June 2016

Pump type	Total Pumping Rate (kL/day)	Current pump numbers			Ave Total Pumping Rate (kL/day/pump)
		Decca	FW	Total	
Wind	104	5	3	8	13.0
Solar	99	3	3	6	16.5
Diesel	32	1	0	1	32.3
Total	235	9	6	15	15.7

Table 7 Proposed changes to production at Four Wells and Decca freshwater lenses

	Target Ave. Future Capacity	Proposed Pump Numbers	
	kL/d/pump	Four Wells	Decca
Solar	20	6	12
Total production (kL/d)		120	260

In addition to increased production, the Project is also proposing to construct a new pipeline to convey water from the Decca galleries directly to Tennessee and London (shown in green on Figure 6). This separation of the network will reduce the impact of problems with the reticulation network in Tabwakea on London and Tennessee and improve water pressure to London.

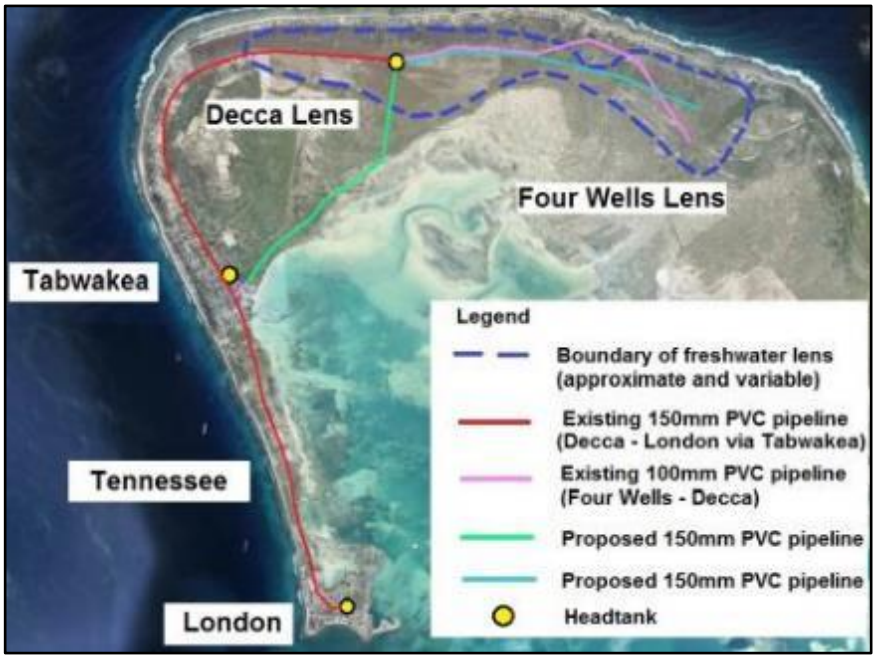

Figure 6 Proposed pipelines at Decca and Four Wells Lenses

(Source: T. Falkland)

3.4 Water supply management structure

Figure 7 illustrates the organisational and governance structure of water supply management in Kiritimati Island. Administrative, strategic and financing decisions are held with the MLPID executive who are required to consult with the Ministry of Public Works and Utilities (MPWU), Ministry for Finance and Economic Development (MFED) and other relevant lead Ministries in Tarawa. The MLPID is considered to play a supporting rather than a lead role to central government Ministries. The budget for each division of the MLPID is controlled by MFED.

At a day-to-day level, the reticulated water supply system is the responsibility of the MLPID WSD which has two divisions:

1. The ***Sanitation Section*** ï responsible for maintenance of plumbing within government buildings. These are predominantly residential properties leased to government workers which are managed by the Department of Housing and some government offices. Any complaints regarding water and sanitation in government housing go firstly to the Department of Housing and then to the Water Foreperson who distributes work to the Leading Hands. The Sanitation Division is also responsible for the operation of the sludge vacuum truck which is used to empty septic tanks.

2. The ***Water Section*** ï responsible for management of all components of the reticulated water supply to government and private properties. This includes management of:

    - ï The infiltration gallery pumps, including maintenance (by the Mechanic) and the re-fuelling of the diesel pump located at Decca
    - ï The water treatment (chlorination) ï no longer operating
    - ï Maintenance of header tanks and household tanks
    - ï Maintenance and reading of water meters (by the Meter Reader)
    - ï Maintenance of reticulation pipes up to the household head tank
    - ï Delivery of tankered water (four staff each day on shifts)
    - ï Borehole and gallery monitoring
    - ï Ordering of spare parts (Store Manager)

It is understood from discussions with the Water Foreperson, that the skills are limited within the tradesmen. Most of them have completed the ôbasicô level Trade Test, which is a test conducted by MLPID as part of the recruitment process. However, there are no tradesmen with the ôintermediateô level qualifications. This means that skills are inadequate. For example, skills to maintain pumps at galleries are limited to the single mechanic on staff.

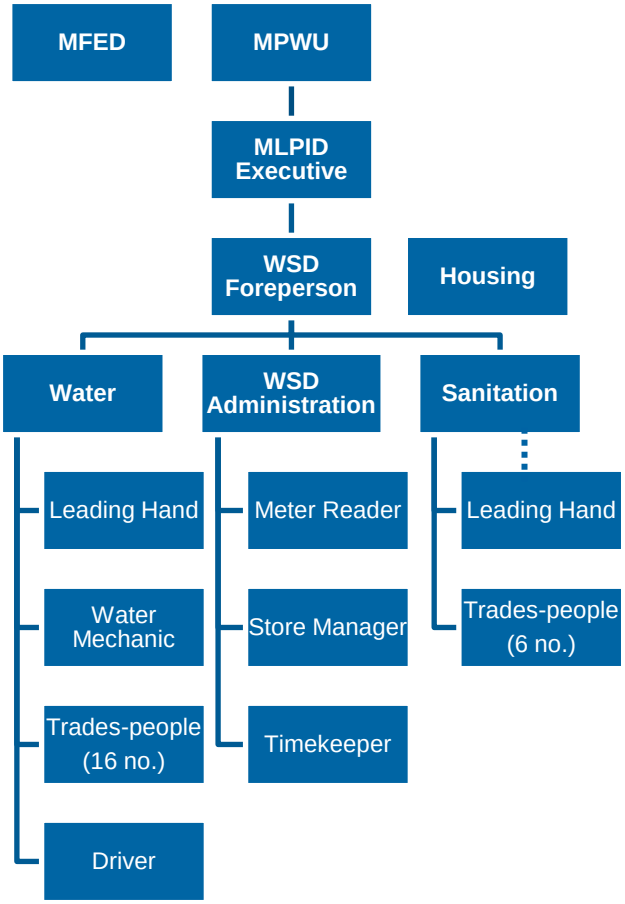

Figure 7 Kiritimati Island water management organisational and governance structure

3.5 Existing water pricing and billing practices

The following charges, pricing and billing practices form part of the current water services provided on Kiritimati Island:

- Metered water has a tiered pricing structure as shown in the table below. In the early 2000s, following implementation of KWASP, the lower tier volume was 10,000 L/mth and up to this volume the price of water was $1.50/kL. This was altered as shown in the table below after concern from customers about the cost, which was a particular issue for large households or where meters were shared between multiple households.

Tier Volume (L/mth)	Tier Rate, domestic $/1000 L	Tier Rate, commercial $/1000 L	Rate for ships (except fishing vessels) $/1000 L
<18,000	$ 1.20	$ 1.50	$10.00
>18,000	$ 5.00	$ 5.00	$10.00

- In the case where customers are disconnected the reconnection fee is $10 and the invoices state that the bill is to be paid within two months to avoid disconnection.

- Water truck delivery for domestic customers is charged at $2.50/500 L. Where a household is in arrears and requires tankered water they are required to pay 10% of their arrears in addition to the delivery charge of $2.50/500 L as a system of encouraging debt repayment.
- Shipping vessels and yachts are charged $10/kL for water delivery.
- Septic tank emptying costs $30 per visit.
- With the current low water pressure in London, Tennessee and the part of Tabwakea supplied from the main pipeline, charges are not based on meter readings. Many meters have been removed or by-passed. Some government staff have opted for automatic deductions from their salary of $10 per month, whilst others are not paying. Some of the government staff who have automatic deductions are also being refunded due to the poor service.
- In Banana there are no meters and people are charged $10 per month.
- In Poland there are meters only on government houses but government households are instead charged a flat rate of $10 per month which is deducted from their salaries. There are two private houses with reticulation connections. These houses were charged for the connection, but are not charged for water usage.
- For new connections in all villages, customers are charged $30 and required to supply materials and labour. A resident in Poland estimated the cost of materials for connection was $300.
- In London, there are no meters as they were removed by the WSD when water pressure was too low. People in Tennessee have meters but with low water pressure these are unreliable and no readings are currently taken. Therefore, some customers receiving water are not charged.
- Houses in Main Camp and the Captain Cook Hotel have meters along with St Francis and Spivey High Schools.

3.5.1 Metered water billing system

The water supply billing system is managed by the WSD Meter Reader and the Revenue Officer within the Accounts section of MLPID. The billing process for metered connections is summarised in Figure 8. This is based on discussions with the Meter Reader, Takeieta Aukitino. Meter readings were stopped from August 2015 after all meters in London were removed to prevent damage or loss, as the readings were unreliable due to low water pressure.

There are a number of inefficiencies observed with the current process, which were discussed with the Meter Reader and the Revenue Officer. Proposed improvements to the process include:

- Invoice dispatches could be undertaken simultaneously with meter readings, as was apparently the process historically.
- The payment records entered in the Microsoft (MS) Access database by the Revenue Officer can be extracted into MS Excel format to provide to the WSD for their records. This will reduce the potential for error in the manual recording process and be more efficient. However, a recent upgrade of the Accounts software has meant that template MS Access reports are no longer available and the Revenue Officer does not have the software skills to re-create these so training and support is needed. This emphasises the need to simplify systems to avoid any difficulties or disruptions in services or procedures.
- Invoicing is currently not occurring as the WSD has run out of invoice books. These books are produced in Tarawa, and the responsibility of WSD to order and maintain stocks. It seemed that whilst books had been requested they had not arrived. It was agreed that substitute invoice books could probably be used instead.

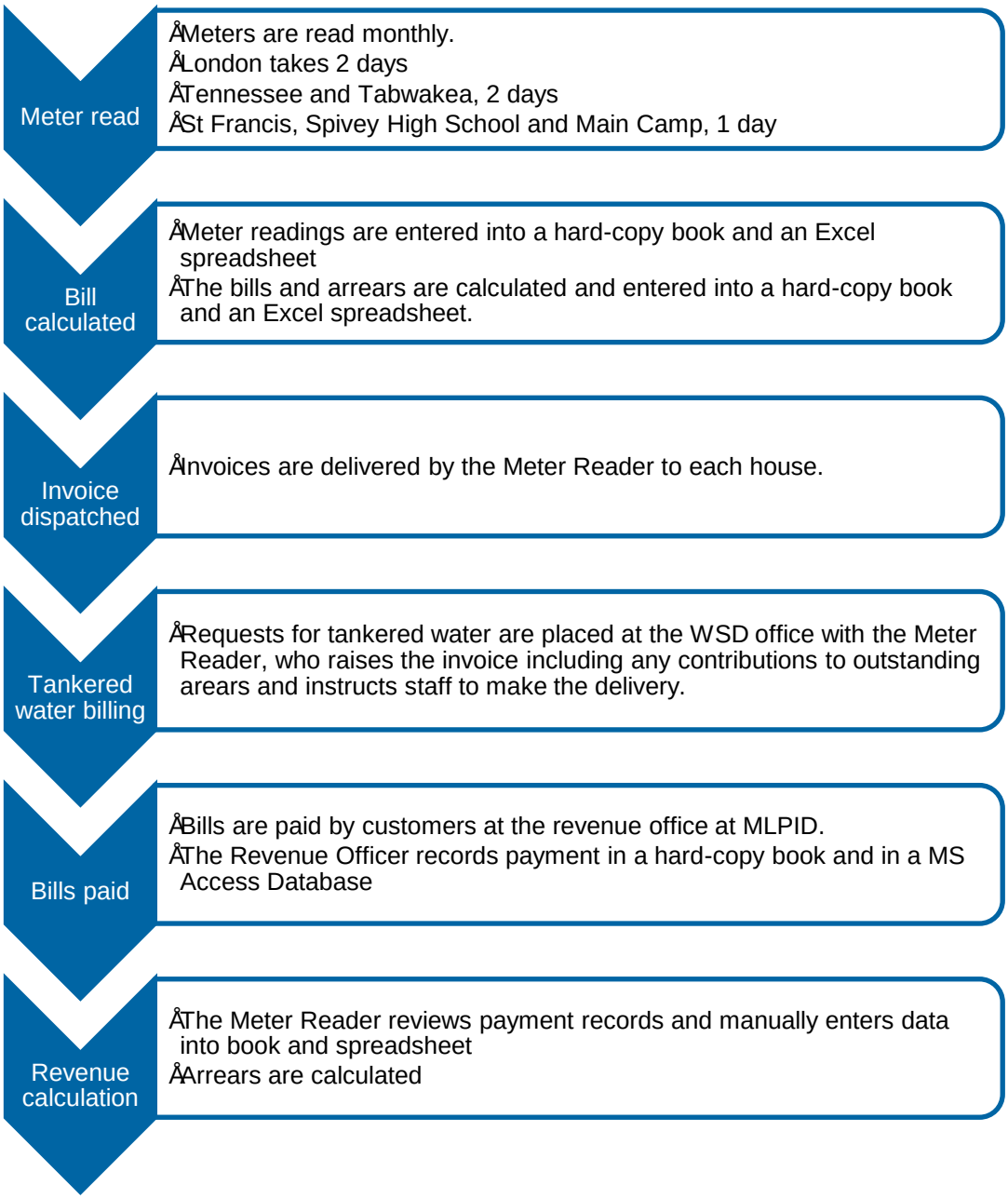

Figure 8 Current metered water billing process

3.6 Budget, expenses and revenue

3.6.1 Recurrent water management budget

Budgets available for the WSD operations are set annually. The budgets are proposed by heads of departments and subject to review and approval by MFED in Tarawa. The budget cycle is based around calendar years and the 2016 budget was being reviewed during the in-country trip in February. Unfortunately, the Water Foreperson had not met the deadline for submission of a proposed budget to MLPID Finance Division and, as a result, the 2016 budget being submitted to MFED was based on the 2015 budget and expenses.

An example of budget documents submitted for the Planning Department of MLPID showed a detailed annual work plan with a breakdown of related costs and a document outlining justifications for increases compared to the previous year. It is clear from discussions with the Water Foreperson that, due to his recent appointment to the post and limited experience in budget management and reporting, he was not confident to undertake this task. Greater support, communication and training is required in this critical area.

An itemised summary of the WSD budget compared to actual expenses for 2013, 2014 and 2015 (up to November) provided by MLPID Finance is in Appendix C and Table 8 provides a high-level summary. This illustrates that across the last three years, not all allocated funds were spent. Surpluses were recorded for both salary and operational expense categories, with the largest surplus associated with salary costs. In discussions with the MLPID Finance Manager, it was determined that there is flexibility to adjust budget allocations between salary and operational items, and hence this surplus could have been spent to cover operational costs such as equipment, spare parts and transport. This is contrary to the claims by WSD that funding has been a key constraint to operating and managing the system.

It is not clear why the full allocation was not expended. However, regular tracking of budgets by the WSD Foreperson is not undertaken, and this practice would improve future planning of activities and operations to optimise the use of available funds.

Table 8 Annual costs compared to budget for WSD 2013, 2014 and 2015

	2013	2014	2015
Salary costs	$243,290	$242,181	$220,613
Operational expenses	$63,510	$101,020	$65,623
Total costs	$306,800	$343,201	$286,237
Allocated Budget	$343,454	$347,259	$352,468
Variance	$36,654	$4,058	$66,231

3.6.2 Expenses

An explanation of the cost codes assigned to operational (non-salary) expenses in Appendix C is provided in Table 9, and the proportion of expenses across these areas is illustrated in Figure 9 and Figure 10. These figures illustrate the following trends

- Salary related expenses are significantly higher than non-salary expenses, with 71ï 79% of costs attributed to staff costs in the last three years.
- Within the non-salary expenses, the largest cost is for transport of workers to and from the office which is approximately 50% of the non-salary expenses.
- Assuming that codes 241 & 243 are used interchangeably it can be inferred that expenditure on supplies which include materials for maintenance and spare parts, as well as office equipment, is approximately $21,000 per annum.

It should be noted that major infrastructure expenses are captured typically through external donor funding ï with the current Project and the donation of a septic vacuum truck by a Rotary club examples of this pattern. As such, the budget breakdown does not reflect actual costs for operation and management of the water system, nor the costs necessary to sustainably maintain the water system and replace components as required, given that the system is in poor condition.

Table 9 Description of cost code assigned to non-salary expenses

Code	Code title	Description
215	Transport to w/place	Fuel for workers home to office
216	Internal Travel	Rental of private cars/transport
241	Stationery & Supplies	Consumable supplies (e.g. stationary & toilet paper)
243	Office equipment & furniture	Longer term supplies (e.g. computers, spare parts) *(note: it is assumed that codes 241 & 243 are used interchangeably and inconsistently)*
250	Local Services	External services (e.g. consultancy, minor repairs, casual labourers etc.)
285	Hire of Plant/Equipment	Hire of truck from Public Vehicle Unit

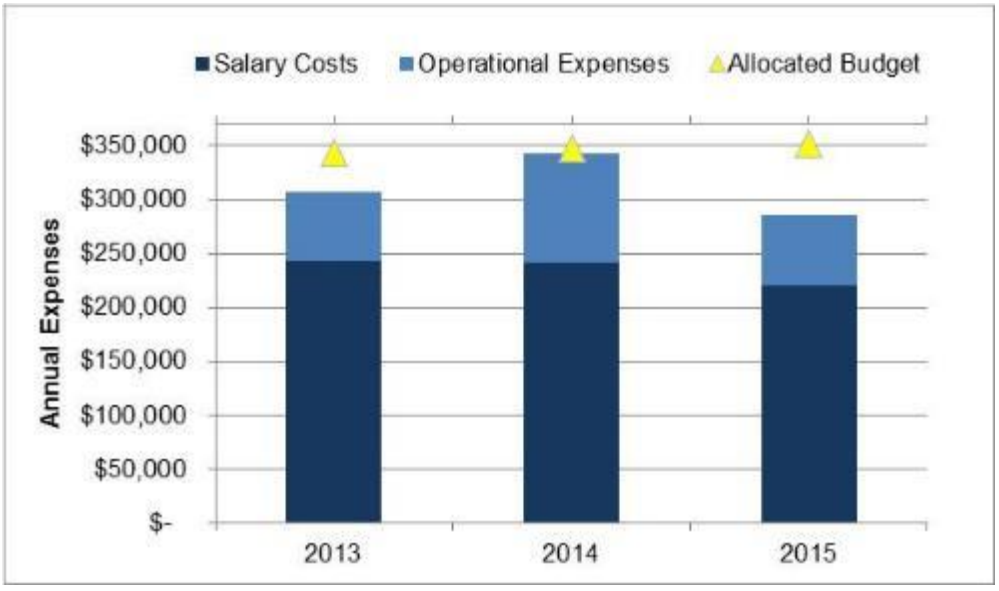

Figure 9 Annual costs compared to budget for WSD 2013, 2014 and 2015

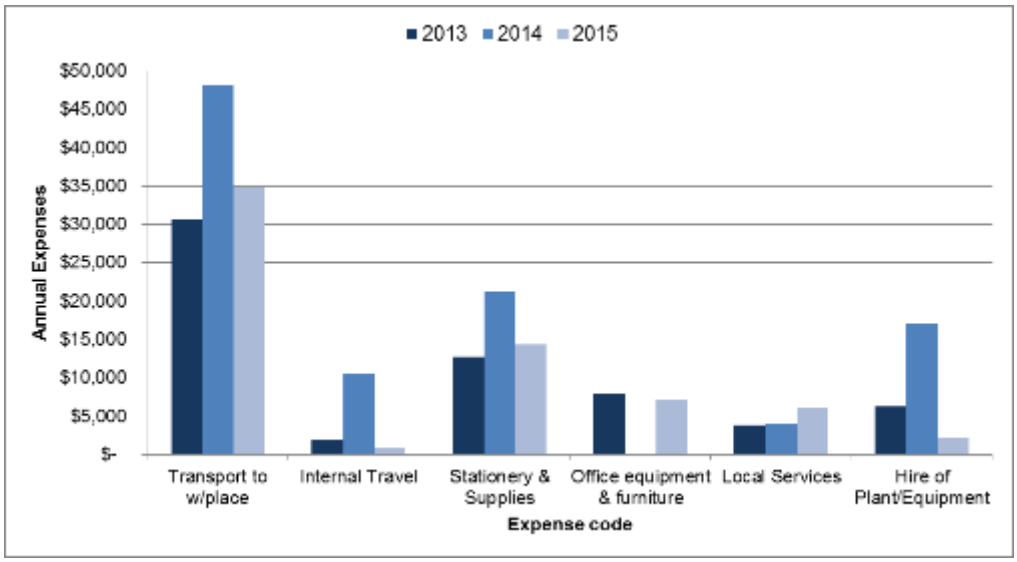

Figure 10 Breakdown of non-salary expenses for 2013, 2014 and 2015.

3.6.3 Revenue

There is currently no link between the WSD budget and revenue generated. The 2016 annual revenue target for the WSD is $31,000. This target was set by the MLPID Finance Division. The Meter Reader indicated that the revenue target was recently revised down from $34,000 when in 2013 and 2014 the revenue generated was $29,000. However, records provided by Finance (Appendix C) indicate revenues for 2013, 2014 and 2015 were $23,605, $20,897 and $34,784, respectively.

In contrast, the MLPID Energy Division has an annual revenue target of $200,000 and annual collection from electricity sales were $381,205 in 2014 and $208,420 by end July 2015. In discussions with the Energy Division staff, they indicated that a typical energy bill is approximately $40 per month and fees for new connections and reconnections are $30 and $10, respectively.

Data provided by the Revenue Officer showing itemised payments received for water services between January and August 2015 are summarised in Table 10. This shows revenue is received for four services; hire of 500 L storage tanks, payment of bills, delivery of tankered water and new connections (of which only one was made in this period). As illustrated in Table 10, the average water bill payment is $34, and the greatest proportion of revenue being generated is from tankered water deliveries. However, the automatic salary deductions from government staff for water supply may not be captured in this data.

Table 10 Summary of water services revenue for Jan - August 2015

Description	Number	Total revenue	Max Payment	Min Payment	Ave. payment
Tank hire	6	$70	$20	$5	$12
Water bill	163	$5559	$882	$1	$34
Water delivery	639	$11,147	$1,070	$2	$17
Connection	1	$30	-	-	-

Analysis of historical water billing data for London in the period August 2001 ï October 2002 shows that the median bill for a government residential property was $13/mth and the average for a private lease residential property was $18/mth. Analysis of the maximum monthly bills shows that the median maximum bill for residential connections is approximately $60/mth, with ranges from $4/mth to $367/mth.

From discussions with the Meter Reader it was clear that many customers are in arrears. This reflects a number of issues which probably include:

- Unaffordability of water services;
- A lack of enforcement of bill paying;
- An unwillingness to pay due to poor services provided;
- A distrust of or errors in the meter records and bills;
- Difficulty in the bill payment process; and
- Poor communication to the customer regarding debts.

It is also interesting to consider the revenue potential using the above analysis. A conservative estimate, with a bill of $15/mth applied to the recorded 451 residential customers connected to the water system in London, Tennessee and Tabwakea could produce a revenue of $81,000 per year. This is more than double the current revenue target. Considering only residential customers in London and Tennessee (278), who will be provided improved supply under the Project, revenue generated could be approximately $50,000 per year, a significant improvement on the current revenue. As discussed in section 7.4.7, peoples WTP is generally higher than $15/month and hence revenue could also be higher.

4. Water demand estimate

4.1 Overview

Water demand has a number of definitions and interpretations, including:

- ***Felt need*** ï the aspirations of communities or government for water consumption. This may be based on a political or equity consideration (Wedgwood and Sansom 2003)
- ***Consumption*** ï the amount of water actually consumed
- ***Effective demand*** ï the demand for water which is driven by or linked to the resources to pay for it

In the context of this Sustainable Water Management Plan for Kiritimati Island each of the above definitions of demand are relevant. It is important to consider the available water supply volumes and constraints on ócconsumptionôthat may be required if future population growth exceeds the water production capacity and therefore limits the per capita ófelt needô

This section outlines information from a number of sources which provide an indication of current water demand. A range of methods have been used to estimate the typical per capita water demand for domestic use and data has also been analysed to understand the water demand for non-residential users including shipping services and hotels. This analysis is required to understand the current and future water needs of the study area.

Importantly, future óeffective demandôis likely to be influenced by key decisions related to the future sustainable management of the water supply system, including:

- Levels of service;
- Tariff rates and structures; and
- Infrastructure and groundwater resource constraints.

Therefore, to understand water demand it is also important to understand community willingness and ability to pay for the proposed service in order to understand how this may influence water consumption.

4.2 Water use from historical metered data

4.2.1 Overview

The current status of the system is such that most meters are not operating, and those that are connected are known to be unreliable due to low water pressure. In the February 2016 in-country trip, some historical metered and billing data was recovered from floppy discs which include records of meter readings from the villages and time periods summarised in Table 11.

Table 11 Summary of historical metered data reviewed (date and connection)

Village	Meter reading dates	Connections (number and type)	
London	August 2001 – October 2002	Church residence	3
		Government house	171
		Private lease	27
		Store	3
		Other Business	10
		Government office/service	3
Prison (London)	August 2001 – January 2005	1	
Tennessee (formally Tibikentaake)	March 2002 – September 2003	Church	2
		Government house	21
		Local hotel	1
		Private lease	24
		School	1
		Store	1
Main Camp	November 2002 – September 2003	Hotel	1
		Government house	13

4.2.2 Approach

Whilst there are some questions as to the reliability of this data, it provides a basis for estimating water consumption. The time periods (all in the early 2000ôs) are around the time of the completion of the KWASP project and so it is expected that meters which had been recently installed were mostly working.

The data contains some gaps and variability, caused by either faulty meters or errors in the meter reading or recording process. To develop an estimate of typical water consumption, the data was audited to illuminate obvious erroneous values or make adjustments and assumptions.

To estimate the ótypicalô water consumption the following method was applied:

- Each connection was assigned a common customer type category (as shown in Table 11).
- The median for each customer was calculated. The median value is used in this analysis (rather than the mean) to eliminate any additional outliers not removed through the initial audit.
- The mean of the medians was then calculated for each customer type – to represent the ótypicalômonthly water consumption.
- The per capita consumption was estimated based on assumed typical household size using results from the 2015 SPC Survey (refer to Figure 31).

4.2.3 Results

Table 12, Table 13 and Table 14 present the per capita water consumption for the period of meter readings available for Tennessee, Main Camp and London. The per capita consumption was estimated based on an assumed average occupancy number of 6.5 people for residential customers as identified in the SPC Survey.

Figure 11 provides a comparison of the residential per capita water consumption for Tennessee, Main Camp and London with a breakdown between government and private households. This illustrates:

- A higher per capita residential consumption in London of 56 - 76 L/person/day, which is likely to reflect the documented poor quality of local well water.
- A low per capita consumption for Tennessee and Main Camp of 19 - 37 L/person/day.
- A discrepancy of 20 L/p/day in London between government and private households. This may reflect that the assumed typical household population (6.5 persons) varies between private leases and government houses. The SPC 2015 survey did not collect information on the house lease type. However, analysis of the smaller data set collected during the February household survey (refer to section 7) reveals that of the 30 private lease households surveyed the average number of people is 8.5, compared with 7.7 people in the 11 government households surveyed. If the assumed household size for private residential leases was increased by 1 to 7.5 people (from the average of 6.5), then the daily per capita demand estimate for London is 66 L/p/d, which brings it closer to the government housing estimate.

