5.9. WATER RESILIENCE STRATEGY - INVESTIGATION INTO SMART WATER METERS

REPORT AUTHOR(S) Peter White, Coordinator Water and Wastewater
GENERAL MANAGER Michael Kriedemann, Acting General Manager Operations

DEPARTMENT Water and Wastewater

RECOMMENDATION

That Council receives and notes the investigation report into the implementation of smart water meters.

EXECUTIVE SUMMARY

The Smart Water Metering Technology Review report documents the benefits of smart metering options for Council's retail meter fleet in order to improve servicing efficiencies for the benefit of all stakeholders. Smart water meters have the potential for efficiency gains in increased accuracy of meter reads, adoption of remote or semi-remote meter read technologies, as well as potential improvement in the measurement of the various components of water losses, are anticipated from the introduction of smart metering systems.

The key objective of this project is the identification of a business case to upgrade Douglas Shire Council water meters in light of their revenue requirements and water resources management in the region.

This report provides Council with a strategic business plan for the future roll-out of smart metering technology.

BACKGROUND

This report outlines the smart metering options for the retail meter fleet in order to derive both servicing efficiencies and customer benefits available through the various technologies. Many of the existing mechanical meter fleets within Douglas Shire Council were found to require replacement to minimise losses and measurement errors. A pre trial pilot program of smart meter technologies is important to Douglas Shire Council to determine what is fit for purpose for their systems, customers and service objectives. Replacing mechanical metering to smart metering has typically potential for efficiency gains in the following areas:

- Increased accuracy of meter reads;
- Elimination of Councils ageing mechanical meter fleet renewal/replacement program;
- Identify and test a sample of our existing water meter fleet and verify at an accredited NMI (national measuring institute) supplier;
- Remote or semi-remote meter read technologies in comparison to existing manual meter reading practices;
- Potential improvement in the measurement and early identification of the various components of water losses, including leakage on the customer property; and
- A provisional assessment of the lifecycle costs of the various technological solutions such that efficiency gains and reductions in the lifecycle costs can benefit all stakeholders.

Analysis of the existing mechanical meter's throughput has determined that the meters with higher than average consumption should be replaced on a more regular basis than Council's current replacement program. As the high usage meters are not being replaced on a more regular basis, the accuracy of readings decrease and Council is not recouping full consumption costs.

In addition there are a number of incorrectly sized meters servicing high volume properties and due to the excessive flows, this accelerates the wear and tear and decreases reading accuracy.

The current annual volume of apparent (e.g. metering) losses is estimated as 295 ML valued at approximately $413,000 per year in lost water sales. This equates to an overall apparent loss for Council meter fleet of 4.73% (based on average daily demand of 17.11 ML/d).

The Shire's current annual meter replacements are approximately 20% of what is required to minimise the apparent losses resulting from measurement error decay of mechanical meters. The estimated costs to undertake annual renewal of mechanical meters to reduce the level of apparent losses to an optimal level is approximately $122,000 and is based on a theoretically determined optimal 11 year replacement period. In addition to this amount, an initial 750 DN20 meters with throughputs that exceed 4,598 kL will require immediate replacement at an estimated cost of $95,000 to be compliant with the Australian in-service requirements.

PROPOSAL

That Council receives and notes the investigation report into the implementation of smart water meters.

FINANCIAL/RESOURCE IMPLICATIONS

The financial analysis comparison suggested the smart metering system to have a positive Net Present Value (NPV) compared to the mechanical meter replacement resulting in negative NPV over a 15 year period. The implication of the current water meter manual reading system and the mechanical meter fleet will require Council to continue to incur ongoing expenditure to comply with meter in-service testing and replacements plus the ongoing expenditure to source external resources to do the manual water meter readings.

The lifecycle assessment required for a commercial assessment is based on a sophisticated capital budgeting technique and net present value (NPV) determination over their full design life. The smart water metering system recommended requires an estimated capital investment of $2.574 million for replacement of the whole fleet within the first two years of the 15 year investment period (the two-year change-out period could be adjusted to suit Council requirements). Summary of the NPV analysis results are as follows:

- The smart metering system proposed is estimated to have a payback period of approximately 9 years (e.g. positive NPV) and positive operating profit (e.g. EBIT) in year 3. Taking into account the time value of money these positive results are achieved within the 15-year investment (analysis) period benchmark. These results depict both positive and negative changes in revenue due to introduction of new smart meters and exclude the current revenue stream from the existing mechanical meter fleet.