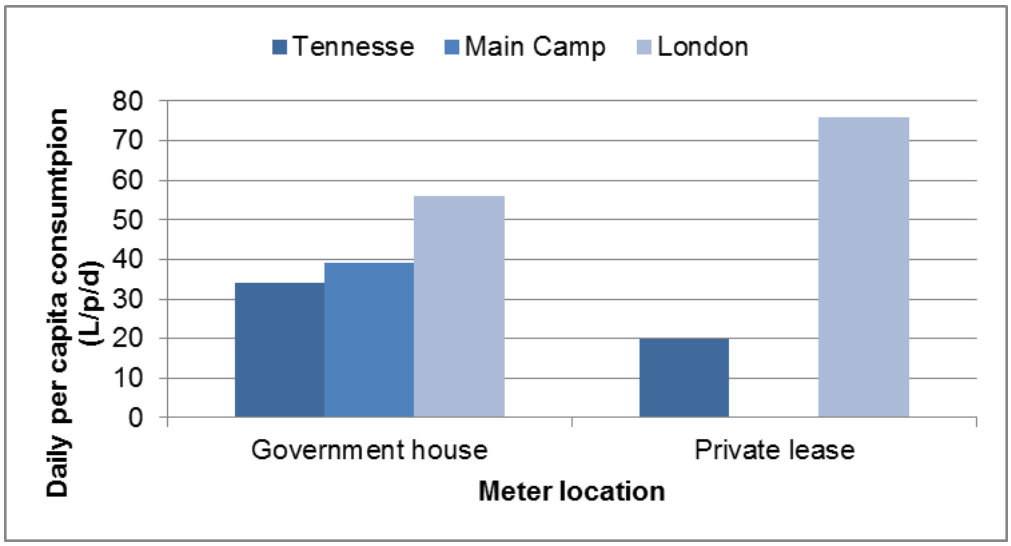

Figure 11 Approximate domestic per capita water consumption from metered data in London, Tennessee and Main Camp, 2002-2003

Table 12 Per capita water consumption by meter type for Tennessee (Mar. 2002 – Sep. 2003)

Category	Assumed population	Monthly consumption (L/person/mth)	Daily per capita consumption (L/person/d)
Government house[2]	6.5	6688	34
Private lease[3]	6.5	3915	20
School	n/a	3850	128
Local hotel	n/a	25600	853
Store	n/a	8426	281
Church	n/a	6375	212

Table 13 Per capita water consumption by meter type for Main Camp (Nov. 2002 – Sep. 2003)

Category	Assumed population	Monthly consumption	Daily consumption
Government house[4]	6.5	7527 L/person/mth	39 L/person/d
Captain Cook Hotel	n/a	128599 L/mth	4286 L/d

Table 14 Per capita water consumption by meter type for London (Aug. 2001 - Oct. 2002)

Category	Assumed population	Monthly consumption (L/person/mth)	Daily per capita consumption (L/person/d)
Business	n/a	8008	267
Catholic priest house[5]	1	1002	33
Church pastor house (SDA) [6]	4	2484	83
Government house[7]	6.5	1682	56
Hospital	n/a	15701	523
KPC pastors house[8]	4	1597	53
Old LINIX office	n/a	6520	217
Pet fish business	n/a	14065	469
Police	n/a	82	3
Prison	n/a	22084	736
Private lease[9]	6.5	2294	76
Store	2	2341	78

[2] Population based on SPC 2015 survey household average
[3] Population based on SPC 2015 survey household average
[4] Population based on SPC 2015 survey household average
[5] Population based on SPC 2015 survey
[6] Population assumed same as KPC
[7] Population based on SPC 2015 survey household average
[8] Population based on SPC 2015 survey
[9] Population based on SPC 2015 survey household average

4.3 Water use from revenue data

The payment data described in section 3.6.3 has been categorised into end-user types as shown in Table 15. Although information about actual water consumption was not available for this time period, it can be inferred from these payments that:

- Residential consumption is the highest proportion of water demand
- The commercial shipping businesses, Dojin Company Ltd and Central Pacific Products Limited (CPPL), are significant water users. CPPL runs shipping services between Tarawa and Kiritimati, and Dojin is the shipping agent for cargo ships that typically arrive in Kiribati every three months. Water is provided to the ships when they dock for ship operations.
- Hotels are also high water users within the community.

Table 15 Summary of water services revenue for Jan. – Aug. 2015 by end-user

Category	Water bill	Water delivery	Total
Church	$350	$452	$801
Commercial	$251	$415	$665
Commercial - shipping	$139	$4,624	$4,763
Government commercial	$61		$61
Government office	$0	$66	$66
Hotel/Motel	$1,072	$1,009	$2,081
Residential	$3,687	$4,566	$8,253
JSS	0	$16	$16
Grand Total	**$5,559**	**$11,147**	**$16,706**

Given that poor water services were occurring during the period of data (Jan ï August 2015), the demand for water from commercial shipping business and motels can be inferred from the tankered water purchases.

Analysis of the frequency of payments for each customer shows that the commercial shipping companies, Dojin and CCPL ordered water 10 and six times, respectively. The hotels/motels ordered water less frequently, with the exception of Sunset Motel which had nine payments. Both Dojin and CCPL had several large payments which, it is understood, reflects orders for docked cargo ships.

From the SPC Household Survey, it is known that Dojin has no reticulation connection or rainwater harvesting and therefore tankered water payments are assumed to reflect water demand from this customer. It is also known that during this period water supply to London was limited. Therefore, it can be inferred that ordered water for those commercial customers based in London reflects typical water demand, for:

- Eritaia
- Ikari House
- Sunset Motel
- Tekabaia
- Terawanibakoa
- Xmas Parish Motel

Conversely, the Villages hotel (FBRCV) is located in Tabwakea, downstream of the header tank and had water supplied during this period. As such, the bill payment reflects metered flow. The total payments made in the eight month period for Villages was $882, which equates to approximately 74 kL per month or 2.5 kL per day (assuming the rate charged was $1.5/kL).

The summary of payments made by these customers is provided in Table 16 and Table 17. The volume of tankered water is inferred, assuming a rate of $10/kL for the shipping services (CPPL and Dojin) and $5/kL for the hotels/motels.

Table 16 Summary of payments made by shipping services and vessels Jan-August 2015

	Water bill	Water deliver payments (total)	Volume of tankered water (kL)	No. deliveries	Average Order volume (kL)	Monthly average ordered volume (kL/mth)
CPPL	$68	$961	96	6	16	12
Dojin	$71	$3,555	355	10	36	44
LC Tioti Kwong	$0	$100	10	2	5	1
Mackenzie	$0	$8	1	1	1	0

Table 17 Summary of payments made by motels Jan-August 2015

	Water bill	Water deliver payments	Volume of tankered water (kL)	No. deliveries	Average Order volume (kL)	Monthly average ordered volume (kL/mth)
Eritaia	$0	$54	11	3	4	1
FBRCV (Villages)	$882	$63	13	2	6	2
Ikari House	$0	$82	16	1	16	2
Sunset Motel	$0	$513	103	9	11	13
Tekabaia	$135	$15	3	1	3	0
Terawanibakoa	$0	$82	16	1	16	2
Xmas Parish Motel	$0	$200	40	1	40	5
Grand Total	$1,017	$1,009	202	18	97	25

Following clarification on the payments made by Dojin and CCPL, additional data was provided on their historical water bills[10]. As shown in Table 18 similar to the 2015 data, Dojin had some large payments which includes monthly orders of approximately 105 kL in March, April May and June 2012. Water orders range in frequency and volume but were monthly from February to November 2012, with an average order of 75 kL, and maximum over this period of 105 kL.

It is understood that Dojin have their own 4 kL capacity truck and use this to transport water from Decca to London, whilst CPPL orders are supplied through the WSD 3 kL truck.

Similar data was also available for CPPL for 2009 ï 2013 which is presented in

Table 19. This data shows that where consistent monthly payments were made (December 2011 ï June 2012) the monthly consumption was consistently 24 kL. This consistent value is suspicious and further discussions with the WSD Meter Reader are required to clarify this. However, calculating the average monthly consumption for larger payments in November 2012 and October 2013 (assuming that the volume recorded reflects the total consumption in the five

[10] This data was copied from hard-copy meter and billing records.

month and 11 month periods between bills) this gives a similar order of magnitude. Hence, for the purpose of water balance analysis it is assumed that the average monthly demand from CCPL is 24 kL.

Table 18 Water supply orders for Dojin shipping from July 2009 – October 2013

Date	Litres Ordered	Cost
31/7/09	6,638	$66
30/09/11	152,448	$1,524
31/10/11	29,000	$290
31/12/11	18,000	$180
28/02/12	20,000	$200
30/03/12	104,936	$1,049
30/04/12	104,936	$1,049
31/05/12	104,936	$1,049
30/06/12	104,936	$1,049
30/07/12	70,054	$701
30/08/12	61,991	$620
30/09/12	60,290	$603
31/10/12	60,892	$609
30/11/12	64,792	$648
30/10/13	40,080	$401

Table 19 Metered water supply orders for CPPL shipping from July 2009 – October 2013

Date	Litres Ordered	Cost	Assumed Monthly demand (kL)
31/01/09	62,000	$622	-
30/11/11	197,000	$1,970	-
30/12/11	24,000	$240	24
30/01/12	24,000	$240	24
28/02/12	24,000	$240	24
30/03/12	24,000	$240	24
30/04/12	24,000	$240	24
31/05/12	24,000	$240	24
30/06/12	24,000	$240	24
30/11/12	160,000	$1,600	32
30/10/13	332,000	$3,320	30.2

4.4 ADB *Preparing the Outer Island Growth Centre's Project* 2007 demand estimates

In 2007, as part of the ADB *Preparing the Outer Island Growth Centre's Project*, a household survey was conducted which covered approximately 10% of each village on Kiritimati Island, including Tabwakea, Poland and Banana which are outside the study area for this current project. The results of this survey were obtained from the report entitled *'Working Paper: Social and Poverty Analysis'* (Powell 2007).

The survey conducted and described in the Powell (2007) report included questions on water usage and the results are compared with Ministry records from 2007. This information is reproduced in Table 20 below. Two household water use estimates were given and these are based on survey participant stated estimates. Comparing these results shows people estimated much lower water ónéedsôcompared to total consumption when broken down by water source and end-use. It is not clear what the MLPID records are based on. However, the report provides some discussion which implies that the MLPID figures are likely based on metered supply.

The following other observations on water demand are provided in Powell (2007):

- The MLPID figures do not include non-revenue water or unallocated water which raises the usage by ñmore than 50%ò with the unaccounted for water at 58% and 47% for Poland and for London-Tabwakea systems, respectively.
- An additional 3 L/p/d on average of tankered water was being ordered in London
- The MLPID records show higher per capita consumption for London compared with other villages, whilst the household survey results show relatively consistent water use across villages. (note: it is not known whether this household survey reflects total consumption or demand for reticulated water).

A comparison of the estimates from the limited metered data analysed in Section 4.2 shows similar orders of magnitude between the MLPID records and the metered records for Main Camp.

Table 20 Water consumption data from 2007 WSD records and 2007 Household survey (source: Powell 2007)

Village	MLPID Records (L/p/d)	Household Survey, Ave. Total Water Use (L/p/d)[11]	Water use estimated by respondents[12] (L/p/d)
London / Tennessee	42.1	53	32
Tabwakea / TRB	28.9	52	34
Banana / Main Camp / North Banana	27.1	49	36
Poland	25.6	55	20

Following analysis of the household survey results, presented in Table 20, the ADB project adopted for design purposes a per capita residential water demand of 90 L/p/day. This was considered sufficient to allow for potable and non-potable water use including toilet flushing (Falkland and White 2007). The project concluded that:

[11] Question 7 from ADB survey ñWhich of the following water supply systems do you have at you home and for what purpose do you use each? Please also estimate the water usage, in litres per person/per day for the different systemsò

[12] Question 8 from ADB survey ñHow many buckets (20L) do you think each person requires each day?ò

- 90 L/p/day will accommodate the move towards additional water using appliances in some households. This is an increase from the approximately 50 L/p/d estimated in the 2007 household survey.
- The piped water use estimated through analysis of metering data is not a good indicator of future demand as it has been constrained by the limited capacity of the existing pumping systems and by the fact that many consumers have been disconnected.
- London (and Tennessee) residents will rely predominantly on reticulated water to meet the 90 L/p/d demand, due to the poor water quality of local groundwater, whilst the other villages, including Tabwakea, will have an assumed demand for reticulated supply of 60 L/p/d and the further 30 L/p/d supplied from supplementary local groundwater (or rainwater when available).
- For non-residential consumption, which includes all institutional and commercial consumption (e.g. hospital, clinics, offices and workshops), it was assumed that this equates to approximately 10% of total residential use.
- System losses (primarily leakage from pipelines but also overflow from tanks) are assumed to be 20% of the combined residential and non-residential consumption. This was considered a conservative estimate.

4.5 Household water consumption survey

During the February 2016 in-country trip, volunteers were requested to conduct a week-long, self-regulated survey, to document their water consumption patterns on a daily basis. This was a relatively onerous task that relied on a champion from each household who was able to clearly communicate the survey requirements and purpose to all householders. As a result, only a limited number of surveys were returned (4 of more than 20). With such a small sample size, the results cannot be relied on. However, the data still provides some interesting results including:

- An understanding of typical household water uses that include bathing, drinking, dishwashing, cooking, toilet flushing, clothes washing and feeding pigs.
- Of the 4 houses surveyed, three have an average per capita consumption of 20-30 L/p/d. This is similar to the average demand estimated for Main Camp and Tennessee using the metered results (section 4.2). The other house, in Main Camp, reported 84 L/p/d including water for pig feeding or 78 L/p/d excluding pig feeding. This includes use of non-reticulated and non-potable water sources (rainwater and local wells).
- Assuming a breakdown between potable water and non-potable water use as shown in Table 21, the proportion of consumption attributed to potable use was between 54% and 59% for three houses (in London, Main Camp and Tabwakea), and 83% for one house (in London). The key differentiator was that the house with the highest proportion of potable water demand recorded a high (69%) of water use for bathing. However, this probably also includes non-potable use for toilet flushing, as no distinction was made for this use, whilst the other three houses reported 31-36% use for bathing.

Table 21 Potable and non-potable end-use allocation

Potable	Non-potable
Bathing	Toilet
Drink	Clothes washing
Dishwashing	Feeding pigs
Cooking	

The detailed data and summary tables from this survey are provided in Appendix D. Overall, whilst interesting, the survey results are limited and cannot be relied on. It is recommended that another survey be undertaken, but that incentives be provided to encourage participation. For example, prizes could be offered for the best results, or through a raffle for participants. In addition, more time would be required to prepare participants in the survey requirements, and then audit results through household visits. This would ideally be facilitated through the WSD.

4.6 Observations from household surveys

The household survey described in Section 7 did not attempt to quantify water consumption, however during discussions some estimates of water use could be inferred.

One household in London (ref no. 1671) with 13 people, stated they emptied their 500 L tank in one day which is not used for toilet use. This equates to 40 L/p/d (500õ13) a cost of $75/mth (assuming tankered water at $5/kL). This is again a similar order of magnitude to the estimates from the ADB survey (section 4.4) and metered data (section 4.2).

4.7 International standards for water quantity

The World Health Organisation (WHO) report on *Domestic Water Quantity, Service, Level and Health* (Howard et. al. 2003) provides an indication of the likely quantity of water that will be used for different levels of service. The WHO report concludes that the volume of water used in the home is sensitive only to gross differences in service level, although there is also some evidence that suggests cost and reliability also have an influence (Howard et. al. 2003).

The service levels considered relate to the distance to or ease of access to water. The current water supply situation in London, Tennessee and Tabwakea fits somewhere between the WHO descriptions of service levels being, ónintermediate accessôwhich is on-plot single supply point (e.g. yard tap such as the diverted pipes accessed at ground level) and ólbasic accessôwhere 5 ï 30 minutes are required to collect water. The expected per capita water consumption for basic and intermediate level of service is 20 and 50 L/p/d, respectively. This aligns with the order of magnitudes described in the previous sections for and documented in other studies for household demand.

The WHO guideline suggests that a minimum for basic health protection corresponds to ólbasic accessôof which, within a typical usage of 20 L/p/d, about 7.5 litres is required for consumption. However, this is not considered sufficient to enable basic hygiene practices.

The equivalent service level for the Kiritimati Island water supply following the proposed improvements from the Project is described as óoptimal accessôin the WHO guidelines - where water is supplied through multiple taps to the household and is a continuous (24 hour) supply. In this situation the expected average per capita consumption is 100 L/p/d or above (Howard et. al. 2003). Hence for the Kiritimati Island system, it could be expected that an improved and continuous supply to households could result in per capita consumption in excess of 100 L/p/d, which would be limited only by availability of supply, flow rates and potential customer self-regulation triggered by the cost of water.

4.8 Summary of water demand estimates

4.8.1 Residential demand

Table 22 provides a comparison of per capita demand estimates from the sources reviewed. This comparison illustrates that:

- The historical per capita demand for reticulated water is in the order of 20-80 L/p/day, with the higher consumption recorded in London and Main Camp.
- The per capita demand for reticulated water in London is higher than for Tabwakea due to the assumption of access to better quality groundwater in Tabwakea. It should be noted that whilst groundwater in Tabwakea has lower salinity levels than in London, there are still issues of contamination of groundwater from latrines and animals and hence treatment is necessary.
- The per capita demand is expected to increase with improved levels of service and access ï this should be considered in future demand projections.

The analysis provides no clear reason to reject the reticulated water supply demand assumptions adopted for the 2007 ADB study (60 L/p/day for Tabwakea and 90 L/p/day for London and Tennessee) as these fall within the expected range. However, further refinement could be justified as follows:

- The 60 L/p/d for Tabwakea may be an over estimate where alternative water sources are available and data shows this is expected to be more in the order of 40-50 L/p/d. However, as illustrated in the WHO Guidelines if access levels are improved, demand is expected to increase. Hence 60 L/p/day seems acceptable given the proposed improvements to the water supply system.
- The WHO guidelines indicate an increased level of access will correlate to an increased demand. Therefore, the typical per capita demand following the project completion, could be in the order of 100 L/p/d ï at least for London and Tennessee where service is to be improved to provide continuous higher pressure supply. Hence, rather than the 90 L/p/day, 100 L/p/day could be adopted as a more conservative estimate for future planning.

Table 22 Comparison of per-capita household demand for London, Tennessee and Tabwakea

Basis of demand estimate	London	Tennessee	Tabwakea
	L/p/d	L/p/d	L/p/d
Historical metered data (2002-2003)	56 - 76	19 - 37	n/a
ADB 2007 Household survey	53		52
ADB 2007 report ï metered records	42		29
ADB 2007 ï adopted demand	90		60
Household consumption survey, 2016	20-30 & 78		
Observations from household, 2016	40 (excl. toilet flushing)	n/a	n/a
WHO Guideline ï intermediate access	20-50		
WHO Guideline ï optimal access	100 +		

Total estimated residential demand

To understand the total demand on the reticulated water system, the results of SPC's 2015 household survey can be applied. The survey indicates that 60% of the 747 households in the study area (London, Tennessee and Tabwakea) have a reticulated water supply connection, and 37% of those connected houses also have a well. It is assumed that these houses with a well have a lower per capita demand for reticulated water than those without a well and as such:

- 37% of the connected population (1090 people) have a daily demand for reticulated water of 60 L/p/d
- 63% of the connected population (1873 people) have a daily demand for reticulated water of 100 L/p/d

This equates to a total current demand for reticulated water from residential consumption of 260 kL/day (165 kL/day for London-Tennessee and 95 kL/day for Tabwakea). This exceeds the current production capacity from Decca and Four Wells (235 kL/day). With the proposed additional galleries at Decca and diversion pipeline, the production to London and Tennessee will be 260 kL/day. The production at Four Wells will also be increased through the replacement of lower capacity wind pumps with solar pumps and this will increase supply to Tabwakea to 120 kL/d. Refer to sections 3.2 and 3.3 for further details.

Table 23 Number of residential customers with wells and calculated residential demand for reticulated water supply.

	London	Tennessee	Tabwakea	Total
Population	1606	353	2949	4908
Total no. residential households	229	49	469	747
No. connected residential customers	212	39	200	451
Proportion of residential households with reticulation connection	93%	80%	43%	60%
No. residential hh with wells	36	11	297	344
Proportion of houses with wells	16%	22%	63%	46%
No. connected households with a well	31	10	125	166
Proportion of connected customers with a well	15%	26%	63%	37%
Proportion of connected customers with no well	85%	74%	38%	63%
Population with connection and with wells	217	72	786	1091
Population with connection and without wells	1269	209	472	1873
Demand (kL/d)	139.9	25.2	94.4	260

4.8.2 Non-residential demand

Table 24 presents the typical daily non-residential consumption estimated from a range of sources. It should be noted that this excludes small shops and given the age of the data is expected to be an incomplete picture of demand from these sources. However, this limited information shows that at least approximately 13 kL/day is required for non-residential purposes. This equates to approximately 5% of the residential demand, in contrast to the 10% assumed in the ADB (2007) study. Further analysis of the highest water users, including hotels and shipping is recommended including understanding the seasonality of the water requirements of these customers. For the purpose of developing supply-demand projections (section 5) it is proposed that 5% be adopted for non-residential consumption.

Table 24 Non-residential consumption

Customer group	Typical daily consumption (L/d)	*Reference*
JSS	128	*2002-2003 metered data*
CCH	4,286	
Government office	217	
Prison	736	
Hospital	523	
Pet fish business	469	
Hotels	3292	*2015 revenue data*
Shipping - Dojin	2,260	*2012 billing data*[13]
Shipping - CPPL	800	*2015 revenue data*
Total	**13,710 L/d ≈ 13 kL/d**	

4.8.3 Losses

There is no data available to quantify actual leakage or wastage volumes for the current system but previous studies have adopted 20% of total demand (ADB 2007; Falkland and White, 2007, Bencke, 2015) for design purposes. However, this has been noted to be an optimistic assumption. The ADB report (2007) noted that non-revenue water or unallocated water was 47% for the London-Tabwakea systems. As described in section 3.2.2, modification of the system by householders trying to access low pressure water has left many pipes open contributing significantly to losses. Whilst the project is proposing to fix all household connections in London and Tennessee, it is essential that extensive maintenance be also undertaken in Tabwakea to rectify leaks and that an ongoing program of leakage control be implemented for all villages with connections.

To show the sensitivity of the supply-demand water balance to the system losses two loss factors , 20% and 50% have been used in the projected water balance calculations in section 5. The lower bound of 20% requires a stringent maintenance regime to be implemented, along with rehabilitation of the system in Tabwakea (which may not be covered by the current project). These physical actions must also be undertaken in combination with a comprehensive community education and awareness program on water conservation and also the enforcement of penalties for tampering of water supply pipes.

[13] Median of ave. daily demand from Feb ï Nov 2012

5. Water balance

5.1 Approach

Using the population projections presented in section 3.1.2 and the estimates for demand for reticulated water supply presented in section 4.8, an estimate of growth for reticulated water supply demand in the next 20 years has been undertaken. The detailed calculations are provided in Appendix E and Fig 12 and 13 shows the projected demand for reticulated supply, based on the following assumptions:

- Coverage of reticulation connections in London and Tennessee will reach 100% by 2020
- Connections to the reticulated system in Tabwakea will increase by 2% each year (note this is an arbitrary number and the actual rate of connection will depend on key policy decisions including connection charges).
- The proportion of population with wells and a connection will remain constant for London and Tennessee as it is assumed that access to groundwater is already at the limit in these areas. However, for Tabwakea it is assumed that the proportion of households with wells and connections will increase at the same rate of connections (2% per year) up to a maximum of 90%. This is because groundwater quality in this area is known to be higher quality and more likely to be used as a supplementary source.
- The non-residential demand is 5% of total residential demand, which is lower than estimates from previous studies (10%), but more in-line with data analysis presented in section 4.8.2.
- The non-revenue water attributed to leakage and wastage has been estimated as a proportion of the total residential and non-residential demand. To show the sensitivity of the supply-demand water balance to the system losses two loss factors, 20% and 50% have been applied. These reflect the range of expected losses depending on the extent of rehabilitation work provided through the project and on future long-term maintenance practices.

5.2 Results

5.2.1 Decca and London – Tennessee demand-supply balance

Figure 12, Figure 13 and Table 25 show the projected supply-demand water balance for reticulated supply to London and Tennessee with two loss scenarios, 20% and 50%. The projected supply from Decca freshwater lens reflects the increase in production from the proposed additional galleries to be constructed under the project. With the higher loss scenario shown in Figure 13 the demand for reticulated water (288 kL/d) is projected to exceed production from Decca (260 kL/d) even after the increased production in 2020. Conversely, if losses are controlled to 20%, the supply from Decca exceeds projected demand (230 kL/d) as population growth is expected to be negligible. This illustrates the significance of the rehabilitation work to be undertaken in London-Tennessee as part of the current project and the importance of continued maintenance and other water use efficiency initiatives.

Figure 12 and Figure 13 also show the maximum sustainable yield from Decca lens of 260 kL/day which matches the projected production of 260 kL/day following construction of the new galleries. This illustrates that there is no opportunity for additional supply from the Decca system. Hence in the event that demand exceeds supply such as in the higher loss scenario (Figure 13), additional water sources will be needed and demand management strategies implemented.

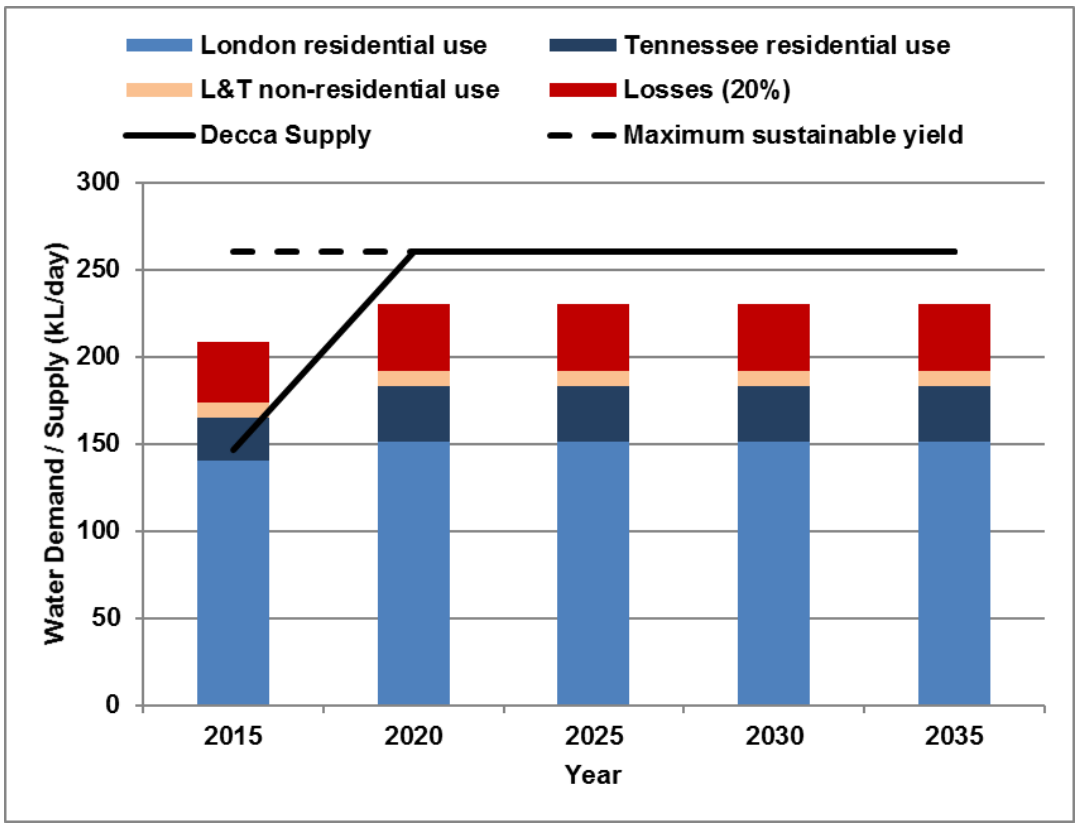

Figure 12 Projected water demand for reticulated supply to London and Tennessee from 2015 to 2035, with 20% losses and supply from Decca freshwater lenses

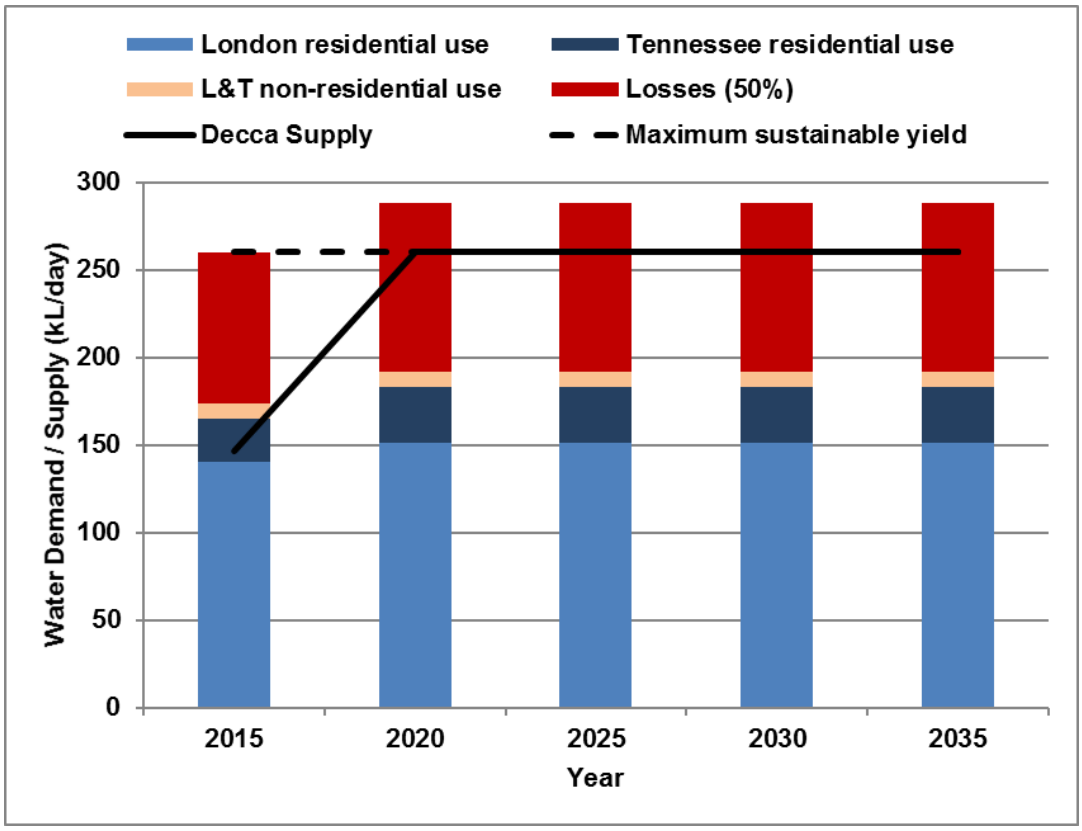

Figure 13 Projected water demand for reticulated supply to London and Tennessee from 2015 to 2035, with 50% losses and supply from Decca freshwater lenses

Table 25 Total projected demand for London and Tennessee from 2015 to 2035 with 20% and 50% losses and supply form Decca lens (units: kL/d).

Year	Residential demand		Non-residential use	Losses (20%)	Losses (50%)	Total Demand (20% losses)	Total Demand (50% losses)	Decca Supply
	London	Tennessee						
2015	140	25	8	35	87	208	147	147
2020	151	32	9	38	96	230	260	260
2025	151	32	9	38	96	230	260	260
2030	151	32	9	38	96	230	260	260
2035	151	32	9	38	96	230	260	260

5.2.2 Four Wells and Tabwakea demand-supply balance

Figure 14, Figure 15 and Table 26 show the projected supply-demand water balance for reticulated supply to Tabwakea with two loss scenarios, 20% and 50%. The projected supply from Four Wells freshwater lens shows a slight increase in production (89 kL/day to 120 kL/day) from the proposed replacement of wind pumps with solar pumps as part of the project. Figure 14 and Figure 15 also show the maximum sustainable yield from Four Wells lens of 300 kL/day compared to the projected production of 120 kL/day. This illustrates the significant potential to increase supply if additional galleries are constructed at Four Wells.

Figure 14 and Figure 15 illustrate that demand currently exceeds supply for Tabwakea, and this will continue to be the case even with the slight increase in production due to replacement of pumps at Four Wells. This is further compounded by a projected exponential increase in population.

The following key points are highlighted through this supply-demand balance:

- There is an urgent need to expand production at the Four Wells lens through the construction of new galleries.
- The lower bound for losses 20% requires a stringent maintenance regime to be implemented, along with rehabilitation of the system in Tabwakea (which is not covered by the current project). These actions must also be undertaken urgently in combination with a comprehensive community education and awareness program on water conservation and also the enforcement of penalties for tampering of water supply pipes.
- There is a need for long term strategic urban planning and population growth initiatives targeting Tabwakea village.
- Minimising losses from the water supply systems occurring from wastage and leakage is critical. This must be urgently considered through rigorous maintenance, leakage control and asset management processes and through customer awareness programs on water conservation.

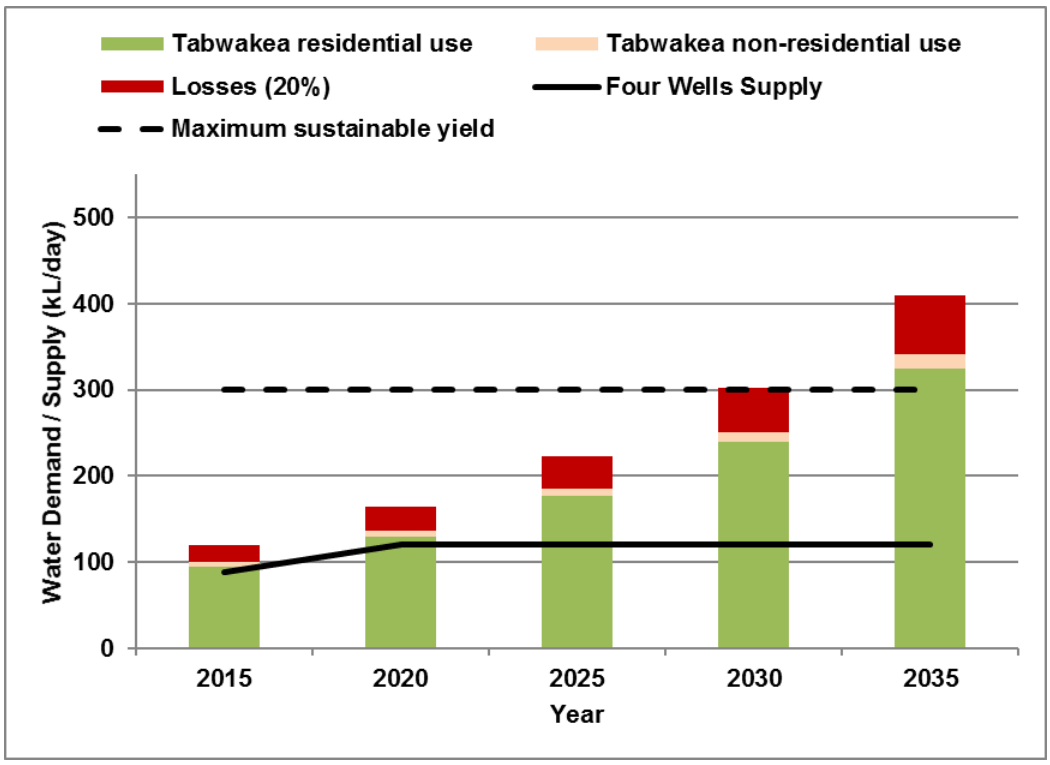

Figure 14 Projected water demand for reticulated supply to Tabwakea from 2015 to 2035, with 20% losses and supply from Four Wells freshwater lenses

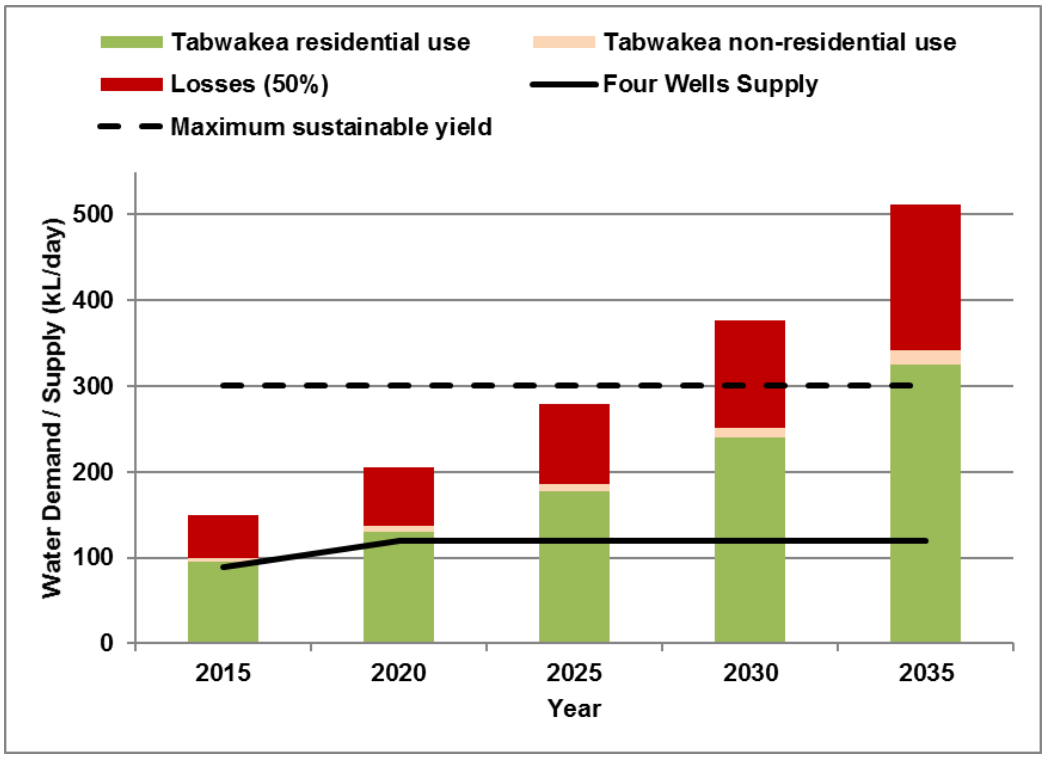

Figure 15 Projected water demand for reticulated supply to Tabwakea from 2015 to 2035, with 50% losses and supply from Four Wells freshwater lenses

Table 26 Total projected demand for Tabwakea from 2015 to 2035 with 20% and 50% losses and supply from Four Wells lens (units: kL/d).

Year	Residential demand	Non-residential use	Losses (20%)	Losses (50%)	Total Demand (20% losses)	Total Demand (50% losses)	Four Wells Supply
2015	95	5	20	50	120	150	89
2020	130	6	27	68	164	205	120
2025	177	9	37	93	223	279	120
2030	239	12	50	126	302	377	120
2035	325	16	68	171	409	512	120

Figure 16 and Figure 17 provide graphical representations of the 2015 and 2035 supply-demand balances for London, Tennessee and Tabwakea This illustrates that the greatest proportion of demand is attributed to domestic consumption and hence any water conservation, efficiency and demand management initiatives are best focused at a household level..

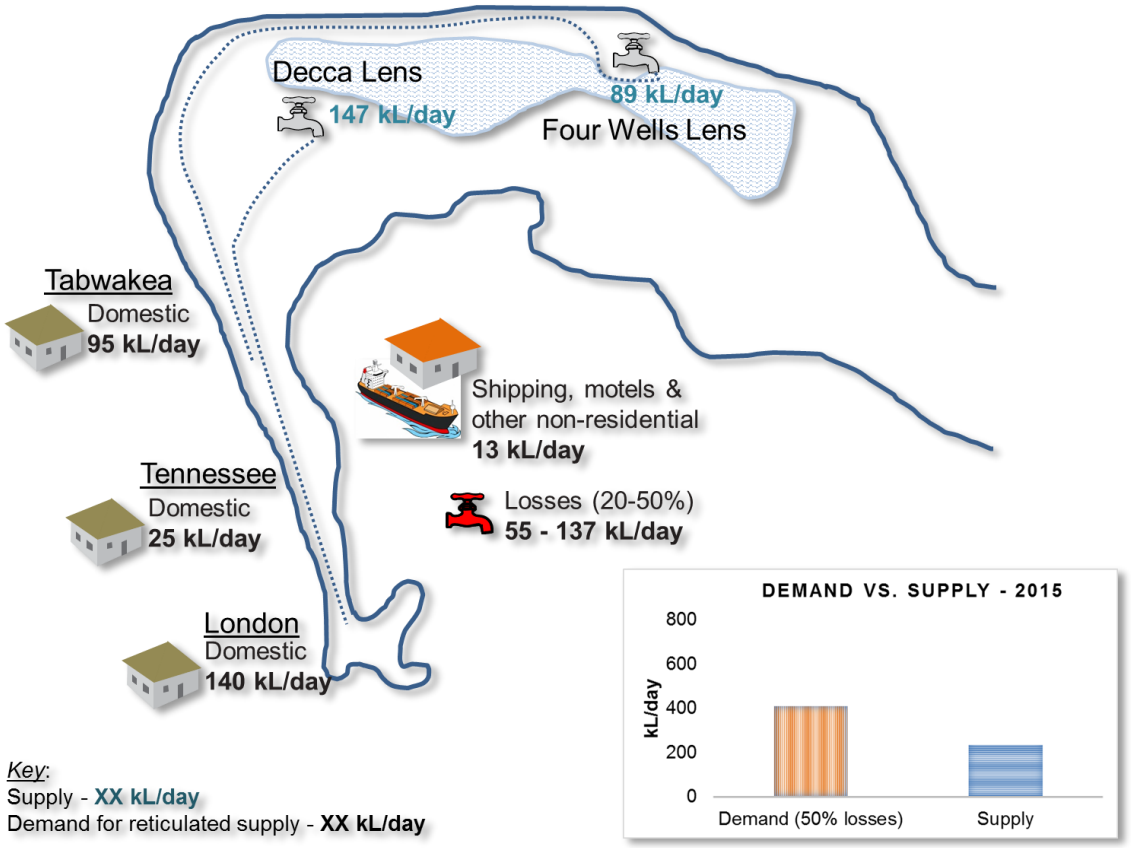

Figure 16 Schematic of 2015 Demand-Supply Balance - London, Tennessee and Tabwakea

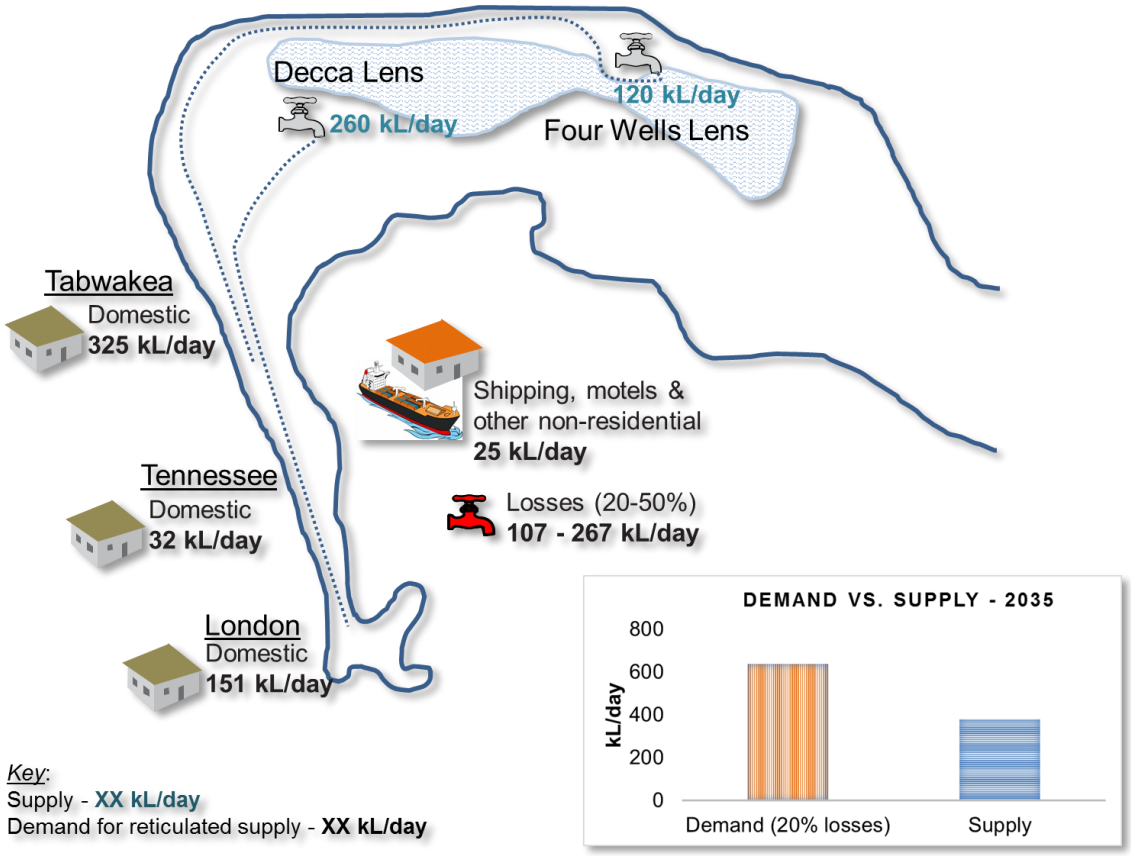

Figure 17 Schematic of 2035 Demand-Supply Balance - London, Tennessee and Tabwakea

6. Stakeholder consultation

6.1 Overview

The following section provides a summary of the outcomes from stakeholder consultation undertaken during the February 2016 in-country trip to Kiritimati Island and a subsequent visit to South Tarawa in April-May 2016.

6.2 Public consultation

Public consultation sessions were held at three community venues[14]. The purposes of these forums were to (a) inform those present about the scope and timing of the Project and the water supply constraints projected with future population growth and (b) get ideas and discussion on options to promote water conservation and sustainable management of the water system into the future. A PowerPoint presentation was used in these forums to present key information on the project, and the following questions were put to the attendees to generate discussion:

- How can we make sure water is shared for all people?
- How can we make sure people are happy to pay for water?
- How can we get people to report issues and work together as a team to protect the water system?

These sessions were also used to inform community groups about the recommendations within the Basic Environmental Impact Assessment (BEIA), and a joint presentation was delivered by project staff.

Figure 18 Consultation at SDA London Maneaba

[14] A fourth venue, the Catholic community in London was not able to be consulted due to poor communication with allocated times on two occasions.

Table 27 provides a summary of key comments and ideas raised during these forums as they relate to the Sustainable Water Management Plan.

Table 27 Summary of comments and ideas from community forums

Community group	Ideas and comments
Tennessee Junior Secondary School Tuesday 16 February 2016, 6 pm Attendees: 5 women, 4 men	• Meter readers to ask householders if there are any issues • Have a small office within each village for reporting problems • Have community volunteers responsible for reporting issues • Example of good system is the Solar Energy Company in the outer islands, which do a regular household checks of the operation. • Conduct water conservation community awareness campaign within schools which will help to pass on messages to parents. A good model of this is the Wildlife and Tourism Office which holds a regular class for Form 2 students which is specific to Kiritimati Island. Currently there is no specific curriculum for JSS level on water. • Develop videos on water conservation to provide to schools and present at community maneabas.
Seventh Day Adventist (SDA) Church, London maneaba Wednesday 17 February 2016, 8 pm Attendees: 11 women, 13 men	• To avoid history repeating in terms of the breakdown there is a need to do a study on the affordability of water to make sure the price set is not too expensive. Otherwise people wonôt pay again for the service and this limits the sustainability of the system. • One unimane indicated support for the current water rates ï noting that 60 cents for 500 L is very cheap. He commented on the need to punish those who vandalise the system, and advocates for KUC to play a role in managing the water system. He also proposed that pipes should be separated between villages so that vandalism that occurs in one village, does not impact those villages downstream. • Support for a public awareness campaign to ensure all people understand how much water is available and that it is a finite resource. Support was also expressed for a linkage between revenue raised and maintenance.
Kiribati Uniting Church London maneaba Thursday 18 February 2016, 6 pm Attendees: 4 women, 6 men	• Comment that most water is used in toilet flushing and recommending that a separate system be adopted using well water for this purpose. • Also propose that rainwater harvesting be promoted to supplement water usage. This was noted as a good idea during wet periods, but that it is not a reliable source in dry periods. • Comment that well water quality in London is improving, due to the substantial rain it appears that the oil contamination is reducing. Note that further investigation is required to corroborate this claim. • The 90 L/p/day estimate was considered be attendees as sufficient and a good assumption.

6.3 Stakeholder workshops

6.3.1 Water and Sanitation Division workshop

A half-day workshop was held with all available staff (11 attendees[15]) from WSD on 18 February 2016. The purpose of the workshop was to introduce the WSD staff to the concepts of sustainable water management, explain the projected deficit in water supply relative to future demand and to understand how the current system operates and identify any issues or opportunities. Key outcomes of this workshop include the understanding of the existing structures and systems described in Section 3. During the workshop, participants were asked to calculate, based on population projections, the projected demand for water and also the potential revenue (Figure 19). They also discussed their current roles and activities, and presented ideas to make their work easier by promoting more sustainable water management (Figure 20).

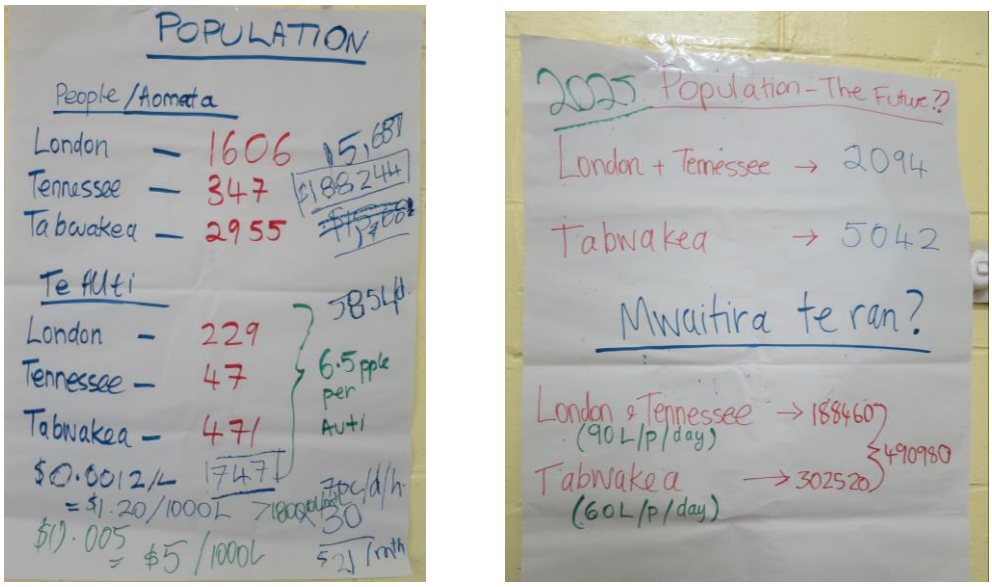

Figure 19 Exercises to calculate population growth, demand and potential revenue undertaken during WSD workshop

Figure 20 Workshop participants outlining their responsibilities and ideas for improvement to promote sustainable water management

[15] Attendees included the Meter Reader, Store Manager, Mechanic, six tradesmen from the water and sanitation divisions and the Water and Sanitation Leading hands. Unfortunately, the Water Foreman did not attend due to personal commitments.

During this discussion the following opportunities and ideas were raised:

- Access to transport is a key issue for the operation of the WSD. Currently, the Water and Sanitation units share a truck; which means that maintenance rates are about three houses per day. It is proposed that a second truck would improve the speed at which maintenance is performed allowing up to seven houses to be addressed in a day. The SPC Project truck also currently assists with delivery of tankered water and transport for maintenance activities. This temporary reliance on a project vehicle is not sustainable. It is also understood that the vehicle used is leased from the Government run Plant and Vehicle Unit (PVU). This continuous outlay of funds could instead be invested in the purchase of a new vehicle and would likely reduce longer-term costs for transport.
- Ideas to encourage people to conserve water:
  - ï Talking and educating people about water conservation.
  - ï During the KWASP, each person within WSD was assigned a set number of houses to check each month. This created a relationship between householders and WSD staff, and subsequently increased accountability for maintenance and customers respect for the system. The workshop participants proposed that this system be reintroduced, with a form being developed to allow reporting of the status of households. If a small problem is identified, this should be fixed immediately and if it is a larger problem this should be reported back to the Leading Hands to add to the teamsôwork plans.
  - ï Enforcing a $50 penalty for tampering, which is already in place but not enforced.
  - ï WSD to report incidents of serious vandalism to the police (e.g. the theft of solar panels which occurred after KWASP and contributed significantly to the decline in pumping rates).
- There is a need for training and capacity building of all WSD staff. As described in section 3.4, the skills of Water and Sanitation Tradesmen are limited. Although the project is proposing on-the-job training through placement of an international consultant plumber this has been delayed due to difficulties identifying a suitable candidate. It is encouraged that the WSD also seek support from the MPWU staff, who have more recent formal training in plumbing.
- A request was made for equipment to assist with the water attendant role at the galleries. Ideas included raincoats, anew shelter whilst attending the diesel pump (note this pump is to be replaced under the project and will require less frequent monitoring) and a phone or radio to communicate to WSD head office from the water reserves.
- The procedures outlined for ordering of spare parts for maintenance by the Store Manager involves seven steps from the initial ordering of stock from suppliers, to the approvals and processing of payments, to purchase and collection of the stock. This system is inefficient and is likely to result in delays in receipt of important spares. In addition, although records of stock are kept, a stock-take is only undertaken annually. The Store Manager identified that more regular stocktakes (e.g. monthly) would improve the system efficiency allowing advance ordering of stock before it is completely exhausted. An example of this issue is the lack of invoice books, which need to be ordered from Tarawa. It was also identified that the use of telephones to order items may also improve the efficiency of this critical process.

6.3.2 Multi-stakeholder workshop

A full day multi-stakeholder workshop was held on 22 February 2016 at the Village Motel. Attendees included a range of government staff, including from the WSD, Energy and Executive staff. The latter staff included the Acting Permanent Secretary (PS), Deputy Secretary, Assistant Secretary, Planning and Accounts Manager, as well as representatives from the Environment and Tourism Ministries. The KUC clerk and Technical Advisor reviewing by-laws also participated along with representatives of community and customers, including from the Villages Motel and several unimanes.

The workshop was divided into five sessions with the following key messages:

1. Additional water production is proposed under the project
2. Water conservation and efficiency are critical for London, Tennessee and Tabwakea
3. Sustainable water management requires all stakeholders to work together
4. Address water scarcity and maximise the benefits from our water
5. Sustainability requires planning and collaboration.

Note that due to an electricity failure the majority of the presentation slides were not displayed and instead this was illustrated through diagrams and charts and verbal presentation. However, the presentation is provided in Appendix F to illustrate the content and activities undertaken.