Financing a pre trial pilot program will give the Council an opportunity to familiarise itself with the application of the technology for the future rollout of the whole meter fleet.

Prior to the full rollout of smart meters a pilot project is proposed in Sheppard Valley, Mossman. The pilot will consist of installing 72 smart meters together with a fixed radio network and drive-by remote read system at an estimated cost of $85,000. This pilot will afford an opportunity for Council to identify the requirements for integration of meter read data that is captured remotely with the Council's billing system. Council will also have an opportunity to familiarise itself with the application of the technology for the future roll-out of the whole meter fleet.

The estimated benefits from installation of the smart meters are derived from their ability to measure very low flows and a larger range of demands over their full design lives. The estimated benefits of these smart meters include a reduction in apparent losses of 212 ML per year valued at approximately $297,000 when compared to that of the existing mechanical meter fleet.

Another estimated benefit of introducing the newer smart metering technology is in substantially reducing the costs of meter reads from the current $2.25 per manual meter read down to $0.45 per read for a drive-by remote read system (e.g. 80% saving). This system has the potential to reduce these costs further with the introduction of remote reads via a fixed radio network.

RISK MANAGEMENT IMPLICATIONS

Council, as a registered water service provider, has a statutory obligation to ensure it is able to provide water services to customers. Council is required to provide meter readings that are accurate and in accordance with Australian Standards. The smart meters will enable Council to comply with these requirements.

SUSTAINABILITY IMPLICATIONS

Economic: It is essential to adequately maintain water and wastewater infrastructure in order to provide satisfactory services in support of economic development in the Shire.

Environmental: Nil.

Social: The smart meters will assist in the early detection of household leaks which should assist the property owner to rectify the leaks quickly and mitigate the potential risk of receiving large excess water consumption bills.

CORPORATE/OPERATIONAL PLAN, POLICY REFERENCE

This report has been prepared in accordance with the following:

Corporate Plan 2014-2019 Initiatives:

Theme 1 - Celebrating Our Communities
1.2.4 - Network, advocate and partner with stakeholders to achieve positive outcomes.

Theme 3 - Improve Environmental Performance
3.2.1 - Identify and invest in energy reduction initiatives in Council-owned facilities and in the delivery of services.

Theme 5 – Governance

5.2.1 - Provide Councillors and community with accurate, unbiased and factual reporting to enable accountable and transparent decision-making.

Operational Plan 2015-2016 Actions:

3.2.5 Investigate the implementation of smart water meters

COUNCIL'S ROLE

Council can play a number of different roles in certain circumstances and it is important to be clear about which role is appropriate for a specific purpose or circumstance. The implementation of actions will be a collective effort and Council's involvement will vary from information only through to full responsibility for delivery.

The following areas outline where Council has a clear responsibility to act:

Asset-Owner	Meeting the responsibilities associated with owning or being the custodian of assets such as infrastructure.
Regulator	Meeting the responsibilities associated with regulating activities through legislation or local law.

CONSULTATION

Internal:	Consultation has been undertaken with water reticulation, water quality, Information Technology and Finance (rates collection).
External:	The review was completed by external engineering consultants who have completed a market analysis and liaised with various providers to arrive at a recommendation.

COMMUNITY ENGAGEMENT

Nil

ATTACHMENTS

1. Smart Water Metering Final Report June 2018 **[5.9.1]**

Douglas Shire Council

Smart Water Metering Technology Review

Final Report

June 2018

Executive Summary

Objectives

Douglas Shire Council (DSC) is investigating the benefits of smart metering options for its retail meter fleet in order to improve servicing efficiencies for the benefit of all stakeholders. Potential for efficiency gains in the reduction in metering (apparent) losses, adoption of remote or semi-remote meter read technologies, as well as potential improvement in the measurement of the various components of water losses, are anticipated from the introduction of smart metering systems. The key objective of this project is the identification of a business case to upgrade the Shire's water meters in light of their revenue requirements and water resources management in the region.