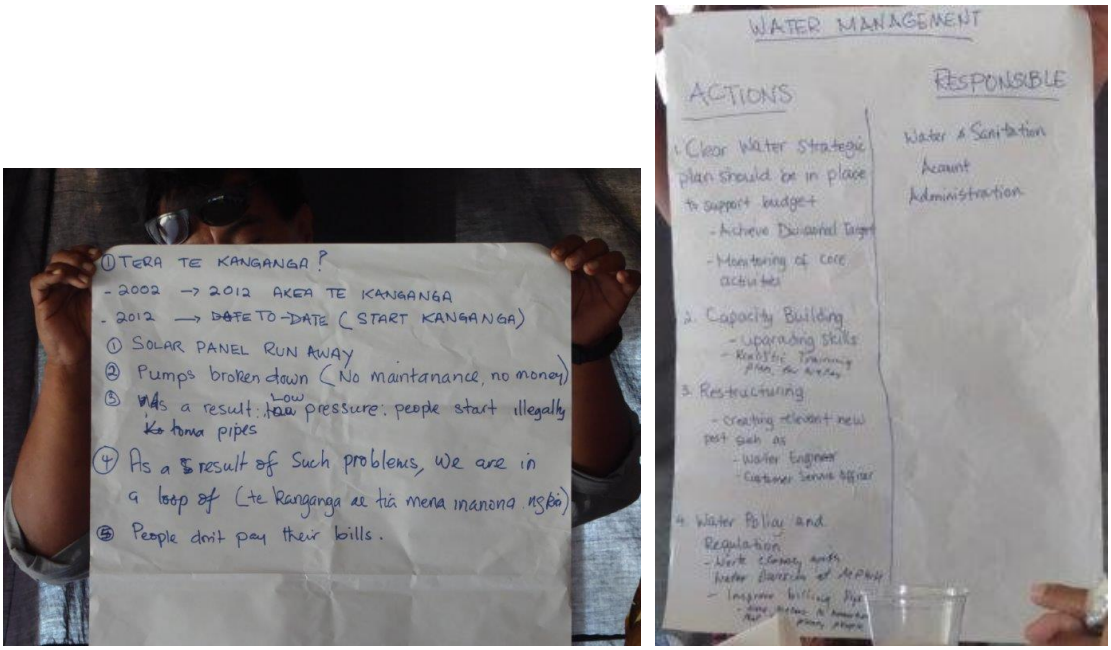

Figure 21 Summary of historical issues with water system (left) and Executive Group of MLPID presentation on actions to improve sustainability of water management (right) (Photos: T. Falkland)

During the workshop, participants were asked to present ideas to promote more sustainable water management practices within government and the customer base. Key outcomes from this discussion were:

- Discussion on the **structure of tariffs** and how to ensure **equality** with the tiered structure, particularly for larger households, whilst still benefiting from the deterrence mechanisms of tiered pricing:
  - ï Provide a flat rate for all householders rather than special rates for larger households;
  - ï Control through the billing process, with a special rate applied to larger households;
  - ï Provide multiple meters to larger households.

- **Restructuring the WSD**, including creation of new posts such as:
  - An awareness/customer service officer – to work with the community and enhance awareness of importance of water conservation practices, and to feedback issues and complaints relating back to the water service to the WSD.
  - A water quality / sustainability officer – responsible for monitoring of boreholes, galleries and other water quality aspects.
  - Water Engineer to provide technical leadership to the WSD.
- Improved **water policy and regulation**, with:
  - Endorsement of a clear strategic plan that is linked to WSD budgets and monitoring of core activities (increasing accountability) to ensure targets are achieved.
  - WSD working more closely with the MPWU in Tarawa, acknowledging the current constraints of limited autonomy of the MLPID.
- An improved **electronic billing system** to make the system more efficient and easier for customers to pay bills and report problems.
- **Capacity building** for WSD, including:
  - On-the job training of WSD through the current SPC project.
  - ôRealisticôtraining for the WSD. It was noted by the Permanent Secretary that a 4 year training plan has been submitted to the Public Service Office and that water is a priority within this training plan, along with energy and power divisions.
- **Council role**:
  - Village wardens who are enforcement officers could undertake enforcement of water related issues as part of their routine duties.
  - KUC has a complaint form related to by-laws and could incorporate water management within this form.
  - KUC inspects the hotels as part of the ôTe Mauri Markôqualification and could include in this inspection an assessment of water sustainability practices.
- **Community education and awareness**:
  - There is opportunity to integrate information and topics on water management and science into the new school curriculum currently being developed. This could be coordinated through the Island Education Coordinator who is based at MLPID.
  - The Wildlife and Tourism office has a program within the Junior Secondary School educating on wildlife protection and conservation. This same approach could be adopted by the WSD and become the responsibility of a new awareness officer (should the post be created)
  - Utilise the ôBotaki n Unimaneô(male leadership group) and the ôNei Baneawa Associationô(womenôs group) to disseminate information to community on water conservation and sustainable water management practices.
- Local **groundwater surveys** to identify areas where groundwater can be used to supplement reticulated water supplies, including in London where well water can be used for toilet flushing.

6.4 Semi-structured discussions

6.4.1 Government stakeholders

Accounts Management, MLPID

Several discussions were held with MLPID staff from 12 ï 16 February to understand the current budgeting process for the WSD. Staff consulted included the Water Foreperson and the Meter Reader from WSD and the MLPID Accounts Manager. The outcomes of these discussions on the current situation are summarised in sections 3.5 and 3.6.

Senior Executive, MLPID

Discussions were held with MLPID Administration staff including the Acting PS, Assistant Secretary and Planning Manager to understand the administrative processes with management of the WSD and future policies and strategic planning activities. Observations from these discussions which highlight the opportunities for improvement in the efficiency and management of WSD include:

- New staff attendance management system, managed by the Assistant Secretary to promote accountability of staff activities. This includes using staff signing in/out procedures and giving warnings to staff not attending duties. This process could be used to ensure that there is greater accountability regarding overtime and help to reduce costs in this area (a similar system is being implemented at the PUB and has resulted in significant cost savings and efficiencies).
- As part of a commitment by the European Union to provide development funding to Kiritimati Island a strategic plan is being developed. The Line and Phoenix Integrated Development Strategy (LPIDS) (COWI Consortium & Prospect Consulting and Services 2015), currently in draft form, is hoped to provide some strategic direction to MLPID and include initiatives linked to water supply planning. The draft LPIDS was provided for review and a summary of this is provided in section 2.3.4.
- The PS has recently submitted to Tarawa, as part of submissions on the update to the KDP, a request for greater autonomy and clarity in the roles of the MLPID. The LPIDS, once finalised, will be incorporated into the KDP.
- If MLPID is to propose that revenue collected by the WSD be used for maintenance this should be put to Cabinet in time for the second sitting of Parliament in June. The PS is supportive of this idea.
- A submission to the Public Service Office in Tarawa was made in July 2015 proposing the creation of a new post in the WSD for a Water Engineer. There has not been any decision made on this proposal, however it is understood that trade-offs may be required with reduction in positions elsewhere in WSD to balance the budget.

Public Utilities Board, South Tarawa

A meeting was held on 28 April 2016 in South Tarawa with the new CEO for the Public Utilities Board (PUB), Mr Perry Tonking. The objective of this meeting was to identify opportunities for collaboration and support between WSD and PUB.

The PUB is responsible for operation and management of the electricity, water and sewerage services in South Tarawa. There are significant parallels with the role of PUB and WSD as operators and managers of urban water supplies and billing and debt collection activities. Key differences in the water services provided by PUB and WSD are:

- PUB water supplies are not currently metered and no billing is occurring.

- PUB water supplies are rationed, with sectors of the island provided water for two to three hours every two to three days.
- The population serviced by PUB supply is approximately 10 times larger than the population serviced in Kiritimati.

The PUB is a state owned enterprise, which operates generally independently of the ómother MinistryôMPWU. As such, PUB has greater control over its budgets, resource decisions and departmental structures than WSD. The recent appointment of an international CEO funded through the New Zealand Aid Program is recognition of the GoK and development partnersô commitment to reforming the PUB which is understood to be under significant financial stress. However, there is still opportunity to share lessons, procedures and resources between the PUB and WSD in particular with some of the new initiatives being implemented by the CEO.

Some initiatives proposed by the PUB CEO which could be transferable to Kiritimati WSD are:

- A request to GoK to recognise the PUB as having a community service obligation (CSO) and provide subsidy for operation of the water and sewer services, independent of the revenue generated from electricity.
- Processes to improve accountability of staff costs and overtime as this is a significant proportion of budget costs.
- Enforcement of billing and debt collection through disconnections (of electricity supply) where bills remain unpaid.
- Route Cause Analysis tools (introduced first for the electricity division) to help monitor issues with the system, calculate failure rates, identify systemic failures and ultimately to provide data to improve decision making on asset management and system operation.
- Electronic billing system using MS Access tools to more easily issue bills and generate reports on debtors.
- Use of private sector for services that are considered outside of core business (of managing assets) ï including tankered water delivery which can more cost effectively be provided by the private sector. This could also extend to septic tank vacuum truck services.
- Asset management plan (being developed for PUB by the MPWU).

Minister for Line and Phoenix Island Development

The recent elections have seen the appointment of a new Minister for Kiritimati Island. A meeting was held with the Honourable Minister Mikarite Temari in South Tarawa on 14 May 2015 (as the Minister was not in Kiritimati during the February visit). The objective of the meeting was to discuss ideas and issues raised during the February 2016 consultations in Kiritimati Island and understand the policy direction of the new government.

The following key points were raised in this discussion:

- In the recent (May 2016) Parliament sitting, Cabinet approved a plan to integrate Ministerial activities on Kiritimati Island and assign MLPID a supervisory role (rather than the current supporting role). This will give MLPID greater autonomy and authority for strategic decisions in Kiritimati Island and increase transparency of activities and coordination between ministries.
- The Minister is an advocate for greater private sector involvement and would like to see the water, sanitation and electricity services privatised. Discussions with the PUB CEO were also encouraged and the prospect of linking the WSD with the PUB is also considered by the Minister as a possibility.

- The Minister recognises the significant gap in leadership and management skills that the WSD have and the need to address this constraint through introduction of new posts and appointment of staff with skills and experience in managing budgets, people, strategic planning and communication ï rather than focused purely on technical skills.

  The Minister is in support of the new posts proposed during the February consultations which include a Water Engineer, Water Sustainability/Quality Officer and Customer Service/Water Awareness Officer and it was noted that MLPID does have sufficient autonomy to implement these proposed changes. However, the availability of appropriately skilled staff in Kiritimati was also raised.

  In particular, it was noted during the February in-country trip, that the WSD Meter Reader may have the necessary skills and drive to lead the WSD and she is already playing a support role to the current Water Foreperson on issues such as strategic planning (e.g. the WSD MOP) and budget planning. However, it was raised by the Minister that staff with appropriate engineering skills may not be available in Kiritimati and need to be recruited from Tarawa. Learning from the resourcing situation in Tarawa at MPWU and PUB, there is also an opportunity to draw on international technical advisors. Currently the MPWU have a New Zealand Volunteer Water Engineer who is developing an asset management plan for PUB. The opportunity to request similar assistance via international development programs to help improve the capacity of the WSD staff was strongly supported by the Minister.

- The Minister, who is also the former Mayor for KUC is supportive of the KUC village wardens being given additional responsibilities to inspect and report on issues with the water supply (refer to discussion in section 6.4.2).

- The Minister is implementing new measures for accountability and efficiency of MLPID staff. These include weekly meetings with all staff to ensure they are informed of changes and progress and inspection of offices every morning and lunch to encourage accountability and attendance.

6.4.2 Kiritimati Urban Council

A meeting was held with the KUC Clerk, Alice, on 12 February 2016.

The KUC currently does not have a formal role in water management. However, the following existing structures and roles were identified as opportunities to support sustainable water management:

- KUC has nine wards, including three in London and two in Tabwakea, and elected Councillors meet monthly. The public can propose meeting agenda items through their local Councillor and this could include issues about the water supply system.

- KUC receives complaints from community on government housing and assists with consultation to the Housing Division of MLPID. Water supply and plumbing within government houses is the responsibility of the Sanitation Section of WSD. KUC has an opportunity to increase the accountability of WSD and Housing on the level of service and maintenance needs.

- Village wardens are employed by KUC to monitor and enforce by-laws on solid waste, building practices and keeping animals such as pigs and dogs. The wardens visit communities weekly and could also include in their routine inspection and reporting of issues with water supplies. This could provide an opportunity for community members to report any issues via wardens to the WSD and to enforce regulations to limit tampering of the water system.

- The KUC by-laws were in the process of being updated in February 2016 and there is an opportunity to include responsibilities related to sustainable water management within these.

  An excerpt from the draft 2016 Public Health by-law (section 8) below, shows underlined the addition of text on sustainable water management which was incorporated into the draft following KUC participation in the multi-stakeholder workshop (refer section 6.3.2) :

  "8 Water safety and storage

  (1) The Council shall have the power to enforce the regulation, use, maintenance, storage or existence of any water kept within the Council area of authority for the purposes of maintaining a sustainable supply of water to the community and protecting public health.

  (2) Where any stagnant water, which, in the opinion of an Enforcement Officer or any other authorised officer or health inspector, is or may become insanitary, lies upon any private land the Council may order the owner or occupier of the land to drain or otherwise properly dispose of the water.

  (3) The Council shall have the power to regulate or prohibit the use of rain, well or other water supply or water reserves within the Council area of authority for the purposes of maintaining a sustainable supply of water to the community and the prevention of the pollution thereof."

6.4.3 Visit to Poland

On Saturday 20 February 2016 travel was arranged to Poland to meet the WSD Water Attendant and discuss the water supply situation in Poland and capture any lessons that could be applicable to the London, Tennessee and Tabwakea water systems. The following observations were made:

- The water system is connected to 10 government houses, the Primary School, the three churches (Kiribati Uniting Church, Catholic and SDA) and two private leases. Most other private houses use local wells for water supply.
- There are meters on government houses, but no meters on private connections. Although meter readings are taken by the Water Attendant, householders are not charged based on water usage, and are instead charged a flat rate of $10 per month which is deducted from their salaries.
- The two private leases with reticulation connections were charged for the connection, but are not charged for water usage. For new connections, customers are charged $30 and required to supply materials and labour. A resident estimated the cost of materials for a connection to be $300.
- There have never been any issues with solar panels being stolen and the system is generally in good operating condition. However, the chlorination system is broken and the float valve for the 500 L tank at one house was observed to be missing, so the system had to be turned off at the inlet manually.

Overall, the Poland situation is not an appropriate comparison to London, Tennessee and Tabwakea, due to the significant difference in number of connections and size of the community. However, one parallel that could be drawn from this situation, is the proposal by WSD staff during the workshop (refer section 6.3.1) to undertake monthly inspections at allocated houses. The benefit of this approach is that relationships can be developed between householders and specific WSD staff perhaps in a similar way to in a small community such as Poland. This approach should help to identify any issues or address poor water practices in a sensitive way and provide communities with direct access to WSD for better customer service.

7. Household surveys

7.1 Background

In 2015, SPC conducted a comprehensive survey of all dwellings within the villages of London, Tennessee and Tabwakea. The survey focused on these three villages which will benefit from the increased supply and infrastructure improvements under the Kiritimati Island Water Supply Improvement Project. The purpose of this survey was to record the population, basic demographic data and information about the type of water supply used at each dwelling including:

- Detailed information on rainwater harvesting systems;
- Use of well water;
- Status of the reticulated water supply system connection;
- Observed leaks; and
- Sanitation system information and water source used.

In 2007, as part of the ADB *Preparing the Outer Island Growth Centre's Project*, another household survey was conducted. This covered approximately 10% of each village on Kiritimati Island, including Poland and Banana which are outside the study area for this current project. The survey included questions on household demographics, water usage and sources, attitudes to water service levels, health and water treatment, willingness to pay and sanitation.

In February 2016, an additional household survey was conducted of a select number of households in the study area to supplement the information collected in the 2015 SPC survey, and update that collected in 2007.

7.2 2016 Household survey overview

7.2.1 Aim

The aim of the 2016 survey was to gather information to help inform the development of the Sustainable Water Management Plan. In particular, it was to understand how the community currently relates to the water supply system and understand its attitudes, values and preferences to inform future improvements.

7.2.2 Objectives

The objectives of the survey were to develop an understanding of:

- Typical household socio-economic conditions in the study area;
- Willingness to pay (WTP) for an improved reticulated water supply;
- Attitudes and beliefs related to management of the reticulated water supply and service levels including water treatment; and
- Preferences for billing options and tariff structures.

7.2.3 Structure

The survey was structured to generate an initial conversation about water supply and usage, household expenses and income to prepare the respondent for the WTP component, and therefore minimise bias. A detailed introduction provided an overview of the purpose of the survey, the proposed changes being considered under the project and a brief history of the issues with the water system.

The contingent valuation method (CVM) was adopted to understand WTP. This method aims to present a realistic scenario of water supply service for which the respondent is asked to value, stating a price they are willing to pay for the service. A number of structures can be adopted for CVM surveys to elicit respondentôs WTP. For this survey, the specific approach applied was a split sample ôbidding gameô method. This involved presenting the respondent with a monthly bill cost and asking if they are willing to pay that value. The value proposed was then increased until a negative response was provided (or alternatively decrease until a positive response was received).

The survey included a mix of closed and open-ended questions. The survey was written in English and two I-Kiribati speaking enumerators conducted the survey, with translation occurring in-situ.

Pilot surveys were conducted with the two enumerators, the survey author and a SPC consultant (Joy Papao) to test and refine the survey. The pilot surveys were conducted at six houses in London. Following the pilot surveys, the survey form was shortened with similar and duplicate questions eliminated and the CVM questions re-structured for application in situations with and without existing reticulation connections.

The final survey questions are provided in Appendix J and contained seven categories:

- Introduction ï confirming WTP and availability to complete survey
- Demographics ï basic household information
- Socio-economic data ï information on employment, education level of respondent, household income and expenses
- Existing water supply ï water sources used for range of end-uses
- Ideas about the water supply system ï attitudes and behaviours related to management and responsibilities for the water supply system
- Willingness to pay ï using the CVM to elicit WTP
- Billing scenario ï attitudes to billing and tariff options

7.3 Approach

7.3.1 Survey development

Scope

The survey was designed to achieve the specific objectives outlined in section 7.1. In order to set the context of the survey, it was agreed with the project team prior to the survey that the Project would be offering an improved water supply to the houses within London and Tennessee which included:

- Continuous (24 hour) daily water supply;
- Sufficient water pressure to enable showering within households; and
- Individual metering for each connected household.

In addition to the supply situation described above, the following possible variables for the supply were still to be confirmed, and hence were presented to respondents to gauge preferences:

- Water quality ï improvement of water quality through chlorination.
- Supply point location - option of connection to the house plumbing or to a tap-stand within the property boundary.

Although the Project is not guaranteed to improve connections in Tabwakea, there is a possibility depending on availability of funding that there may be some improvements there. At the time of the survey additional galleries were being considered for installation at both Decca and Four Wells and this would have provided improvements in supply to Tabwakea. Consequently, Tabwakea was included in the household survey. It is now unlikely that this will occur as part of the current project. However, Tabwakea will still benefit from a slight increase in production due to the replacement of lower yielding wind pumps with solar pumps. In addition, the separate of the Decca and Four Wells system will provide increased supply to Tabwakea, from the current arrangement.

7.3.2 Household selection

Due to time and available resources, a target survey population of 5% of households stratified across the three villages was chosen. As shown in Table 28, a larger proportion was surveyed in Tennessee (14%) due to the smaller number of households to ensure the sample size was sufficient to provide reasonable confidence in any trends in results.

A total of 43 surveys were completed and Figure 22 shows the spatial distribution of houses surveyed.

Table 28 Number of households surveyed

Village	Total Households (residential)[16]	Total Households Surveyed	Proportion surveyed
London	229	12	5%
Tennessee	49	7	14%
Tabwakea	469	24	5%
Total	747	43	6%

[16] Recorded in 2015 SPC survey

1:15,000

0 75 150 300 450 600 750

Metres (at A3)

Map Projection: Universal Transverse Mercator (WGS 84)
Horizontal Datum: WGS 84
Grid: Northern Hemisphere, Zone 4

N

CLIENTS | PEOPLE | PERFORMANCE

SPC Secretariat of the Pacific Community

Secretariat of the Pacific Community
Kiritimati Island Sustainable Water Managment Plan

Household survey coverage in London, Tennessee and Tabwakea.

Job Number 55-10110
Revision A
Date March 2016

Figure 22

N:\AU\Canberra\Projects\55\10110\Technical\6. SPC Survey GIS\Phoebe\Kiritimati Island Survey.wor
8/180 Lonsdale St Melbourne VIC 3000 Australia 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au W www.ghd.com.au

Data source: Secretariat of the Pacific Community, Kiritimati HH Survey & Ortho, 2016. Created by: P. Mack

The households selected were based on the 2015 SPC household survey, to ensure a cross-section of reticulated water supply conditions was captured. As illustrated in Figure 23, conditions encountered included:

- Connected houses with service (ôYes, workingô)
- Connected houses without service (ôYes, not workingô)
- Connected on shared lease (ôShared on leaseô)
- Disconnected houses (ôNone, disconnectedô)
- Houses without connections (ôNoneô)

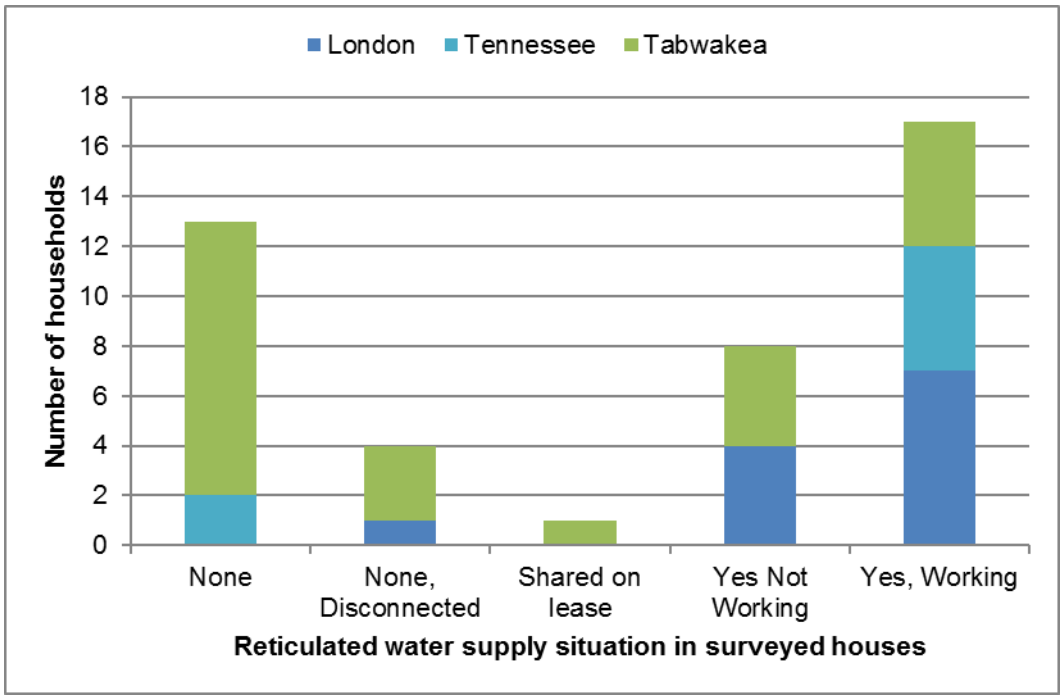

Figure 23 Reticulated water supply situation in surveyed houses

7.3.3 Limitations

The two enumerators were instructed on the format and purpose of the survey and in particular the basis for the CVM question structure. Prior to commencing the survey, time was spent with the enumerators to review and practice. To reduce the variability in delivery style, the survey team initially worked together and the pilot surveys was undertaken with the team resulting in agreed modifications. Surveys were conducted over four days, with the initial two days and the final day undertaken with a consultant (GHD or SPC) present to record additional discussion and provide quality control on the enumeratorsô survey delivery.

Whilst every effort was made to conduct a consistent and reliable survey, the following limitations are acknowledged:

- Two enumerators were used resulting in variability in the way in which questions were phrased. Due to the limited time and resources, the questions were not translated and enumerators therefore translated in-situ. This was observed to lead to variation in the phrasing of open-ended questions. In particular variation was observed in respondents understanding of question 7.02[17]

[17] Do you believe the community should pay for the cost to operate the water supply system?

- The method adopted for elicitation of WTP was the ôbidding gameô This was selected to reduce bias in answers and required the enumerators to órandomlyôselect a starting price offered to the respondent. However, it is suspected that the selection of price was not actually random and that instead enumerators made a judgement based on the answers to questions on income, as to where to start. Figure 24 shows the frequency of the starting ôpriceôoffered for the two groups of respondents, those with and those without connections. This shows that $50 and $100 was more frequently used compared with the lower prices. However, analysis of the response or final ôpriceôcompared with the starting price (as shown in Figure 25), shows that:
  - ï The majority of respondents offered a start price of either $100 and $50 had a finish price of $50, but this did not prevent lower answers being provided.
  - ï The survey results donôt have strong clusters of answers around the starting point with only 33% of final ôpricesômatching the starting ôpriceô This shows that the starting point does not have a significant influence on the final answer. However, there does appear to be a bias with answers rarely (only on four occasions) increasing from the start price. This is probably an indication that the more frequent starting price ($50 and $100) are at the upper limit of community WTP.

  It was also observed that whilst most households indicated a desire for chlorination most (70%) were not willing to pay an additional fee showing their ôlimitôwas set in the CVM price given.

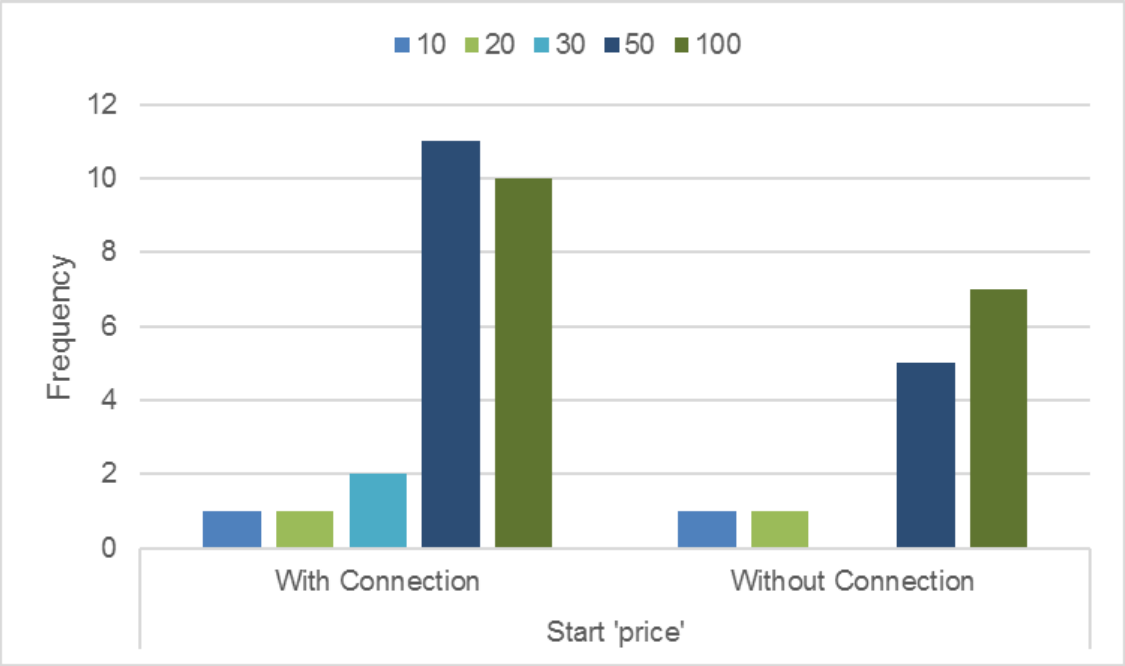

Figure 24 Frequency of starting price used during contingent valuation bidding game

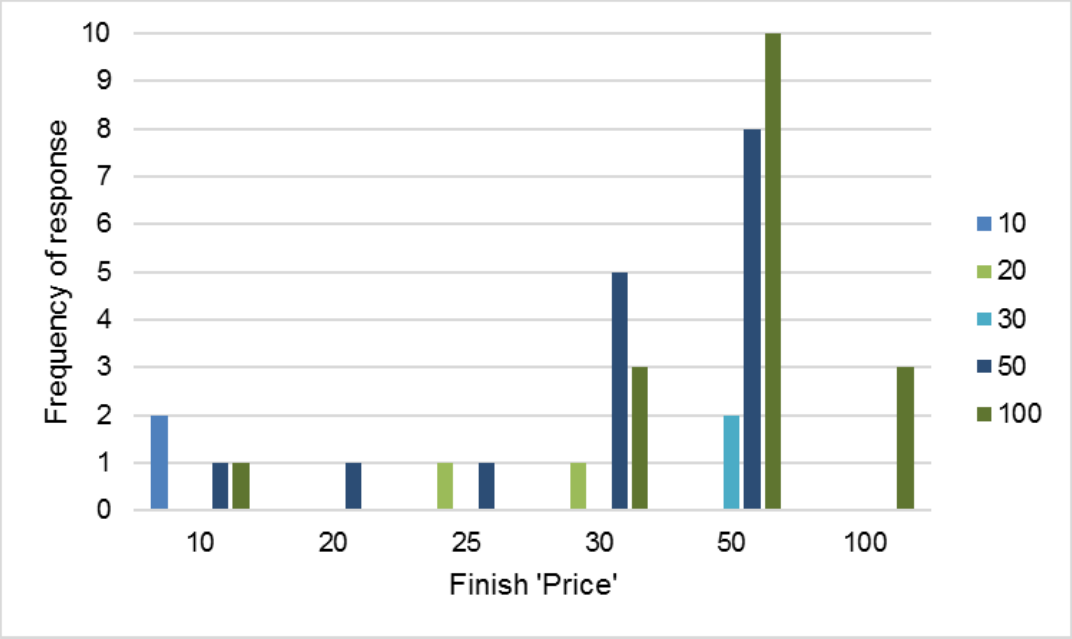

Figure 25 Frequency of finish price based on start price used during contingent valuation bidding game

7.4 Analysis of survey results

7.4.1 Summary

The following section provides analysis for each of the seven areas of the survey. Where relevant comparisons have been made between the SPC 2015 survey results and the 2007 household survey (ADB 2007).

7.4.2 Introduction

All respondents were asked initially about their WTP for an improved water supply prior to proceeding with the survey and all respondents indicated they were willing to pay. This indicates a recognition of the value of the service provided and an acceptance that payment is necessary for water. This differs from attitudes observed in South Tarawa where in a 2014 study (ADB 2014), only 75% or respondents were willing to pay for water.

7.4.3 Demographics

The basic household information, presented in Table 29, Table 30 and Table 31 shows:

- The average household size is higher in Tabwakea than London and Tennessee and generally higher for private housing compared with government rentals.
- The majority of respondents were female, with the highest proportion of female respondents in Tennessee and Tabwakea.
- The average age of respondents is 43 years and average length of time respondent living in the village is 11 years.
- The majority of private leases were surveyed in Tabwakea.

Table 29 Number of private and rental houses and average household size

	Average of household size	Number of houses surveyed
London	**7.9**	**12**
Private	8.6	5
Rental (Council)	2.5	2
Rental (Government)	9.4	5
Tabwakea	**8.6**	**24**
Private	8.6	23
Rental (Government)	8.0	1
Tennessee	**6.3**	**7**
Private	7.0	2
Rental (Government)	6.0	5

Table 30 Maximum household size and proportion of private leases surveyed

	Maximum household size	Proportion of private houses surveyed
London	23	42%
Tennessee	9	29%
Tabwakea	18.0	96%

Table 31 Proportion of female respondents, average age of respondents and average time in village

	Proportion of female respondents	Average age of respondents (years)	Average time in village (years)
London	50%	47	13
Tennessee	86%	38	5
Tabwakea	71%	43	11
All	67%	43	11

7.4.4 Socio-economic data

The following trends were observed from responses to the socio-economic questions:

- The typical number of employed persons per household is between 1 and 2, with a higher average (2) for households in London which are predominantly government employees (Table 32).
- Approximately 50% of respondents had an education level equivalent to senior high school, with only one respondent having an undergraduate qualification and the remainder less. The education level of respondents was lowest for those surveyed in Tabwakea (Table 32).
- The median monthly income is almost double in London compared with Tabwakea and Tennessee and ranges from $0 ï $3,300. The overall median income is $400/mth (Table 33). Four houses reported an income less than $200/mth, and three respondents were not able to estimate income (Figure 26).
- There was a large range in expenditure estimates (Figure 26), with 12 households (30% of respondents) reporting an income less than expenses. This indicates that the estimates provided are unreliable and it is expected that this is particularly the case for estimates of expenditure rather than income. Nevertheless, the median monthly expenditure is similar across each village, with a total median of $205/mth and this is approximately 50% of the median income.
- Further analysis of expenditure (Table 35) shows that:
  - ï Comparing median values (to remove outliers from analysis), food costs were the largest proportion of household monthly expenditure (median $120), followed by electricity expenses (median $30) and transport (median $10). All other median expenses can be considered negligible.
  - ï Houses with large expenditure estimates included a house with an estimated electricity bill of $800. This residence included seven self-employed people with an estimated income of $1200/mth from a rental car, bakery and catering. In addition, a household which included a kava bar and mechanic business estimated a monthly electricity bill of $400, relative to a monthly income of $300.
  - ï The median electricity bill was $30/mth and average electricity bill was $70 (Table 35). This is approximately 8-18% of the total median income ($400/mth).

Table 32 Average number of employed people and education level of respondents

	Ave. number employed in household	Primary education	Junior Secondary School	Senior High School	Undergraduate University
London	2	-	33%	67%	-
Tennessee	1	-	29%	71%	
Tabwakea	1	17%	38%	38%	4%
All	1.5	9%	35%	51%	2%

Table 33 Household income, average, median and range

	Average (AU$/mth)	Median (AU$/mth)	Income range (AU$/mth)
London	$1040	$900	$100 ï $2800
Tabwakea	$640	$400	$0 ï $3300
Tennessee	$386	$300	$200 - $800
All	$696	$400	$0 - $3300

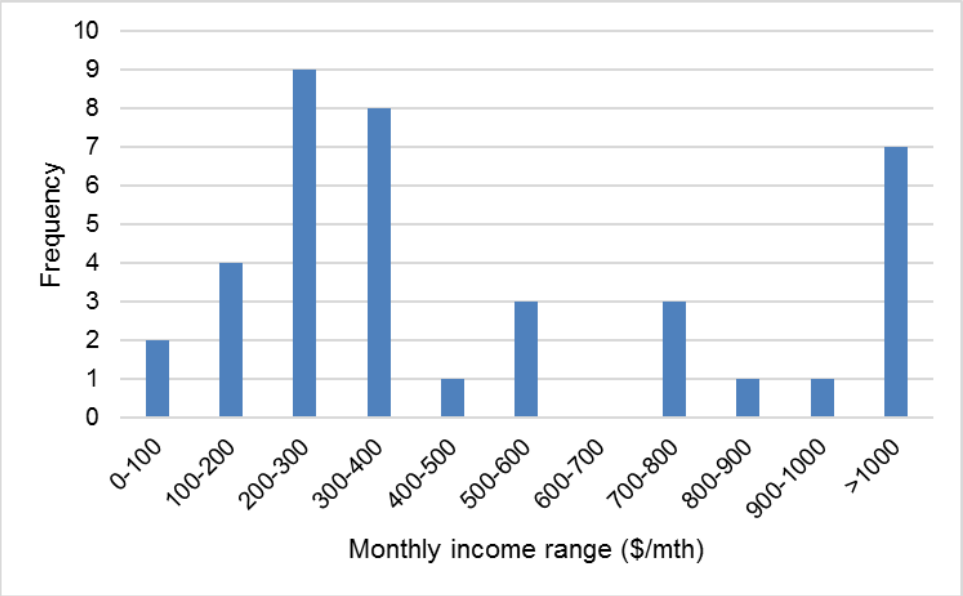

Figure 26 Monthly income range of respondents

Table 34 Household expenditure, average, median and range

	Average (AU$/mth)	Median (AU$/mth)	Expenditure range (AU$/mth)
London	$476	$247	$37 - $1424
Tabwakea	$317	$210	$10 - $1990
Tennessee	$308	$143	$30 - $1184
All	$360	$205	$10 - $1990

Table 35 Estimates of expenditure breakdown.

	Electricity bill (AU$/mth)	Rent (AU$/mth)	Debts (AU$/mth)	Transport (AU$/mth)	Food (AU$/mth)	Other (AU$/mth)
Range	$0-$800	$0-$500	$0-$686	$0-$600	$0-$1000	$0-$1800
Median	$30	$0	$0	$10	$120	$0
Average	$70	$21	$18	$53	$173	$49

7.4.5 Existing water supply

As outlined in section 7.3.2, households were selected to ensure a cross-section of water supply access scenarios. The following trends were observed and are illustrated in Figure 27 and Figure 28:

- Drinking water:
  - ï All households rely on rainwater as their primary source of drinking water, with the majority of rainwater captured at the household.
  - ï Well water is only used as a secondary source of drinking water in Tabwakea.
  - ï Households in London relied mostly on tankered water as a secondary drinking water source, whilst most houses in Tennessee accessed reticulated supply.
- Bathing water:
  - ï A range of sources are used for bathing in London, including 25% using well water, and 67% using water sourced from the water galleries (either tankered or piped supply).
  - ï 88% of households in Tabwakea use well water from their house or neighbours well for bathing, compared with 25% and 28% for London and Tennessee, respectively. The remaining houses rely on water sourced from the water galleries (either tankered or piped supply).
- Toilet flushing:
  - ï 42% of houses surveyed in London use well water for toilet flushing. This is contrary to assumptions in the ADB (2007) design for per capita demand, which assumes that all households in London require reticulated water for toilet flushing. This may reflect an increase in well coverage in London since 2007 or a result of the poor reticulated water supply. It is noted that respondents in Tennessee, which was experiencing better reticulated water pressure than London at the time of the survey, reported a much higher reliance on reticulated supply for toilet flushing (71%). In addition, the SPC survey recorded only 15% of households in London with wells. This lower number of wells, relative to the results from the 2016 survey may reflect the smaller sample size for the 2016 survey.
  - ï 25% of households in Tabwakea reported having no toilet, compared with 8% and 14% for London and Tennessee, respectively.

In Tabwakea, there was mention by some householders of a well owned by Tekarimi which is understood to have good water quality. Consequently, householders indicated that if they used this source they believed no treatment was required. It was explained by residents that the well was constructed within hard rock and that water was once tested at the hospital and showed no contamination. It is highly unlikely that this source is not contaminated, and hence it is recommended that the WSD and Ministry of Health undertake further testing and awareness on water safety risks.

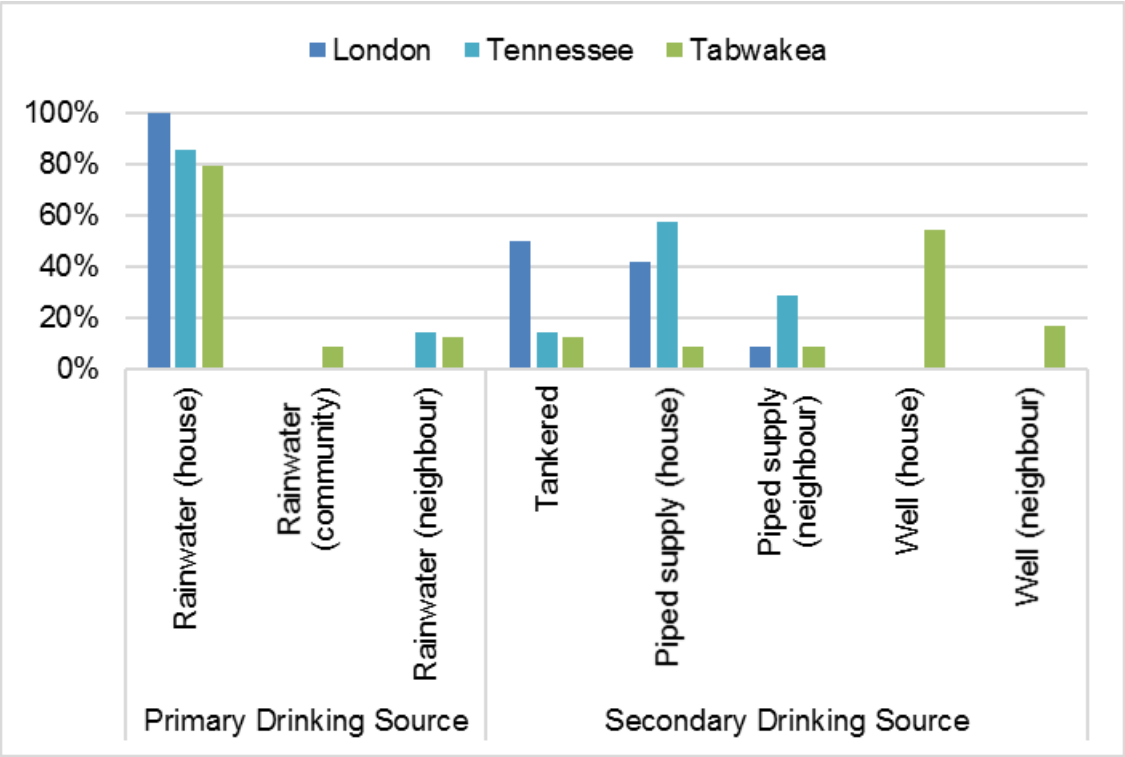

Figure 27 Primary and secondary drinking water source for London, Tennessee and Tabwakea

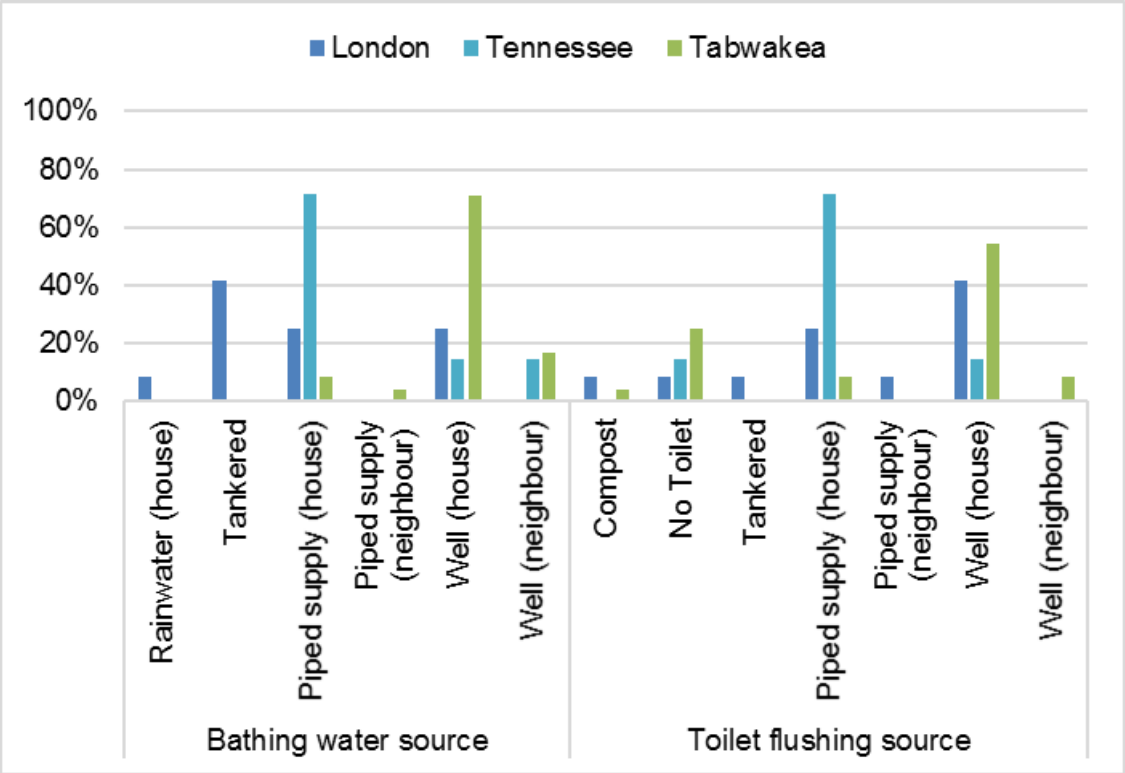

Figure 28 Water source for bathing and toilet flushing in London, Tennessee and Tabwakea

7.4.6 Ideas about the water supply system

Several open questions were posed to gain an understanding of respondentôs attitudes and behaviours related to management and responsibilities for the water supply system.

Responsibilities

All respondents indicated a belief that the government was responsible for managing the water system. However, there was a mixture of responses on who is responsible for maintenance at the household. As illustrated in Table 36, only 53% of private householders understood that they are responsible for maintenance of the water system at their house, and 37% were unsure. For leased houses, the majority understood that the landlord (government or KUC) is responsible for maintenance.

When asked what action they take when there is a problem with the water system, the majority of households indicated that they report the issue to MLPID or WSD. Three households in London indicated that rather than reporting to WSD they have sought alternative water from relatives in London, the hospital or from relatives in Tabwakea. Two opted to use well water for bathing and toilet flushing.

Table 36 Responsibility for household water system maintenance

	KUC	Government	Householder	Unsure
Private	0%	10%	53%	37%
Rental (KUC)	50%	50%	0%	0%
Rental (Government)	0%	73%	18%	9%

Perceptions on level of service

In discussions with respondents in Tabwakea, there appeared to be a general acceptance of the poor service levels for water supply. Houses in the parts of Tabwakea that have connections were no longer receiving water due to the decision by government to divert all supply to Tennessee and London. However, it was observed through discussions that knowledge of this decision by respondents was low and rather it was presumed by customers that the lack of supply was due to faults with the system rather than a decision to redirect water.

New connections

Most houses without connections are in new lease areas of Tabwakea, and one property in Tennessee. This is because these new leases were allocated since the installation of the water supply network under KWASP. In discussions with the unconnected householders two factors were highlighted as inhibitors for connecting:

1. The cost to connect. One resident in Poland estimated it cost approximately $300 for materials to connect. However, the cost will depend on the distance of a property from the main water supply pipeline.
2. Understanding of the connection process. It seemed that some respondents were waiting for the government to connect them and were not aware that they are required to initiate the connection and pay for parts and labour.

It is recommended that the MLPID reconsider their policy on new connections and evaluate the cost for householders to connect to inform this decision. If cost is an inhibitor to connections, the government should consider the economic and health costs of poor water supplies. This may outweigh the cost of subsidising connections. In particular, it is understood that some of the new

lease areas in Tabwakea have poor local groundwater quality. Without access to the reticulated water system, one tenant indicated they could not move to their property and instead were sharing housing in Tennessee.

In the CVM component of the survey, respondents who were not yet connected were asked about their willingness to pay a connection fee. All respondents indicated their willingness to pay for a connection, with the average WTP value $93 (standard deviation (SD) = 115) and median value $50.

7.4.7 Willingness to pay

Traditionally, CVM surveys are analysed using detailed statistical models and econometric analysis to interpret the WTP of respondents and confirm the validity of results[18]. However, this is outside the scope of this consultancy and hence the following section provides a high level analysis of the WTP survey results.

Who is willing to pay?

All respondents indicated they were willing to pay for an improved water service, including those currently not connected.

Size of payment

The average WTP amount for households with an existing connection was $43/mth (SD = A$30), and for households without a connection $41/mth (SD = $28) and the median values were $50/mth and $30/mth for households with and without existing connections, respectively. The minimum WTP was $10/mth and maximum $100/mth.

This differs from attitudes observed in South Tarawa where water is unmetered and a flat rate of $10/month is irregularly applied (mainly to government employees). In a 2014 study (ADB 2014), only 75% or respondents were willing to pay for water and the average WTP was $13/mth with a median WTP of $10/mth (ADB 2014).

Table 37 shows that there is a higher average WTP in London than Tabwakea and Tennessee, and Tennessee has a lower median WTP ($30/mth) compared with $50/mth for London and Tabwakea.

The average WTP ($43/mth) is approximately 10% of the median income ($400/mth). This proportion is significantly higher than commonly accepted international benchmarks of 2 to 4% (Hutton, 2012).

Table 37 Willingness to pay for improved water supplies by village

	Average WTP ($/mth)	Median WTP ($/mth)
London	50	50
Tabwakea	41	50
Tennessee	36	30
All	43	50

Figure 29 shows the proportion of respondents within each price bracket, with the majority in the $40-$50/mth bracket or less.

[18] Wedgwood and Sansom (2003) suggest that for smaller towns of populations between 5000-50,000 CVM surveys without econometric analysis is acceptable, as long as 5% of the population has been represented and rigorous samples, pre-testing and CV methodology has been applied.

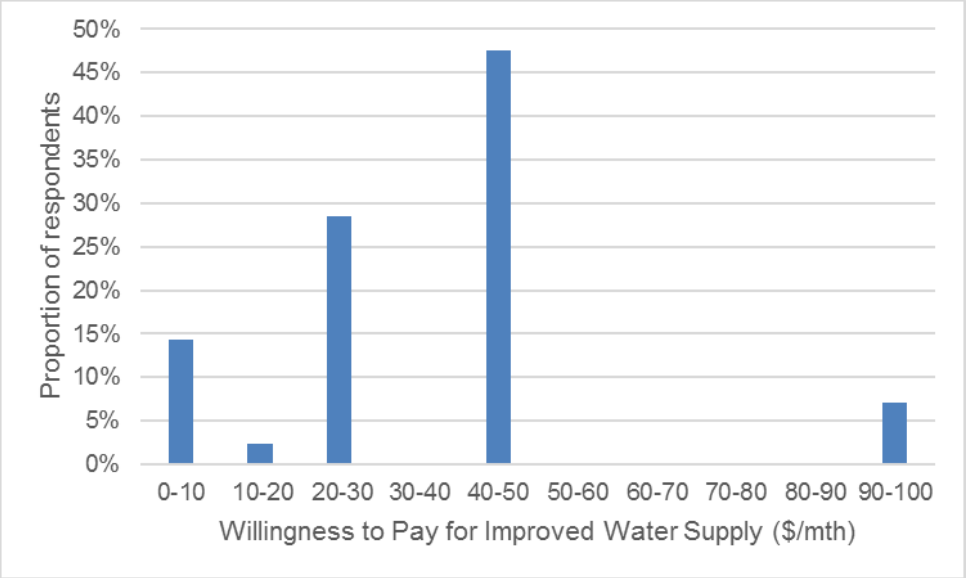

Figure 29 Willingness to pay, proportion of respondents within each price bracket

Factors influencing WTP values

The following factors were considered to understand the influence on the size of payments respondents were WTP:

- Household income;
- Household expenditure;
- Education level;
- Government or private housing; and
- Gender.

Figure 30 shows the WTP compared with average monthly income for both the raw data (blue points) and average monthly income for each WTP value (red points). This shows that when considering average monthly incomes there is a correlation between increasing WTP and higher average income. However, considering the raw data it shows that the majority of WTP values occur at $30/mth and $50/mth and these are for a large range of income levels. Therefore, whilst there is a slight correlation, income is not considered to be a significant influence on WTP. The other factors analysed are presented in figures in Appendix J. These show limited correlation between WTP and other factors, with the exception of housing type, which shows that respondents in government leased houses had a WTP of $30-$50/mth, and only private houses had WTP less than $30/mth. This is also expected to reflect income levels and hence ability to pay.

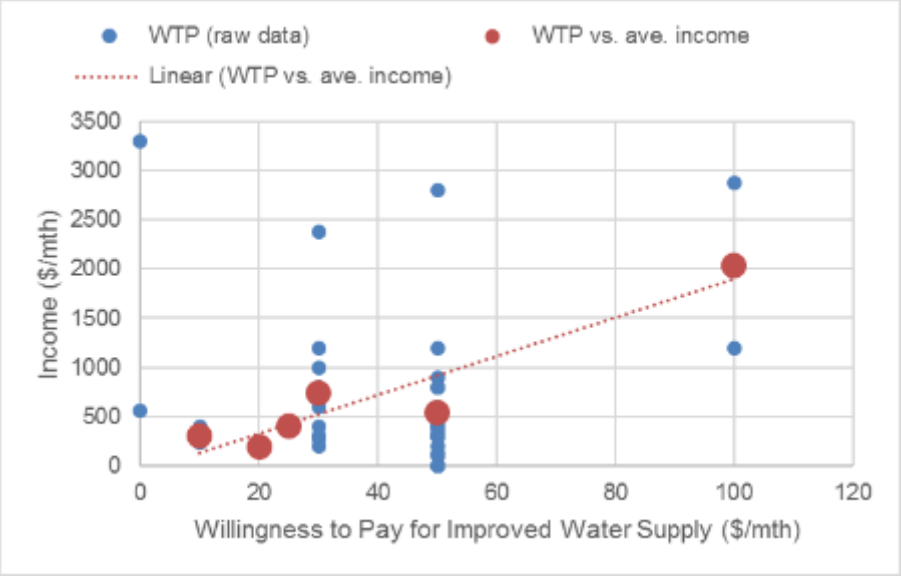

Figure 30 Willingness to pay vs. monthly income (raw data and average)

Chlorination treatment

Whilst most households indicated a desire for chlorination, most (70%) were not willing to pay an additional fee showing their ólimitô was set in the price given for the earlier CV questions on water supply ópriceô This indicates, however, that a high value is placed on chlorinated water across the community. Of the 12 (30%) of respondents who indicated they were happy to pay an additional monthly fee for chlorination, the majority (67%) stated a fee of $10.

One respondent indicated a WTP of $20/mth for chlorination and this respondent also had a high willingness to pay ($100/mth) for improved water supply. This household had a high income ($2880/mth) and was located in a lease with more than one family sharing water from a neighbours piped supply.

7.4.8 Billing scenario

Some questions were included in the survey to understand attitudes to billing and tariff options. Questions were asked of respondents to indicate their preferences for tariff structures and payment system.

Results showed that the majority (67%) of respondents preferred to be charged for water based on consumption, rather than a flat rate which is consistent with the proposed metering system to be implemented through the SPC project. Similarly, for the payment system the majority of respondents (72%) indicated their preference to continue with the current system of paying for water bills at the MLPID office after consumption. No respondents indicated a preference for a prepay system.

16% of respondents also indicated they were happy to have bills deducted directly from government salaries and 24% also indicated a willingness to have the water bill combined with their electricity bill.

8. Water pricing and affordability

8.1 Analysis of cost of metered water services

The 2015 SPC survey collected information on household occupancy numbers, which can be used to assess the cost of water supply under the current tariff structure and rates. Figure 31 shows the distribution of household numbers across a range of increments. The largest frequency is a household size between five to six people. The average size is 6.5 persons and the maximum recorded is 25 people. As shown in Table 38, the proportion of houses with five or more people is approximately 70% and approximately 45% of houses have between five and eight occupants.

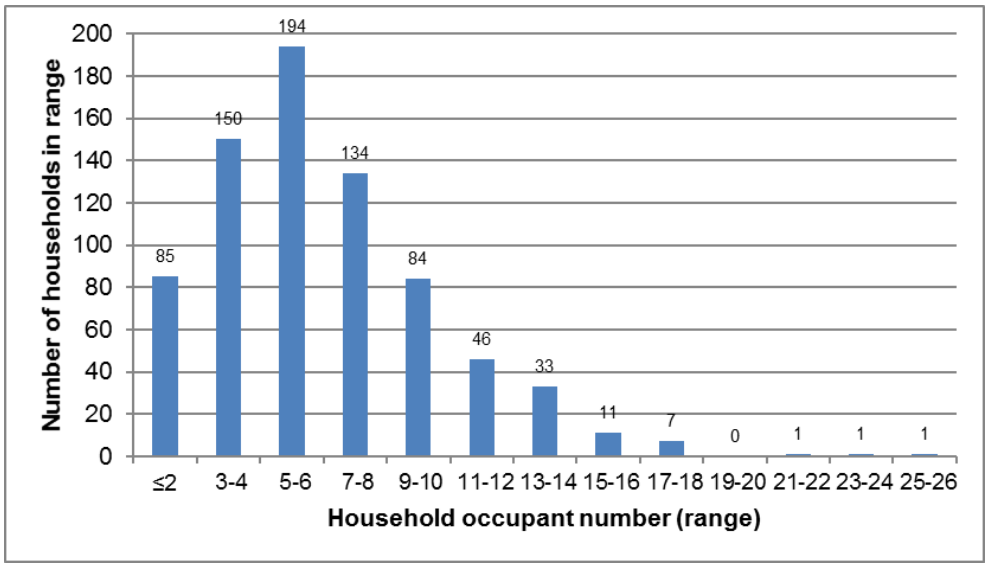

Figure 31 Residential household occupancy (2015 SPC survey)

Table 38 Proportion of households in London, Tennessee and Tabwakea with more than 5, 7 and 9 people and between five and eight.

	London	Tennessee	Tabwakea	All
Households Ó5 people	72%	78%	66%	69%
Households Ó7 people	46%	49%	40%	43%
Households Ó9 people	26%	24%	24%	25%
Households 5-8 people	46%	53%	42%	44%

Taking the two per capita water consumption rates used in the water balance analysis, of 60 L/p/day for houses with access to local well water to supplement demand, or 100 L/p/day for houses without access to groundwater such as many houses in London and Tennessee, the typical monthly bill has been calculated for a range of household sizes. This includes an additional charge for 20% wastage ï making the equivalent per capita consumption 72 L/d and 120 L/d. Using these volumes and the current two-tier tariff structure ($1.20/kL up to 18 kL/mth and $5/kL thereafter), Figure 32 illustrates the monthly household bill and shows the proportion of the cost attributed to each rate. This analysis illustrates that:

- The higher or second pricing tier ($5.00/kL) is triggered for households using 60 L/p/day when the household size exceeds eight people, whilst it is applied for households of six or more people if the per capita consumption is 100 L/p/day. The household size analysis in Table 38 shows that in London, where a larger proportion of houses with the higher per capita consumption is expected, more than 50% of households have 6 or more people. This means that the majority of households will be paying the higher rate for at least some of their water.
- There is a significant difference in monthly costs between households using 100 L/p/day and those using 60 L/p/day for houses in the eight to 10 occupancy range. For an eight person household using 60 L/p/day (with additional 20% losses), the bill would be $21/mth, whilst for a similar household using 100 L/p/day the bill would be $76/mth. This creates a question of equity for householders in areas with limited access to alternative water supplies, such as parts of London.

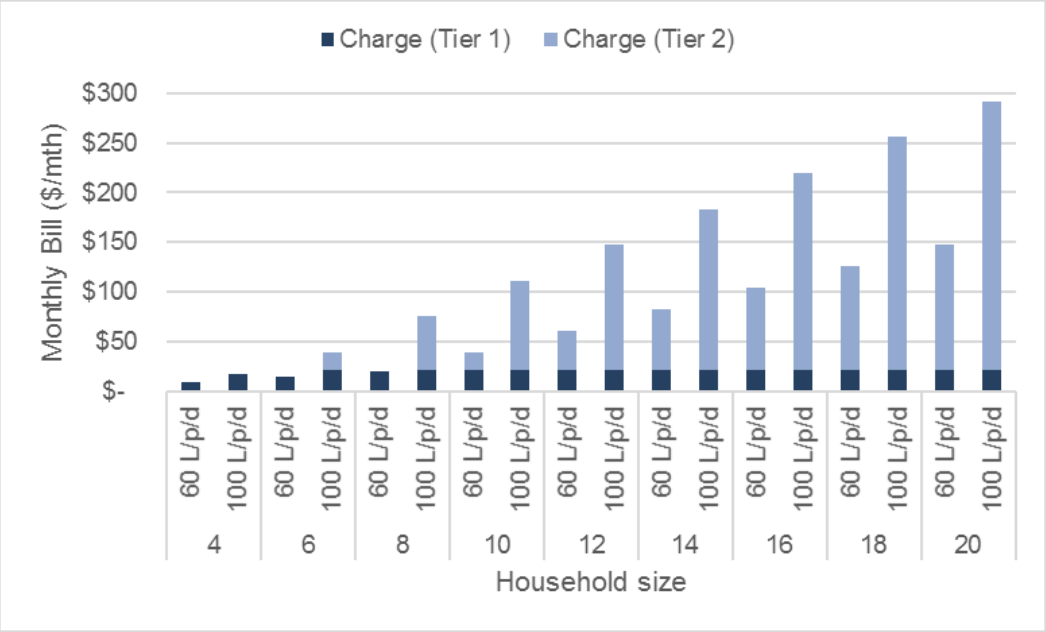

Figure 32 Monthly bill for range of household occupancy and daily per capita water consumption of 60 L/p/d and 100 L/p/d

8.2 Affordability and willingness to pay

The average WTP stated in the household survey (refer Section 7.4.7) was $43/mth for households with an existing connection. Based on this average WTP and the current tariff structure houses where no alternative water supply is available (e.g. in parts of London and Tennessee) could support up to approximately 6 people. This highlights the issue of equity for larger households and illustrates that the current tariff structure is potentially unaffordable for many households.

As stated previously the average WTP ($43/mth) is approximately 10% of the median income ($400/mth). This proportion is significantly higher than commonly accepted international benchmarks of 2 to 4% of household income (Hutton, 2012).

8.3 Policy, tariffs, subsidies and cost recovery

It is recommended that a review of the existing tariffs, subsidies and cost recovery mechanisms be undertaken as a key outcome of this Sustainable Water Management Plan.

The consequences of poorly considered tariffs and financial management of the WSD will likely result in a continued low level of development, poor operation and maintenance practices leading to a degraded water supply system with high losses as at present, low valuing of the system by customers and continued negligent interactions with the water systems by people wanting to access water, but not able to afford it.

8.3.1 Policy considerations

There is a need for government to consider their strategic objectives and policies as they relate to the provision of water services in Kiritimati. In particular, consideration should be given to:

- The economic benefits provided by good water services. A 2014 study in South Tarawa estimated the annual cost of poor water and sanitation to be A$3.7ï A$7.3 million, or A$553-A$1,083 per household (ADB 2014). Recognition of the value of water services to the economy and productivity of Kiritimati Island should therefore drive policy decisions.
- The level of water service that is to be provided i.e. is only a basic level of service, including intermittent supply acceptable or is provision of 24 hour continuous supply the objective.
- The nature and extent of subsidy, including:
  - ï The extent of cross-subsidisation with non-domestic tariffs covering costs of servicing domestic customers.
  - ï Community Service Obligation payments such as that recently requested by the PUB for South Tarawa.
- The objectives of tariffs, which could include:
  - ï Considering the extent that cost recovery is a target and the nature of costs that are to be recovered i.e. does cost recovery extend to new capital investment and asset depreciation, or only to general operational and maintenance costs.
  - ï To encourage demand management and water conservation.
  - ï To provide a lifeline quantity of water at affordable rates for low or no-income households.
  - ï To promote economic growth including supporting tourism.
  - ï To facilitate social equity including not penalising large households.
- The extent of reliance on external grants and development assistance funding to facilitate service provision and future development and expansion.
- Whether existing fees for new connection are to remain, or will they be waived to promote increased access to water supplies.

9. Recommendations for sustainable water management

9.1 Overview

Stakeholder consultations and analyses have revealed a number of issues with the current water management systems and water resources. These issues include governance structures, skills and capacity, funding, tariffs, inadequate maintenance leading to high water losses and involvement and the role of communities and customers in management of the water system. This section provides a summary of opportunities for sustainable water management initiatives to address these issues. These opportunities have been integrated into the draft WSD MOP (Appendix A) developed with the WSD Water Foreperson and Meter Reader during the in-country trip in February 2016 (and align with the seven objectives of the Sustainable Water Management Plan (Section 2.2).

9.2 Water and Sanitation Division restructure

A need for additional posts has been identified to support WSD planning and operations including:

- A Water Engineer
- A Customer Service/Water Awareness Officer
- A Water Resource Sustainability/Quality Officer

There is also a need to review the current leadership of the WSD and consider the appointment of a divisional head with skills and experience in managing budgets, people, strategic planning and communication ï rather than focused purely on technical skills. Alternatively, strong focus on capacity building in this area is essential.

9.3 Tariff structures, rates and affordability

There is a need to review the current tariff structure and rates, with the following issues identified:

- The current two-tiered structure results in inequity and unaffordable charges for large households and leases with multiple households sharing a single meter. There is a need to develop a mechanism to allow for large households. Options explored include extra meters and special rates and consideration for these customers.
- The current rate for smaller households using lower per capita consumption is relatively cheap, providing 60 L/person/day for houses with up to eight people within the lowest pricing tier ($1.20/kL). However, there is inequity for those customers without alternative water sources and who have higher per capita consumption up to 100 L/p/day.
- The existing tariff rates and structure are not understood in relation to the actual operational costs. Analysis of the long-term marginal costs of the water supply system combined with analysis of the communityôs ability and willingness to pay is required to understand the cost recovery potential through tariffs.
- Arrears should be audited in detail to understand the specific circumstances for each customer. It is expected in some cases that arrears may result from faulty meter readings or due to high charges from large household or lease populations sharing a single meter where the second tier tariff was charged although the per capita consumption may not be excessive.

9.4 Budget management and links to revenue collection

Revenue collected for water and sanitation services should be linked to operational budgets to increase accountability and incentives for billing and revenue collection. Substantial support in the form of skills and capacity development and review and revision of the existing administrative, accounting and financial systems is necessary to strengthen the billing system.

The 2016 annual revenue target for the WSD is $31,000. In 2015 the revenue collected was $34,000. The 2015 annual budget for the WSD was approximately $350,000. The *potential* annual revenue, assuming that the approximately 500 connections in London, Tabwakea and Tennessee have an average monthly bill of $30/mth is $180,000 per year. This very simple calculation demonstrates the significant potential for increased revenue generation with an improved water supply and improved administration and operational systems. More detailed financial analysis is required to refine this estimate including consideration of other customers in Poland, Banana and Main Camp.

9.5 Review of governance arrangement

The current governance arrangement provides limited authority for the WSD and MLPID Executive to make decisions regarding water services. This limited autonomy was identified by stakeholders as a constraint to the sustainable management of the water system. In line with the first draft of the *Line and Phoenix Integrated Development Strategy (LPIDS)*, decentralisation of MLPID from Tarawa is proposed as an opportunity to improve water management.

Revised governance options discussed during consultations include:

- Strengthening MLPID as the lead agency with greater autonomy to manage operational and financial aspects of the water system.
- Creating a water utility similar to or linked to the Public Utilities Board in South Tarawa.

9.6 Community roles in sustainable water management

The community plays a key role in the management of the water system and a culture of customer service and community engagement needs to be created as part of water management. Communication with customers is critical and opportunities and ideas raised during consultation for improved community engagement include:

- Working with the KUC village wardens to report issues with the water supply system at a community level and WSD to respond to issues promptly.
- Creation of a dedicated customer relations and awareness officer post within the WSD.
- Improved systems for customer service including making it easier for people to pay bills and report problems or processes for complaints resolution.
- Integrating water awareness specifically tailored to Kiritimati Island into the new curriculum.
- Engaging with youth on water conservation and management through the schools with a similar program to that of the Wildlife and Tourism office at the JSS.
- Each WSD tradesman to be allocated a set number of houses for monthly inspections where they can identify issues and discuss water issues with householders.
- Enforcement and fines for those damaging the water system, stealing property (e.g. solar panels) or wasting water.

9.7 Capacity building and training

The capacity of the WSD and its resources require strengthening, including training and support to improve skills in:

- Technical areas required to undertake daily activities such as plumbing, pump mechanics, GIS, computer skills, water quality testing and gallery and borehole monitoring.
- Customer relations and community awareness on water issues, in particular for tradespeople when doing their monthly inspections.
- The use of electronic billing and revenue management system (in Microsoft Access or Excel) and general computing skills of the Meter Reader and Accounts Staff.
- Training on budget management for Head of Department, Foreperson, Store Manager and meter reader/revenue collector.
- Training and support on team leadership and management for the WSD Head of Department.

9.8 Improving knowledge and monitoring

The Project has installed a number of additional groundwater monitoring boreholes and a weather station at Decca. This presents an opportunity for improved knowledge and monitoring of water resources. It is also important that the WSD develops linkages with the Kiribati Meteorological Service for early warnings of extreme climate conditions and drought planning. The proposed new Water Resource Sustainability/ Quality Officer should be responsible for monitoring and water resource management activities. This should include monitoring of the galleries and groundwater boreholes at Decca and Four Wells, the weather station at Decca, chlorine residual tests at selected locations in the distribution system, and collection of samples from selected sites for bacteriological testing by Ministry of Health (MOH) staff at the hospital laboratory.

9.9 Improving water quality

The household survey highlighted a high demand from the community for chlorinated reticulated water which has the advantage of reducing the burden of household treatment on customers. The project will install a new chlorination facility at Decca. There is also opportunity to involve WSD and the Ministry of Health staff in water quality monitoring and the project should support capacity development in this area including supporting the recommencing meetings of the technical water quality committee which should meet regularly to review water quality results.

9.10 Improving access to all

In line with the National Water Resources Policy, an objective of this Sustainable Water Management Plan is *"to increase access to safe and reliable water supplies"*. Whilst this objective conflicts with the knowledge that projected demand by 2035 for reticulated water will exceed the available supply, it recognises that access to water is of critical importance for the health and development of the Kiritimati Island community.

As such, MLPID should consider opportunities enable easier access to reticulated water supply for additional households within the sustainable limits of the freshwater lenses. This includes:

- Improving the processes and affordability for new residential connections, particularly in new lease areas where local groundwater quality is not suitable for use.
- Prioritising supply to core community services including schools and the hospital.

9.11 Private sector involvement

A significant proportion of the activities undertaken by the WSD is taken up with managing orders and delivery of tankered water. There is potential for this service to be delivered by the private sector, thereby enabling WSD staff to focus on their core activities of maintenance and operation of the water supply system. This is already occurring to some extent with the Dojin shipping company using their own 4 kL truck to deliver water from Decca to London. This arrangement has been driven by the customerôs need for large bulk water deliveries. If this system is to be introduced WSD would play a regulatory role, managing contractors and would need to enforce stringent water safety and quality processes to protect public health. A similar system is currently being introduced in South Tarawa by the PUB.

9.12 Performance monitoring, accountability and operational efficiency

Performance monitoring should be incorporated into MLPID procedures to improve the effectiveness and efficiency of WSD operations and in turn improve the efficiency of the water supply system. Areas of WSD operations where more efficient and effective processes can be implemented include:

- Stock management and ordering, which involves seven steps from the initial ordering to the collection of stock. This system is inefficient and causes delays in accessing important spares.
- Meter reading and billing process.
- Staff management, including allocation of targets and work planning and more stringent management and accountability for overtime.
- Linking the WSD operational budget to water bill revenue

There is also opportunity to learn from and share information, procedures and resources being used or in development at the PUB in South Tarawa to improve the operational efficiencies in Kiritimati. These include:

- Route Cause Analysis tools to help monitor issues with the system, calculate failure rates, identify systemic failures and ultimately to provide data to improve decision making on asset management and system operation.
- Electronic billing system using MS Access tools to more easily issue bills and generate reports on debtors.
- Use of private sector for services that are considered outside of core business (of managing assets) including tankered water delivery which can more cost effectively be provided by the private sector. This could also extend to septic tank vacuum truck services.
- Other initiatives as presented in section 6.4.1.

9.13 Water use efficiency

Water conservation and efficiency should be a high priority for the MLPID. If system losses remain high (50%) it is projected that even with the increased production at Decca the demands for reticulated water will exceed the available supply for London and Tennessee. However, if losses are minimised (to 20%) supply from Decca can support the population of London and Tennessee, which is expected to remain stable.

Conversely, the supply from Four Wells to Tabwakea will continue to exceed demand unless there is an increase in production through the construction of additional galleries at Four Wells. Even if production at Four Wells is increased to match the sustainable yield of 300 kL/day the

demand is expected to exceed supply by 2030. As such, water conservation and efficiency measures are important to help optimise the use of this finite resource.

There exist a range of water use efficiency opportunities and these are summarised in Table 39. Many of these opportunities overlap with those described previously.

Table 39 Potential water use efficiency opportunity at Kiritimati Island

Category	Potential water use efficiency initiative
Supply efficiency	• Improvements to the system including maintenance procedures, an active and ongoing leakage control unit within WSD, funding etc. to reduce the likelihood of wastage from leakage and poor infrastructure • Regular monitoring of flows at galleries, main pipeline and consumer connections and water balance assessments of losses within the system • Development of a better enabling environment to improve water supply operations, maintenance and management ï i.e. policies, legislation, financing and incentive structures. e.g. current funding for water supply operations and maintenance is provided through central government, rather than being linked to revenueï hence there is low incentives to provide customer satisfaction, maintain the system and collect payments. • Private sector participation in provision of water services, e.g. water tankering. • Technical skills capacity development in system operation and maintenance for the WSD • Reducing losses from existing leaks and poor infrastructure, particularly at connections by replacing and repairing.
User efficiency	• Behaviour change information, education and communication campaigns on water use practices ï encouraging fit-for purpose use, water conservation strategies etc. • Enforcing penalties for misuse or damage to the water system • Tariff structure that influences consumer behaviour and manages consumption, whilst remaining equitable and affordable for basic level of water supply. • Water stewardship concepts for larger non-residential water users such as the shipping services and hotels including analysis of water use practices to identify opportunities to reduce consumption and wastage and encourage fit-for-purpose use.
Water recycling and reuse	• Fit-for-purpose use of water, i.e. rainwater, reticulated groundwater, household well water. • Promotion of rainwater harvesting • Remediation of polluted urban groundwater in London and Tennessee and a survey to identify areas where groundwater is suitable for non-potable uses. • Improvement of sanitation system services to improve local groundwater quality, and hence opportunities for supplementary use of this water to reduce demands on reticulated supply.
Allocative efficiency	• Drought planning and management • Allocation of resources for key services ï review the current uses and allocations of water to key services, e.g. schools, government and hospital or private e.g. shipping services and hotels. Consideration of whether in times where water is scarce the allocations are limiting development, productivity or progress towards sustainable development goals.

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Appendices

Appendix A ï WSD Ministry Operational Plan (draft), 2016-2019

MLPID WATSAN OPERATIONAL COSTED **WORKPLAN 2016 - 2019**

EXPECTED RESULTS & ACTIVITIES	PERFORMANCE INDICATORS	4 Year Targets	TIMELINE																DIVISION	RESPONSIBLE STAFF	COSTS
			2016				2017				2018				2019						
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4			
Use money carefully and don't spend money when it is not necessary **Kabongana raoi te mane n taina ae riai**																					
Check the budget and expenses at the end of every month to see how much has been spent and identify any issues where the budget has been over spent and note any future expenses. **Tuoakin te kabanemane nikatoa namakaina bwa iraua ae e a tia nibane ao iraua ae na manga kabaneaki nakon are imwin.**																			WSD	Foreman & Store Lady	nil
Submit annual budget and justifications for additional expenses every year.																			WSD	Foreman – to work with accounts and store lady	nil
Purchase small office assets (stationary, paper, invoice book etc.) twice a year **Karekean bwain te aobiti aika a kainnanoaki n aron bebwa,booki ni waremiita ao a maiti riki.**																			WSD	Store Lady	$8000/year 1 $5000 year 2 $32,000 total
Purchase new computer for Head of WSD																			WSD	Store Lady	$1000

Purchase stocks & materials for water system plumbing to make sure there is enough spare parts, every quarter **Karekean bwaai ni makuri n aron bwaibu, toma ni bwaibu (fitting) etc.**																				WSD	Foreman & Store Lady	??
Good administration and management of Water and Sanitation Division staff																						
Organized leave roster																				WSD	Foreman	nil
Revise WSD structure, to include new post for Water Engineer, Water Sustainability/Quality Officer and Customer Service/Water Awareness officer – send to PSO																				Administration & WSD	Permanent Secretary/OI C & Foreman	nil
PSO to approve new structure																				PSO		nil
Employ the three new staff to fill the posts																				PSO		3 salaries: WE: level 6 $13,390/yr SWQ: level 16/15 $6,162/yr CS/Awareness: level 15/14 $6,890/yr
Ensure the staff sign in and update timesheets for the salary																				WSD	Time keeper	nil
Hold a staff meeting once a month to update all staff on WSD operations, and give staff opportunity to discuss any issues or give any ideas.																				WSD	Foreman (& all staff)	nil

Sanitation – prepare daily work plan from Housing and the new building projects																			Housing/WSD	Leading hand - sanitation	Nil
Water division leading hand to organise their staff work plans for each day																			WSD	Leading hand – water & Foreman	Nil
Foreman and Leading hands to develop long-term, monthly work plan every three months																			WSD	Foreman & leading hand	Nil
New system of archiving and storing information, reports, data and billing records.																			WSD	Support from SPC	nil
Work with the EU Water Project to improve the infrastructure at Decca and Four Wells, and in London and Tennessee																					
Install new pumps and galleries at Decca and Four Wells																			WSD & SPC/EU	All staff	
Work with Water Project plumber to fix connections in London and Tennessee																			WSD & SPC/EU	All staff	
Improve access to water for all people																					
Water connection to new leases – project with finance to be approved																			Finance	Finance	$586,595 (from water progress report April 2015)
Implement new connections to leases																			WSD	Foreman	??
Purchase of new tanker truck to cater for water demands of communities with no connections to the system.																			WSD/ Planning	Foreman	??$40,000
Tasks for sustainable management of existing water supply infrastructure																					
Daily routine of attending of water pumps such as windmills, solar pumps and generator pumps. Making																			WSD	Tradesman	???

Commented [PM1]: What about connecting houses in Banana?

Commented [PM2]: Installing windmills and solar pumps from Decca and Four Wells at Banana

sure that the flow of water is continuous.																							
Daily collection of water maintenance forms from the Housing Unit																					WSD	Sanitation Division	
Each tradesman to be allocated a set number of houses for monthly inspections.																					WSD	Foreman	???
Monthly inspections of houses for leaks including pipes at non-government houses to be undertaken.																					WSD	Tradesman	???
Check unusual billing patterns, where high water usage (meter readings) the tradesman are to check for leaks.																					WSD	Meter Reader & Tradesmen	???
Equipment for sustainable management of existing water supply infrastructure																							
New truck to assist with maintenance at households as only one truck currently on hire.																					WSD/ Planning	Foreman	$40,000
Equipment for staff undertaking maintenance and water attendance work (rain coat, safety boots, gloves, shelter at Decca, VHF radio)																					WSD	Foreman & Leading hands	???
Additional tools for maintenance																					WSD	Foreman & Leading hands	???
Management of water quality and water resources																							
Monitoring boreholes at Decca, Banana and Poland every month																					WSD	Tebororo	
Data entry and review from borehole monitoring. Report to Foreman on thickness of freshwater.																					WSD	Tebororo with support from SPC	nil
Develop equipment at the hospital Lab for water quality testing (EU Project)																					EU/SPC Project	Project	

Install chlorination plant at Decca																				EU/SPC Project	Project	
Submit request to Finance for chlorination systems at Banana and Poland. Possible funding from Japanese grants																				Planning	Senior resource economist	nil
Install chlorination plant at Banana and Poland																				WSD	Foreman	
Test water quality, monthly																				Health/WSD	WQO	
Technical committee on Water quality to meet every 2 months to review the WQ data.																				MLPID	Committee	
Community awareness on water conservation and management of the water system																						
Work with the EU water project on water awareness to develop a long term awareness plan for the community																				WSD	Project & Foreman	nil
Ongoing awareness activities by new officer (Customer Services and Awareness)																				WSD	Customer Services and Awareness Officer	
Contact the curriculum development committee in Tarawa to consider integrating water awareness into the new curriculum																				WSD and IEC	Foreman & Island education coordinator	nil
Establish committee for awareness events including WSD, Health, Environment, Youth, Education, the project.																				WSD	Foreman	
Hold annual water awareness on World Water Day – 22 March																				WSD	Committee	???
Hold annual water awareness on World Toilet Day – 19 November																				WSD	Committee	???

Tradesmen to discuss water issues with households when doing their monthly inspections																					WSD	Tradesman	nil
Review and improve water revenue, billing system and charges (tariffs)																							
Set up committee to review tariff structure and levels.																					Administration (MLPID)	Permanent Secretary/OIC	nil
Undertake community consultation on tariff structures and rates.																					Administration (MLPID)	Permanent Secretary/OIC	??
Update tariff structures and rates according to decisions from committee																					Administration (MLPID)	Permanent Secretary/OIC	nil
Ensure all connected houses have working meters at London and Tennessee – EU Project.																					WSD/Project	SPC/EU	Nil (EU funded)
Ensure all connected houses have working meters at St Francis, Spivey, Crystal Beach, CCH and Main Camp - WSD																					WSD	Leading hand & Tradesmen	??
Ensure all connected houses have working meter in Tabwakea – wait until receive water, when new pumps installed at Four Wells - WSD																					WSD	Leading hand & Tradesmen	??
Provide equipment for meter reading and dispatching invoices all in a single trip. Requires motorbike, regular stock of invoice books and clip-board with calculator.																					WSD	Foreman	??
Provide training on use of electronic billing and revenue management system (in Microsoft Access) to Meter Reader and Accounts Staff. Support from SPC.																					SPC IT Section/WSD	Meter reader, time keeper and revenue collector	nil

Commented [PM3]: What about putting in new meters at Banana

Implementation and enforcement of water protection and conservation measures																					
Enforcement and fines for those damaging the water system or stealing property (e.g. solar panels) or wasting water.																			Police and WSD	Foreman	
Council village wardens to report any issues on the water system and WSD to respond to issues																			Council & WSD	Foreman	
Monthly inspections of houses for leaks including pipes at non-government houses to be undertaken by tradesman. Any tampering to be reported to the police and disconnections made.																			WSD	Foreman and Tradesmen	
Improve skills and capacity of Water & Sanitation Section staff																					
Training – on-the job training with the EU Water Project																			EU/SPC/WSD		
Submit priority training plan and request to PSO																			Administration and WSD	Permanent Secretary/OIC and Foreman	
PSO approve agreed training plan																			PSO		
Training for Kokuria in Australia (3 months) on ???																			Administration and WSD	Permanent Secretary/OIC and Foreman	???
Technical training on GIS																			WSD/PSO	PSO	???
Technical training on plumbing																			WSD/PSO	PSO	???
Technical training on mechanics																			WSD/PSO	PSO	???
Training on the computer skills																			WSD/PSO	PSO	???
Training for Foreman, Store Lady and meter reader/revenue collector on																			WSD/PSO	PSO	???

budget management																					
Improving the sanitation systems																					
Developing a well water connections for household toilets rather than using treated water																			WSD & Housing	Foreman	
New septic tanker truck																			Planning & WSD	Senior resource economist	

Appendix B – Examples of water system modifications at households in London

Water accessed at ground level. Pipe blocked off with stick.

Open pipe, with continuous flow at ground level.

Booster pump at house lifting water into 500 L header tank.

Appendix C – Water Budget and Expenses 2013 – 2015

Water Unit Report for 2014 and 2015

		2013				2014				2015 as at 30.11.15			
		Budget	**Rev. Budget**	**Actual**	**Variance**	**Budget**	**Rev. Budget**	**Actual**	**Variance**	**Budget**	**Rev. Budget**	**Actual**	**Variance**
Revenue													
C29070000007	Water Supply fees	46,000.00	46,000.00	23,605.45	- 22,394.55	47,288.00	47,288.00	20,897.64	- 26,390.36	31,000.00	31,000.00	34,783.60	3,783.60
Expenditure													
201	KPF Contribution	15,820.00	15,820.00	10,643.25	5,176.75	15,959.00	15,959.00	12,088.06	3,870.94	15,378.00	15,378.00	11,738.99	3,639.01
202	Salaries	206,934.00	158,419.00	135,057.53	23,361.47	208,780.00	148,137.00	148,101.56	35.44	202,046.00	202,046.00	136,303.90	65,742.10
204	Allowances	8,200.00	14,342.00	14,341.47	0.53	8,200.00	11,138.00	11,137.82	0.18	6,500.00	6,500.00	5,793.88	706.12
205	Overtime	16,000.00	58,373.00	58,372.39	0.61	12,000.00	37,864.00	37,863.42	0.58	10,000.00	20,000.00	28,944.85	- 8,944.85
206	Temporary Assistance	4,000.00	4,000.00	4,000.00	0.00	4,000.00	11,241.00	11,240.40	0.60	3,000.00	3,000.00	19,803.00	- 16,803.00
208	Leave grants	22,500.00	22,500.00	20,875.00	1,625.00	22,500.00	21,750.00	21,750.00	-	23,250.00	23,250.00	18,028.78	5,221.22
Sub Total		**273,454.00**	**273,454.00**	**243,289.64**	**30,164.36**	**271,439.00**	**246,089.00**	**242,181.26**	3,907.74	**260,174.00**	**270,174.00**	**220,613.40**	**49,560.60**
215	Transport to w/place	18,000.00	30,643.00	30,642.62	0.38	18,300.00	48,011.00	48,010.03	0.97	26,984.00	26,984.00	34,829.37	- 7,845.37
216	Internal Travel	2,000.00	2,000.00	2,000.00	0.00	2,000.00	10,571.00	10,570.50	0.50	2,000.00	2,000.00	934.50	1,065.50
217	Local training				0.00	-	-	-	-	-	-	-	-
227	External Travel				0.00	-	-	-	-	-	-	-	-
231	Telecommunications				0.00	-	-	-	-	1,500.00	1,500.00	-	1,500.00
232	Electricity & Gas				0.00	-	-	-	-	-	-	-	-
233	Water				0.00	-	-	-	-	-	-	-	-
239	Entertainment				0.00	-	-	-	-	-	-	-	-
241	Stationery & Supplies	8,000.00	12,753.00	12,752.37	0.63	18,200.00	21,275.00	21,274.97	0.03	11,400.00	21,400.00	14,359.33	7,040.67
243	Office equipment & furniture	8,000.00	8,000.00	8,000.00	0.00	-	-	-	-	18,860.00	18,860.00	7,183.77	11,676.23
244	Repairs Equipment				0.00	-	-	-	-	-	-	-	-
250	Local Services	4,000.00	4,000.00	3,875.30	124.70	4,000.00	4,000.00	4,000.00	-	6,000.00	6,000.00	6,107.52	- 107.52
251	Overseas services				0.00	-	-	-	-	-	-	-	-
285	Hire of Plant/Equipment	30,000.00	12,604.00	6,240.00	6,364.00	33,320.00	17,313.00	17,164.00	149.00	25,550.00	5,550.00	2,208.70	3,341.30
287	Fixed Plant and Equipment				0.00		-	-	-	-	-	-	-
289	Bldg & Infrastructure Maint				0.00		-	-	-	-	-	-	-
291	Vehicle Maintenance				0.00		-	-	-	-	-	-	-
		70,000.00	70,000.00	63,510.29	6,489.71	**75,820.00**	**101,170.00**	**101,019.50**	**150.50**	**92,294.00**	**82,294.00**	**65,623.19**	**16,670.81**
		343,454.00	**343,454.00**	**306,799.93**	**36,654.07**	**347,259.00**	**347,259.00**	**343,200.76**	**4,058.24**	**352,468.00**	**352,468.00**	**286,236.59**	**66,231.41**

Appendix D – Water consumption survey

D1 - Water consumption data summary

D2 - Water consumption detailed data

D1 - Water consumption data summary

House:	1	London	5 People
Date	Average Total (L/p/d)	Average Potable (L/p/d)	Average Non-Potable (L/p/d)
13-Feb	12	12	0
14-Feb	15	11	4
15-Feb	50	18	32
Average	26	14	12

House:	2	Main Camp		6 People		
Date	Average Total (L/p/d)	Average Potable (L/p/d)	Average Non-Potable (L/p/d)	Average Total (L/p/d)	Average Potable (L/p/d)	Average Non-Potable (L/p/d)
	Note: This includes water use for feeding pigs.			*Note: This excludes water use for feeding pigs.*		
17-Feb	76	40.8	35	69	41	28
18-Feb	68	40.0	28	65	40	25
19-Feb	72	41.7	30	65	42	23
20-Feb	80	53.3	27	73	53	20
21-Feb	122	71.7	50	115	72	43
Average	84	50	34	78	50	28

House:	3	London	6 People
Date	Average Total (L/p/d)	Average Potable (L/p/d)	Average Non-Potable (L/p/d)
17-Feb	30	23	7
18-Feb	25	22	3
19-Feb	29	24	5
20-Feb	27	24	3
Average	28	23	5

House:	4	Tabwakea III Abotoro	12 People
Date	Average Total (L/p/d)	Average Potable (L/p/d)	Average Non-Potable (L/p/d)
13-Feb	32	13	20
14-Feb	26	12	13
15-Feb	13	13	0
16-Feb	16	9	7
Average	22	12	10

D2 - Water consumption detailed data

Village:	London						
Adults	2	**Children**	3	**TOTAL PPL**	**5**		
Date	**Time**	**Source**	**Collection method**	**No.**	**Volume**	**End-use**	**Potable End-Use**
13/02/2016	7:00	Rainwater	Jug	1	3	Drink	Y
13/02/2016	7:00	Piped Supply (tank)	Small bucket	1	6	Dishwashing	Y
13/02/2016	12:30	Rainwater	Jug	1	3	Drink	Y
13/02/2016	12:30	Piped Supply (tank)	Small bucket	1	6	Cooking	Y
13/02/2016	19:20	Piped Supply (tank)	Large bucket	2	40	Bathing	Y
13/02/2016	19:45	Rainwater	Jug	1	3	Drink	Y
14/02/2016	7:30	Rainwater	Jug	1	3	Drink	Y
14/02/2016	7:30	Piped Supply (tank)	Large bucket	1	20	Bathing	Y
14/02/2016	7:30	Piped Supply (tank)	Small bucket	1	6	Dishwashing	Y
14/02/2016	12:57	Rainwater	Small bucket	1	6	Cooking	Y
14/02/2016	15:22	Piped Supply (tank)	Large bucket	1	20	Bathing	Y
14/02/2016	19:30	Piped Supply (tank)	Large bucket	1	20	Toilet	N
15/02/2016	8:00	Rainwater	Jug	1	3	Drink	Y
15/02/2016	8:00	Piped Supply (tank)	Large bucket	1	20	Dishwashing	Y
15/02/2016	8:00	Piped Supply (tank)	Large bucket	1	20	Cooking	Y
15/02/2016	8:00	Piped Supply (tank)	Small bucket	1	6	Bathing	Y
15/02/2016	12:30	Piped Supply (tank)	Large bucket	1	20	Toilet	N
15/02/2016	12:30	Rainwater	Jug	1	3	Drink	Y
15/02/2016	13:45	Piped Supply (tank)	Large bucket	7	140	Clothes washing	N
15/02/2016	20:15	Piped Supply (tank)	Large bucket	2	40	Bathing	Y

Village:	Main Camp						
Adults	2	**Children**	4	**TOTAL PPL**	**6**		
Date	**Time**	**Source**	**Collection method**	**No.**	**Volume**	**End-use**	**Potable End-Use**
17/02/2016	6:45	Piped Supply (tank)	-	-	20	Toilet	N
17/02/2016	6:45	Rainwater	-	-	40	Bathing	Y
17/02/2016	6:45		-	-	20	Drink	Y
17/02/2016	6:45		-	-	20	Dishwashing	Y
17/02/2016	11:30				20	Bathing	Y
17/02/2016	11:30				20	Toilet	N
17/02/2016	14:45				20	Bathing	Y
17/02/2016	14:45				20	Dishwashing	Y
17/02/2016	15:50				20	Cooking	Y
17/02/2016	15:50				20	Feeding pigs	PIG
17/02/2016	15:50				20	Bathing	Y

Village:	Main Camp						
Adults	2	Children	4	TOTAL PPL	6		
Date	Time	Source	Collection method	No.	Volume	End-use	Potable End-Use
17/02/2016	15:50				60	Clothes washing	N
17/02/2016	18:45				40	Toilet	N
17/02/2016	18:45				20	Feeding pigs	PIG
17/02/2016	19:00				40	Bathing	Y
17/02/2016	19:30				20	Toilet	N
17/02/2016	19:30				10	Bathing	Y
17/02/2016	19:30				5	Cooking	Y
17/02/2016	20:00				10	Toilet	N
17/02/2016	20:00				10	Bathing	Y
18/02/2016	6:30				20	Toilet	N
18/02/2016	6:30				20	Bathing	Y
18/02/2016	7:00				10	Bathing	Y
18/02/2016	7:30				10	Bathing	Y
18/02/2016	7:30				10	Dishwashing	Y
18/02/2016	8:00				10	Toilet	N
18/02/2016	8:00				10	Bathing	Y
18/02/2016	9:15				10	Drink	Y
18/02/2016	10:45				10	Feeding pigs	PIG
18/02/2016	10:45				10	Cooking	Y
18/02/2016	13:00				10	Bathing	Y
18/02/2016	13:00				5	Cooking	Y
18/02/2016	15:30				60	Clothes washing	N
18/02/2016	15:35				10	Toilet	N
18/02/2016	15:35				5	Drink	Y
18/02/2016	16:35				10	Toilet	N
18/02/2016	16:35				10	Feeding pigs	PIG
18/02/2016	16:35				20	Cooking	Y
18/02/2016	19:30				60	Bathing	Y
18/02/2016	19:30				20	Dishwashing	Y
18/02/2016	20:00				20	Bathing	Y
18/02/2016	22:15				20	Toilet	N
18/02/2016	22:15				20	Bathing	Y
18/02/2016	22:40				20	Toilet	N
19/02/2016	6:30				20	Toilet	N
19/02/2016	6:30				40	Bathing	Y
19/02/2016	7:15				20	Toilet	N
19/02/2016	7:15				20	Bathing	Y
19/02/2016	8:30				20	Toilet	N
19/02/2016	8:30				20	Feeding pigs	PIG
19/02/2016	11:35				20	Toilet	N
19/02/2016	11:35				20	Cooking	Y
19/02/2016	13:20				20	Dishwashing	Y
19/02/2016	13:20				20	Toilet	N
19/02/2016	14:15				20	Bathing	Y
19/02/2016	16:30				20	Bathing	Y

Village:	Main Camp						
Adults	2	Children	4	TOTAL PPL	6		
Date	Time	Source	Collection method	No.	Volume	End-use	Potable End-Use
19/02/2016	16:30				20	Feeding pigs	PIG
19/02/2016	19:00				20	Toilet	N
19/02/2016	19:00				20	Bathing	Y
19/02/2016	19:00				20	Dishwashing	Y
19/02/2016	19:00				10	Cooking	Y
19/02/2016	21:00				20	Drink	Y
19/02/2016	21:30				20	Drink	Y
19/02/2016	21:30				20	Cooking	Y
19/02/2016	22:30				20	Toilet	N
20/02/2016	7:00	Rainwater			20	Toilet	N
20/02/2016	7:00	No piped supply available from Banana this day			20	Bathing	Y
20/02/2016	7:00				20	Dishwashing	Y
20/02/2016	8:30				20	Bathing	Y
20/02/2016	8:30				20	Drink	Y
20/02/2016	8:30				20	Feeding pigs	PIG
20/02/2016	9:45				20	Cooking	Y
20/02/2016	9:45				20	Bathing	Y
20/02/2016	9:45				20	Toilet	N
20/02/2016	12:10				20	Cooking	Y
20/02/2016	12:10				20	Toilet	N
20/02/2016	13:30				20	Dishwashing	Y
20/02/2016	13:30				20	Toilet	N
20/02/2016	16:15				20	Bathing	Y
20/02/2016	18:30				20	Bathing	Y
20/02/2016	18:30				20	Drink	Y
20/02/2016	18:30				20	Feeding pigs	PIG
20/02/2016	18:30				20	Dishwashing	Y
20/02/2016	18:30				20	Cooking	Y
20/02/2016	20:00				20	Toilet	N
20/02/2016	20:00				20	Bathing	Y
20/02/2016	21:30				20	Bathing	Y
20/02/2016	21:45				20	Toilet	N
20/02/2016	21:45				20	Bathing	Y
21/02/2016	5:25				20	Toilet	N
21/02/2016	5:37				20	Bathing	Y
21/02/2016	5:37				20	Toilet	N
21/02/2016	7:20				20	Toilet	N
21/02/2016	9:30				20	Drink	Y
21/02/2016	9:30				20	Feeding pigs	PIG
21/02/2016	9:35				20	Dishwashing	Y
21/02/2016	9:35				20	Cooking	Y
21/02/2016	10:30				20	Toilet	N
21/02/2016	10:30				20	Bathing	Y
21/02/2016	11:10				10	Cooking	Y
21/02/2016	11:10				20	Bathing	Y

Village:	Main Camp						
Adults	2	Children	4	TOTAL PPL	6		
Date	Time	Source	Collection method	No.	Volume	End-use	Potable End-Use
21/02/2016	11:10				20	Toilet	N
21/02/2016	11:10				10	Cooking	Y
21/02/2016	11:15				20	Toilet	N
21/02/2016	12:40				40	Bathing	Y
21/02/2016	12:40				120	Clothes washing	N
21/02/2016	13:25				20	Bathing	Y
21/02/2016	18:20				80	Bathing	Y
21/02/2016	18:20				10	Dishwashing	Y
21/02/2016	18:20				40	Cooking	Y
21/02/2016	18:20				20	Feeding pigs	PIG
21/02/2016	20:30				20	Bathing	Y
21/02/2016	20:45				20	Toilet	N
21/02/2016	20:45				10	Dishwashing	Y
21/02/2016	22:55				70	Bathing	Y

Village:	London						
Adults	2	Children	4	TOTAL PPL	6		
Date	Time	Source	Collection method	No.	Volume	End-use	Potable End-Use
17/02/2016	6:00	Piped supply	Basin	2	3	Dishwashing	Y
17/02/2016	6:05	Piped supply	Large Bucket	0.5	10	Cooking	Y
17/02/2016	6:45	Piped supply	Large Bucket	3	60	Bathing	Y
17/02/2016	7:15	Piped supply	Jug	1	3	Drink	Y
17/02/2016	14:30	Piped supply	Jug	1	3	Drink	Y
17/02/2016	16:00	Piped supply	Large Bucket	2	40	Clothes washing	N
17/02/2016	20:00	Piped supply	Large Bucket	3	60	Bathing	Y
18/02/2016	6:15	Piped supply	Basin	2	3	Dishwashing	Y
18/02/2016	6:17	Piped supply	Large Bucket	0.5	10	Cooking	Y
18/02/2016	7:00	Piped supply	Large Bucket	2.5	50	Bathing	Y
18/02/2016	7:18	Piped supply	Jug	1	3	Drink	Y
18/02/2016	14:45	Piped supply	Jug	1	3	Drink	Y
18/02/2016	17:00	Piped supply	Large Bucket	1	20	Clothes washing	N
18/02/2016	19:00	Piped supply	Large Bucket	3	60	Bathing	Y
18/02/2016	19:20	Piped supply	Jug	1	3	Drink	Y
19/02/2016	6:00	Piped supply	Basin	2	3	Dishwashing	Y
19/02/2016	6:15	Piped supply	Large Bucket	0.5	10	Cooking	Y
19/02/2016	6:48	Piped supply	Large Bucket	3	60	Bathing	Y
19/02/2016	7:06	Piped supply	Jug	1	3	Drink	Y
19/02/2016	14:56	Piped supply	Jug	1	3	Drink	Y
19/02/2016	17:08	Piped supply	Large Bucket	1.5	30	Clothes washing	N
19/02/2016	18:00	Piped supply	Jug	1	3	Drink	Y
19/02/2016	19:30	Piped supply	Large Bucket	3	60	Bathing	Y
20/02/2016	6:05	Piped supply	Basin	2	3	Dishwashing	Y

20/02/2016	6:10	Piped supply	Large Bucket	0.5	10	Cooking	Y
20/02/2016	6:36	Piped supply	Large Bucket	3	60	Bathing	Y
20/02/2016	7:00	Piped supply	Jug	1	3	Drink	Y
20/02/2016	14:54	Piped supply	Jug	1	3	Drink	Y
20/02/2016	17:00	Piped supply	Large Bucket	1	20	Clothes washing	N
20/02/2016	19:00	Piped supply	Jug	1	3	Drink	Y
20/02/2016	19:15	Piped supply	Large Bucket	3	60	Bathing	Y
21/02/2016	6:20	Piped supply	Basin	2	3	Dishwashing	Y
21/02/2016	6:26	Piped supply	Large Bucket	0.5	10	Cooking	Y
21/02/2016	6:58	Piped supply	Jug	1	3	Drink	Y

NOTE: DID NOT COMPLETE ALL OF 21 FEB 2016 SO EXCLUDED FROM SUMMARY

Village:	Tabwakea III Abotoro						
Adults	9	**Children**	3	**TOTAL PPL**	**12**		
Date	**Time**	**Source**	**Collection method**	**No.**	**Volume**	**End-use**	**Potable End-Use**
13/02/2016	6:00	Rainwater	Jug	2	6	Cooking	Y
13/02/2016	7:00	Piped supply	Small Bucket	0.5	3	Cooking	Y
13/02/2016	8:00	Well	Large Bucket	1	20	Bathing	Y
13/02/2016	12:20	Rainwater	Jug	1	3	Drink	Y
13/02/2016	14:30	Rainwater/Well	Large basin	2	236	Clothes washing	N
13/02/2016	16:00	Rainwater	Large Bucket	1	20	Cooking	Y
13/02/2016	18:00	Well	Large Bucket	5	100	Bathing & Toilet	Y
14/02/2016	7:15	Well	Large Bucket	3	60	Toilet	N
14/02/2016	7:15	Rainwater	Jug	2	6	Drink	Y
14/02/2016	8:11	Well	Large Bucket	1	20	Dishwashing	Y
14/02/2016	11:15	Rainwater	Large Bucket	1	20	Cooking	Y
14/02/2016	16:30	Rainwater/Well	Large Bucket	2	40	Cooking/Dishwashing/ Bathing/Toilet	Y
14/02/2016	18:11	Well	Large Bucket	5	100	Clothes washing	N
14/02/2016	18:11	Rainwater	Small Bucket	0.5	3	Drink	Y
14/02/2016	19:35	Well	Large Bucket	3	60	Bathing & Toilet	Y
15/02/2016	6:11	Rainwater	Small Bucket	1	6	Drink	Y
15/02/2016	6:11	Piped supply	Large Bucket	1	20	Cooking	Y
15/02/2016	11:12	Well	Large Bucket	2	40	Dishwashing	Y
15/02/2016	12:22	Piped supply	Large Bucket	0.5	10	Cooking	Y
15/02/2016	16:30	Well	Large Bucket	3	60	Bathing & Toilet	Y
15/02/2016	18:03	Piped supply	Large Bucket	1	20	Cooking	Y
16/02/2016	6:13	Rainwater	Large Bucket	0.5	10	Drink	Y
16/02/2016	8:05	Piped supply	Large Bucket	1	20	Cooking	Y
16/02/2016	10:12	Well	Large Bucket	1	20	Toilet	N
16/02/2016	11:06	Well	Large Bucket	3	60	Clothes washing	N
16/02/2016	13:03	Piped supply	Large Bucket	1	20	Dishwashing	Y
16/02/2016	15:00	Piped supply	Small Bucket	0.5	3	Drink	Y
16/02/2016	17:30	Well	Large Bucket	2	40	Bathing & Toilet	Y
16/02/2016	19:03	Piped supply	Large Bucket	1	20	Cooking	Y

Appendix E – Water balance calculation tables

Table E1: Population Projections and connection projections

Year	Population - Total Projected			Proportion of population connected			Population - with connections			Proportion of population with wells and connection		
	London	Tennessee	Tabwakea	London	Tennessee	Tabwakea	London	Tennessee	Tabwakea	London	Tennessee	Tabwakea
2015	1606	353	2972	93%	80%	43%	1487	281	1267	15%	26%	63%
2020	1606	353	3822	100%	100%	47%	1606	353	1793	15%	26%	69%
2025	1606	353	4915	100%	100%	52%	1606	353	2536	15%	26%	76%
2030	1606	353	6321	100%	100%	57%	1606	353	3588	15%	26%	83%
2035	1606	353	8129	100%	100%	62%	1606	353	5075	15%	26%	90%

Table E2: Projected demand with 20% losses

Year	Per capita demand (L/p/day)		Daily Residential Demand (kL/day)				London - Tennessee		Tabwakea		Total Demand (kL/d)		
	Without wells	With wells	London	Tennessee	Tabwakea	Total	L&T non-residential use	Losses (20%)	Tabwakea non-residential use	Losses (20%)	London –Tennessee	Tabwakea	Total
2015	100	60	140	25	95	260	8	35	5	20	208	120	328
2020	100	60	151	32	130	313	9	38	6	27	230	164	394
2025	100	60	151	32	177	360	9	38	9	37	230	223	453
2030	100	60	151	32	239	422	9	38	12	50	230	302	532
2035	100	60	151	32	325	508	9	38	16	68	230	409	640

Table E3: Projected demand, 50% losses

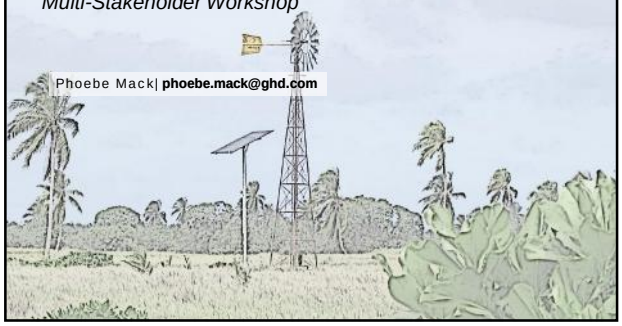
Year	Per capita demand (L/p/day)		Daily Residential Demand (kL/day)				London - Tennessee		Tabwakea		Total Demand (kL/d)		
	Without wells	With wells	London	Tennessee	Tabwakea	Total	L&T non-residential use	Losses (50%)	Tabwakea non-residential use	Losses (50%)	London –Tennessee	Tabwakea	Total
2015	100	60	140	25	95	260	8	87	5	50	260	150	410
2020	100	60	151	32	130	313	9	96	6	68	288	205	493
2025	100	60	151	32	177	360	9	96	9	93	288	279	567
2030	100	60	151	32	239	422	9	96	12	126	288	377	665
2035	100	60	151	32	325	508	9	96	16	171	288	512	800

Table E4: Projected supply

	Supply (kL/d)		
	Decca Supply	Four Wells Supply	Total Supply
2015	147	89	235
2020	260	120	380
2025	260	120	380
2030	260	120	380
2035	260	120	380

Appendix F – Multi-stakeholder workshop slides

Babairean kateimatoan nakoraoin butin te ran
Sustainable Water Management Planning -
Multi-Stakeholder Workshop



Phoebe Mack| **phoebe.mack@ghd.com**

Introduction

1. Update on the Water Project
2. Review of water availability
3. Water system history

MORNING TEA

4. The concept of water use efficiency

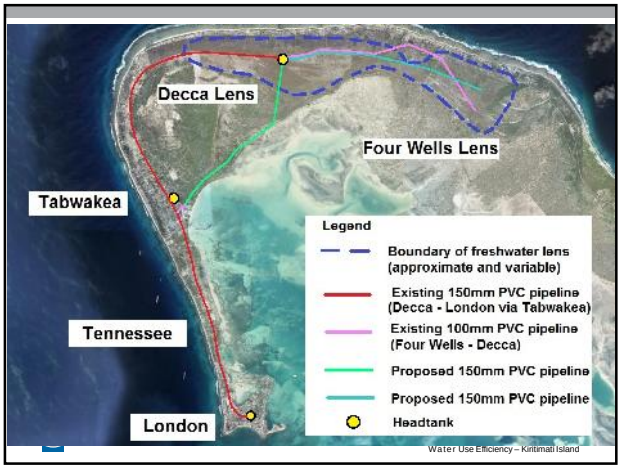
LUNCH

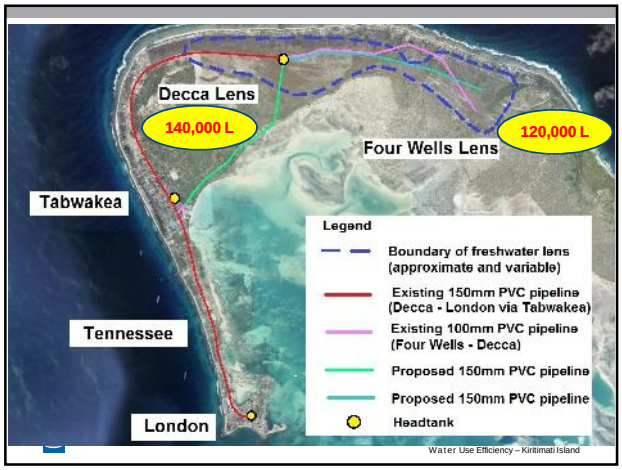
5. Developing the sustainable water management plan

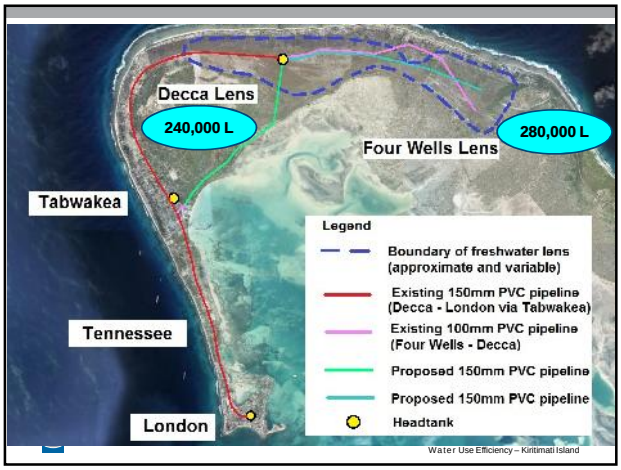
AFTERNOON TEA

MESSAGE # 1 – ADDITIONAL WATER PRODUCTION

1. THE PROJECT







MESSAGE # 1 – ADDITIONAL WATER PRODUCTION

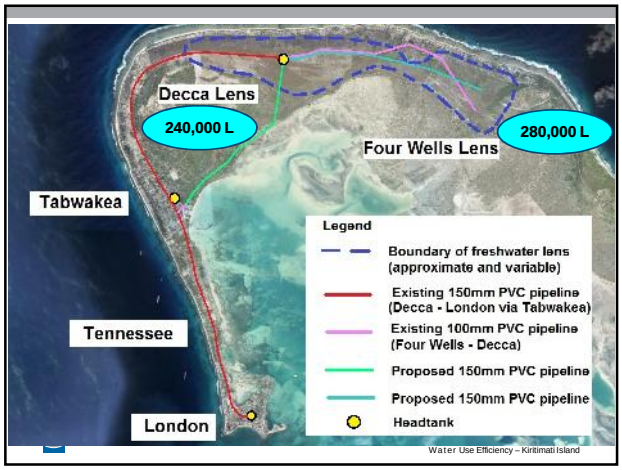
MESSAGE # 2 – WATER CONSERVATION AND EFFICIENCY ARE CRITICAL

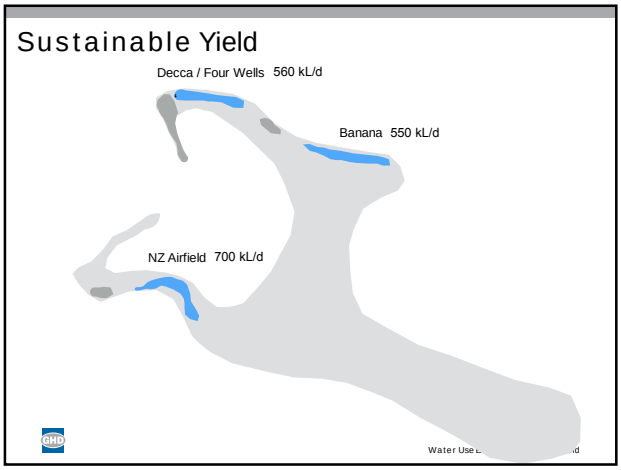
2. AVAILABILITY – SUPPLY AND DEMAND

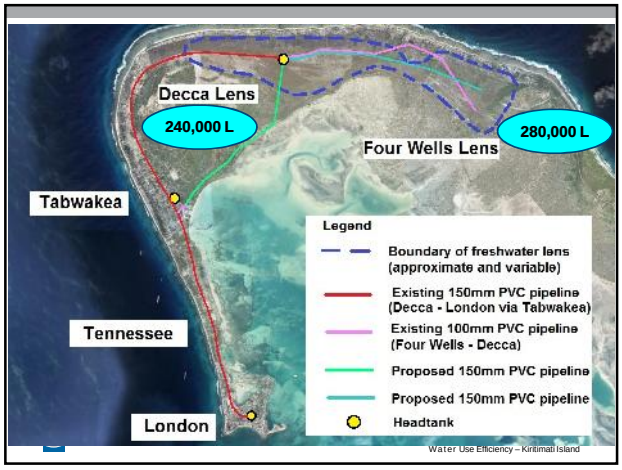
MESSAGE # 1 – ADDITIONAL WATER PRODUCTION

MESSAGE # 2 – WATER CONSERVATION AND EFFICIENCY ARE CRITICAL FOR LONDON, TENNESSEE & TABWAKEA

2. AVAILABILITY – SUPPLY AND DEMAND


Decca Lens
240,000 L
280,000 L
Four Wells Lens
Tabwakea
Tennessee
London
Legend
Boundary of freshwater lens (approximate and variable)
Existing 150mm PVC pipeline (Decca - London via Tabwakea)
Existing 100mm PVC pipeline (Four Wells - Decca)
Proposed 150mm PVC pipeline
Proposed 150mm PVC pipeline
Headtank
Water Use Efficiency – Kiritimati Island


Sustainable Yield
Decca / Four Wells 560 kL/d
Banana 550 kL/d
NZ Airfield 700 kL/d


Decca Lens
240,000 L
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Boundary of freshwater lens (approximate and variable)
Existing 150mm PVC pipeline (Decca - London via Tabwakea)
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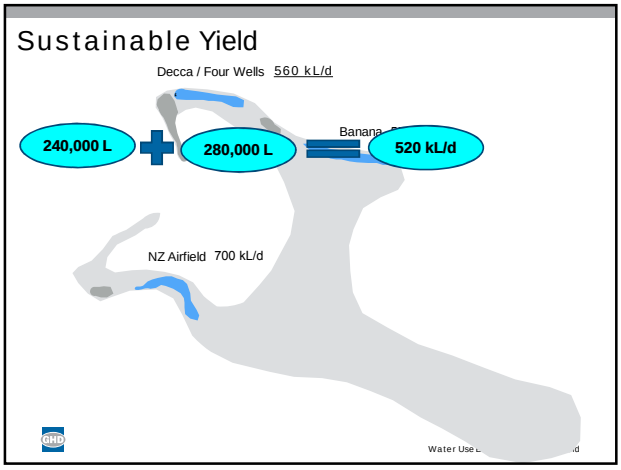
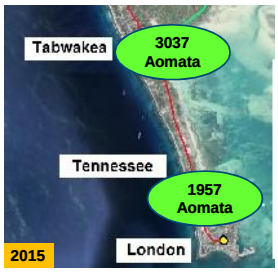
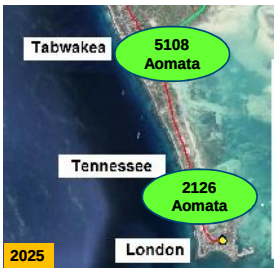

Sustainable Yield
Decca / Four Wells 560 kL/d
240,000 L
280,000 L
520 kL/d
NZ Airfield 700 kL/d

How much do we need?.... **Te bong aio?**



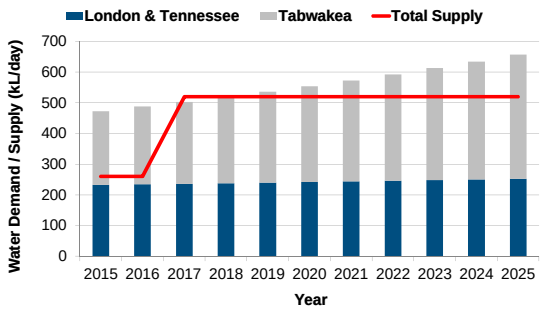
- 60 L/person/day??
- 90 L/person/day??

How much do we need?.... **Ningabong?**



- 60 L/person/day??
- 90 L/person/day??

Population and water demand



MESSAGE # 1 – ADDITIONAL WATER PRODUCTION

MESSAGE # 2 – WATER CONSERVATION AND EFFICIENCY ARE CRITICAL FOR LONDON, TENNESSEE & TABWAKEA

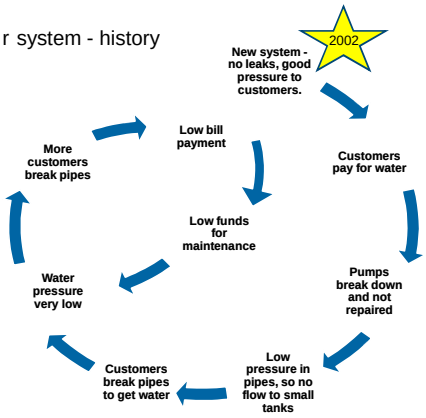
MESSAGE # 3 – SUSTAINABLE WATER MANAGEMENT REQUIRES ALL STAKEHOLDERS TO WORK TOGETHER

3. WATER SYSTEM HISTORY

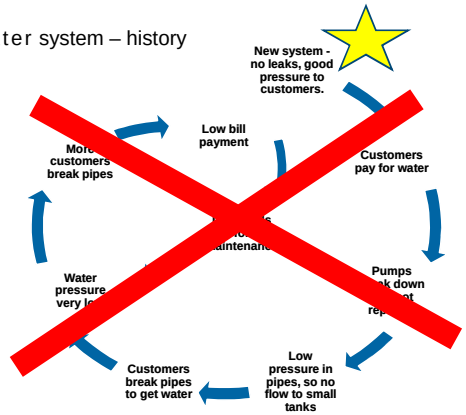
MESSAGE # 1 – ADDITIONAL WATER PRODUCTION
MESSAGE # 2 – WATER CONSERVATION AND EFFICIENCY ARE CRITICAL FOR LONDON, TENNESSEE & TABWAKEA
MESSAGE # 3 – SUSTAINABLE WATER MANAGEMENT REQUIRES ALL STAKEHOLDERS TO WORK TOGETHER

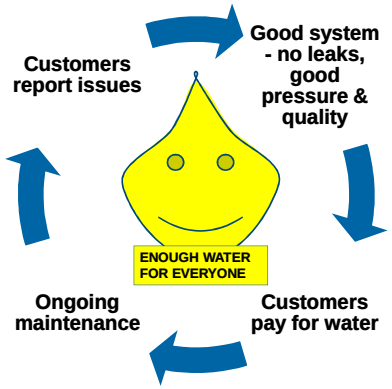
3. WATER SYSTEM HISTORY

Water system - history



Water system – history





Group exercise – (5 minutes)

- Why did the water system fall into disrepair?
- How long did it take?

MESSAGE # 1 – ADDITIONAL WATER PRODUCTION

MESSAGE # 2 – WATER CONSERVATION AND EFFICIENCY ARE CRITICAL FOR LONDON, TENNESSEE & TABWAKEA

MESSAGE # 3 – SUSTAINABLE WATER MANAGEMENT REQUIRES ALL STAKEHOLDERS TO WORK TOGETHER

MESSAGE # 4 – ADDRESS WATER SCARCITY AND MAXIMISE THE BENEFITS FROM OUR WATER

4. WATER "EFFICIENCY"

MESSAGE # 1 – ADDITIONAL WATER PRODUCTION

MESSAGE # 2 – WATER CONSERVATION AND EFFICIENCY ARE CRITICAL

MESSAGE # 3 – SUSTAINABLE WATER MANAGEMENT REQUIRES ALL STAKEHOLDERS TO WORK TOGETHER

MESSAGE # 4 – ADDRESS WATER SCARCITY AND MAXIMISE THE BENEFITS FROM OUR WATER

4. WATER "EFFICIENCY"

The concept of water use efficiency

Technical efficiency
- User efficiency
- Water recycling and alternative sources
- Supply efficiency

Allocative efficiency
- Supply to the highest value and most 'productive' uses

Product choice efficiency
- Reflecting consumer preferences and ability or willingness to pay

The concept of water use efficiency

Technical efficiency
- User efficiency
- Water recycling a lternative so s
- Supply efficiency

Allocative efficiency
- Supply to the highest valu d most 'productive' uses

Product choice efficiency
- Reflecting consumer pref ces and ability or willingness to pay

User efficiency – the customer

COMMUNICATION - BEHAVIOUR CHANGE AND COMMUNITY AWARENESS

FINANCIAL MECHANISMS, TARIFF STRUCTURES TO MANAGE CONSUMPTION

LEADERSHIP FROM LARGE CUSTOMERS ON WATER CONSERVATION … HOTELS

TECHNICAL SUPPORT TO FIX PROBLEMS IN THE HOUSEHOLD

FINES AND PENALTIES FOR TAMPERING WITH THE PIPES – ENFORCEMENT BY THE COUNCIL

MAKE SURE WATER IS AFFORDABLE

ENCOURAGE RAINWATER HARVESTING

USE TE MWANEBA FOR THE TOILET FLUSHING

Supply efficiency – the system operation

Fix leaks – London & Tennesse (the Project), Tabwakea (the WSD)

Strengthen WSD – training, reliable transport, better access to spare parts

Link revenue from water bills to operation & maintenance budget

Monthly inspections by WSD of all house connections

Improve billing system

WSD linked to PUB or a new government utility

Council reps report problems to WSD

Council by-law on water management

Increase pump supply – Decca & Four Wells (the Project)

MAINTENANCE, MAINTENANCE, MAINTENANCE…

Allocative efficiency

Prioritise good water supply to key services – hospital, schools etc.

Good water supply to hotels – support the local economy

Drought planning

Ensure new connections are affordable for the most vulnerable, poorest households

Product choice efficiency

Customers willing to pay for improved water system – including water treatment

Different connection options, different prices – tap outside vs. into the house

Group exercise – ideas on kateimatoan

Group 1 – User efficiency "The Customer"

- Communication - community awareness
- Financial mechanisms, tariff structures to manage consumption
- Leadership from large customers on water conservation … hotels
- Technical support to fix problems in the household
- Encourage rainwater harvesting
- Make sure water is affordable
- Use te mwaneba for the toilet flushing
- Fines and penalties for tampering with the pipes – enforcement by the council

Group 2 – Supply efficiency "The Operators & Managers"

- Fix leaks
- Strengthen WSD – training, reliable transport, better access to spare parts
- Monthly inspections by WSD of all house connections
- Link revenue from water bills to operation & maintenance budget
- WSD linked to PUB or a new government utility
- Improve billing system
- Council by-law on water management
- Council reps report problems to WSD
- Increase pump supply – Decca & Four Wells (the Project)

MESSAGE # 1 – ADDITIONAL WATER PRODUCTION
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MESSAGE #5 – SUSTAINABILITY REQUIRES PLANNING AND COLLABORATION

5. SUSTAINABILITY – DEVELOPING THE PLAN

MESSAGE # 1 – ADDITIONAL WATER PRODUCTION
MESSAGE # 2 – WATER CONSERVATION AND EFFICIENCY ARE CRITICAL FOR LONDON, TENNESSEE & TABWAKEA
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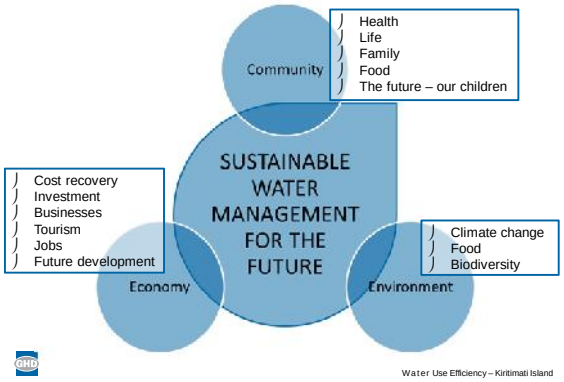
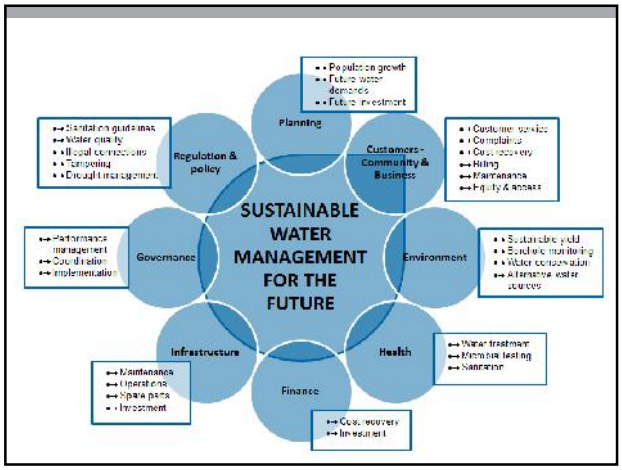
5. SUSTAINABILITY – DEVELOPING THE PLAN

Why do we need sustainable water management?





Babairean kateimatoan nakoraoin butin te ran – te toko??

Water Sustainability Plan – Objectives…???

The current water system is in disrepair, and there is a finite amount of water that can be supplied.

The objectives of the plan:

- To create a more **sustainable management system**, where operation and maintenance can be done and to prevent it going into disrepair again
- To identify how the system can be operated so that the **supply of water is fair** to all customers (i.e. each customer can get their share)
- To encourage **water conservation**

Water Sustainability Plan – Stakeholder Roles

- Who are we?
- What do we do – related to water? And why?
- What can we do or what do we need to make it easier to protect and manage the water system in the future?

The government:

- Technical - Operation and Maintenance
- Institutional, Governance and Policy
- Enforcement
- Communication

The customer:

- Reporting issues - communication
- Looking after the system
- Sharing water so there's enough for everyone

Your ideas

WSD linked to PUB or a new Government Utility

Monthly inspections by WSD at all houses

Te mwaneba ibukin te roki

Council reps report problems to WSD

Link revenue from water bills to operation & maintenance budget

Strengthen WSD – training, reliable transport, better access to spare parts

Fines and penalties for tampering of pipes – enforcement by Council

Rainwater tanks

Financial mechanisms, tariff structures to manage consumption

communication - behaviour change and community awareness

leadership from large customers on water conservation … hotels

fines and penalties for tampering with the pipes – enforcement by the council

make sure water is affordable

technical support to fix problems in the household

Improve billing system

Fix leaks – London & Tennesse (the Project), Tabwakea (the WSD)

Council by-law on water management

Increase pump supply – Decca & Four Wells (the Project)

MAINTENANCE, MAINTENANCE, MAINTENANCE…

Babairean kateimatoan nakoraoin butin te ran *Water Sustainability Plan*

- Integrate with the MOPS
- How can we make use of a plan, each year, each month, each day?

Summary

- MESSAGE # 1 – ADDITIONAL WATER PRODUCTION
- MESSAGE # 2 – WATER CONSERVATION AND EFFICIENCY ARE CRITICAL FOR LONDON, TENNESSEE & TABWAKEA
- MESSAGE # 3 – SUSTAINABLE WATER MANAGEMENT REQUIRES ALL STAKEHOLDERS TO WORK TOGETHER
- MESSAGE # 4 – ADDRESS WATER SCARCITY AND MAXIMISE THE BENEFITS FROM OUR WATER
- MESSAGE #5 – SUSTAINABILITY REQUIRES PLANNING AND COLLABORATION

Kam bati n rabwa ao tekeraoi te mwakuri n te ran!

Appendix I – 2016 Household Survey Questionnaire

HOUSEHOLD SURVEY

INTRODUCTION

Explain purpose of survey, structure of survey, length of time required.
The purpose of the survey is to understand how the water system is currently working, and how it can be improved as part of the Water Project. We would like to ask some questions about how you use water in your house, and also about the household demographics. We would also like to understand how much you are willing to pay for water, looking at how much you would pay for different levels of service. We'd also like to hear from you any ideas about how the water system can be improved.

Explain institutional setting, and any proposed changes that are being considered under the project .
The Water Project is currently proposing to upgrade the water system so that:
1. There is more than double the amount of water being pumped from the Decca and Four-Wells galleries
2. The connections to the houses which have been broken because of the low pressure are fixed in London & Tennessee, and in some parts of Tabwakea

Explain project and history of the water system, poor maintenance and lack of funds for maintenance, so the current project is hoping to improve on this system and to make it more sustainable in the future.

The water system which was built in 2002 is now broken. One of the main problems is that there has not been enough maintenance and so there have been many leaks. Because there are now lots of leaks, the water pressure is very low. This has meant that more people have broken into the pipes to try and get water, and then this has caused even more leaks and even lower pressure.

Right now only some people are paying for water, and most of the customers have large amount owing on their bills. People are not happy to pay for water because the service is bad, and because many of the meters are broken the billing system is no longer functioning properly. Now those houses who have no working meters are charged about $10 per month which is not based on how much water they use.

1.0 INTRODUCTION **TIME STARTED:**

1.01	Do you have a connection to the piped water supply?	
1.02	Do you think you should have to pay for water?	
	If yes - do you have time, and are you happy for me to do a survey that will take about 30 minutes? *If not arrange for a better time or move to next house.*	
	If **no** - please explain why you don't think you should pay for the water. NOTE: *if answer that wont pay if service not good ask if willing to pay if the service was improved.*	

2.0 DEMOGRAPHICS

2.01	Village:	
2.02	House/name: [optional]	
2.03	House type:	Government / Private / Rental
2.04	How long been living in village	
2.05	Number in household:	
2.06	Number of men:	
2.07	Number of women:	
2.08	Number of children, below 18 yrs:	
2.09	Position in household:	Male head of household / Female head of household Other ……
2.10	Age:	

3.0 SOCIO-ECONOMIC DATA

3.01	Number of people with jobs:	
3.02	Education level of respondent	Primary School / JSS / Senior School / Undergraduate / Postgraduate / Technical Trade
3.03	Description of jobs:	Regular / Seasonal Government / Private Other Comments ……
3.04	Approximately fortnightly income **/ monthly** [can be range]:	
3.05	Any other income e.g. from family working overseas, rental etc. and how often?:	
3.06	How much money spend per month [can be range] on :	Water Electricity Rent Other debts Transport Food Other

4.0 EXISTING WATER SUPPLY

PS *Piped supply at household*
PSN *Piped supply at neighbour*
T *Tankered supply*
RWH *Rainwater at house*
RWN *Rainwater at neighbour*
RWC *Rainwater at community building*
WH *Well at house*
WN *Well at neighbour*

4.01	Main source used for drinking
4.02	Alternative source used for drinking if above not available
4.03	Is source at the house or another location? Where?
4.04	If source shared, with how many others?
4.05	Main source used for washing/bathing
4.06	Is source at the house or another location? Where?
4.07	If source shared, with how many others?
4.08	Main source used for toilet
4.09	How much did it cost to install these supplies/connections?
4.10	Are there any problems with the water supply? E.g. water quality, reliability, quantity, leaks, distance from house, waiting time to get water, low water pressure, disconnection, etc.

5.0 IDEAS ABOUT THE WATER SUPPLY SYSTEM

5.01	If you have a problem with the water system in your house what do you do? E.g. fix it yourself, pay someone to fix it, report to WSD, leave it be…	
5.02	Who should be responsible for managing the water supply system?	Government | Council | Private Sector | Public Utility | Community Group | Church | Other…….
5.04	Who should be responsible for maintenance at the house?	

6.0 - A WATER SUPPLY SCENARIOS – WITH EXISTING CONNECTION

6.01	If you had water supply to your house with enough pressure to use the shower, the kitchen and the laundry which was available to turn on any time of day would you be willing to pay for this water?
6.02	Would you be willing to pay: • $10/mth • $20/mth • $30/mth • $50/mth • $100/mth
6.03	If you had this water supplied so it had chlorine treatment, and so there's no need to boil the water would you pay more than the monthly rate quoted above? How much?

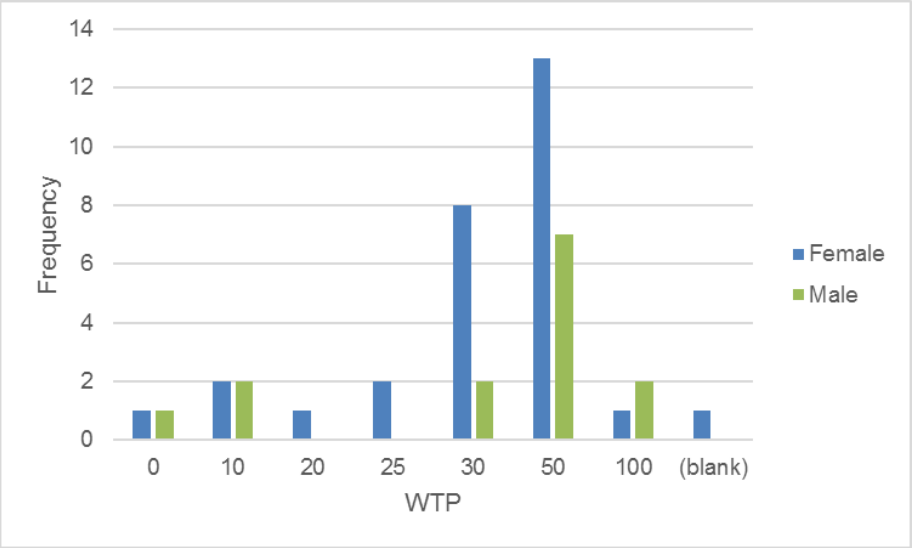
6.0 - B WATER SUPPLY SCENARIOS – WITH NO EXISTING CONNECTION

6.01	If you had water supply to your house with enough pressure to use the shower, the kitchen and the laundry which was available to turn on any time of day would you be willing to pay for this water?
6.02	Would you be willing to pay a one-off fee for this to be connected, of: • $30 • $50 • $100 • $200
6.03	Would you be willing to provide materials, pipes etc. and labour for this connection?
6.04	Do you think this connection fee should be the same for everyone or depend on the location of your house from the main water pipe?
6.05	Would you be willing to pay: • $10/mth • $20/mth • $30/mth • $50/mth • $100/mth
6.06	If you had this water supplied so it had chlorine treatment, and so there's no need to boil the water would you pay more than the monthly rate quoted above? How much?
6.07	If you had water supply to a tap near your house inside the lot, which was available to turn on any time of day, would you be willing to pay for this water?
6.08	Would you be willing to pay: • $10/mth • $20/mth • $30/mth • $50/mth • $100/mth

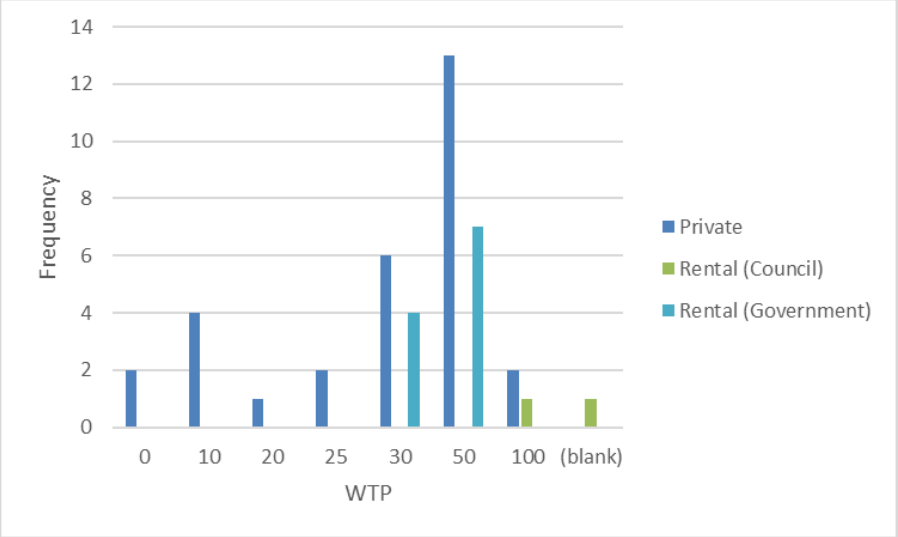
7.0 BILLING SCENARIO

	The current billing process is that people with meters are charged based on the amount of water they use. The charges are at two levels • $1.20/kL or $0.0012/L up to 18 kL/month • $5.0/kL or $0.005/L above 18 kL/month • Tankered water $5.0/kL or $0.005/L	
7.01	If you had water supply to your house which was available to turn on any time of day, would you be willing to pay for this water at: 1. a flat rate per month ? 2. a rate depending on how much water you have used?	
7.02	Do you believe the community should pay for the cost to operate the water supply system?	
7.03	How do you think the payment for water should be collected? A. Pay in advance based on estimate of water usage B. Invoice paid at the LINIX office after water used C. Deducted from the government pay D. Invoice together with power bill	

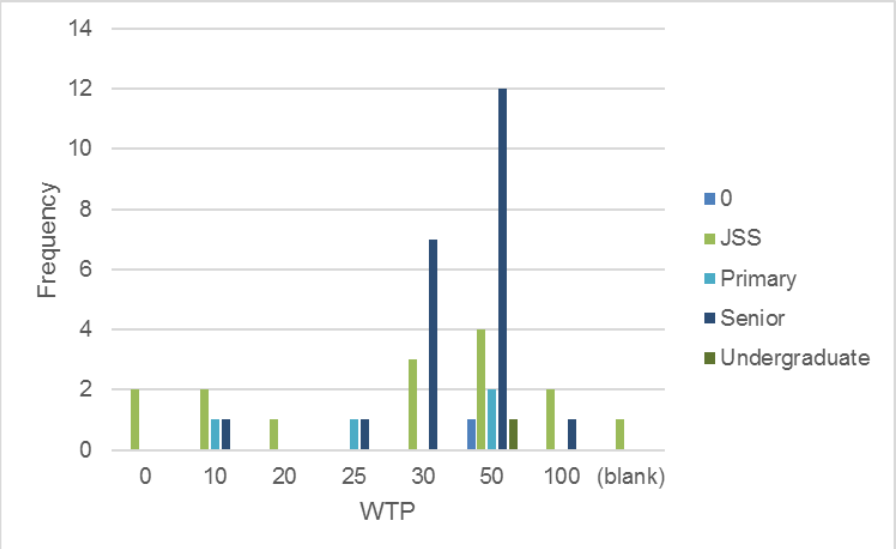
Appendix J – WTP relationship with other factors



Willingness to pay and gender of respondent



Willingness to pay and type of house (private or rental)



Willingness to pay and education level of respondent

GHD

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Melbourne, Victoria 3000
T: (03) 8687 8000 F: (03) 8687 8111 E: melmail@ghd.com.au

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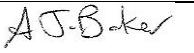
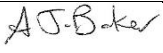
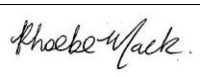
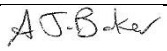
Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	P. Mack	A. J. Baker		A. J. Baker		8/08/16
1	P. Mack	P. Mack (SPC amendments)		A. J. Baker		29/08/17

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