Existing Mechanical Meter Fleet

Analysis of the existing mechanical meter's throughput (e.g. totalised volume passing) indicates that the 3,384 DN20 meter cohort have an average throughput volume of 3,220 kL. This is relatively high when compared to the trigger for in-service requirements stipulated by the Australian Standards AS 3565.4 of a 1,920 kL throughput. The existing DN20 meter cohort has, on average, exceeded its volumetric throughput 'life'. According to these current estimates, approximately 750 meters will require immediate replacing if the DN20 cohort type are to be retained as mechanical meters. Indicative results are that the existing DN20 to DN40, plus the DN 100 mechanical meters, are 'on average' undersized and subject to excessive flows accelerating their wear and tear (e.g. increased degradation in accuracies).

The current annual volume of apparent (e.g. due to meter under-registration) losses is estimated as 295 ML valued at approximately $0.413 million per year in lost water sales. This equates to an overall apparent loss for DSC's meter fleet of 4.73% (based on average daily demand of 17.11 ML/d). The Shire's current annual meter replacements are approximately 20% of what is required to minimise the apparent losses resulting from measurement error decay of mechanical meters. The estimated costs to undertake annual renewal of mechanical meters to reduce the level of apparent losses to an optimal level is approximately $122k and is based on a theoretically determined optimal 11 year replacement period. In addition to this amount, an initial 750 DN20 meters with throughputs that exceed 4,598 kL will require immediate replacement at an estimated cost of $95k to be compliant with the Australian in-service requirements.

Assessment and Benefits of Smart Metering System

Various criteria have been identified as relevant to the assessment of the key components of smart water metering technologies in terms of their impact on service efficiencies, compliance and customers. The key categories identified for assessment included the following:

- **Metrology and measurement**: The specific criteria within this category include those related to metrological regulations, pattern approvals and specifications required to continuously and accurately monitor a wide range of customer water usages.
- **Operation, environment and materials**: This category relates to selected parts of the data pathway/chain which are potentially susceptible to the introduction of data anomalies and failures. Includes the potential susceptibility of the meter technology to damage and/or under-performance through normal operating and extreme environmental conditions.
- **Data conversion, logging & radio communications**: Ability of the system to accurately, efficiently, effectively and securely record, cipher, transmit and receive data. Aspects related to obtaining the assurance necessary for investing in battery powered technologies is also provided.

Six smart water metering technologies have been assessed in terms of their potential technical and commercial performance risks, i.e. in terms of the degree to which they achieve the pre-specified criteria required to improve efficiencies and compliance. The risk assessment relates to the whole metering system. This technology benchmarking is a prerequisite for commercial benchmarking as it identifies the smart metering technology that should be included in further financial analysis because of its lowest risk. The 6 technologies considered were:

i. Elster V100 & Coronis Waveflow.

ii. Elster V200 & Taggle System.

iii. Itron TD8 & EverBlu Cyble.

iv. Enware (Diehl) Hydrus Model171 & Taggle.

v. Kamstrup FlowIQ 2102 & READy.

vi. Sensus (Xylem) iPerl & Sensus RF

The technology identified as having the lowest technical and commercial risk was the Sensus iPerl RF remnant magnetic solid state electronic meter.

The estimate benefits from installation of the Sensus iPerl RF (DN 20 to DN 40) and Sensus MeiStream Plus RF (DN 50 to DN150) are derived from their ability to measure very low flows and a larger range of demands over their full design lives. This is because their respective R-ratios (e.g. turn-down ratios) of 1:800 and 1:500, currently exceed that of any other types of meter available and are as certified by the NMI. The estimated benefits of these smart meters include a reduction in apparent losses of 212 ML per year valued at approximately $297 k/yr when compared to that of the existing mechanical meter fleet.

Another estimated benefit of introducing the newer Sensus RF smart metering technology is in substantially reducing the costs of meter reads from the current $2.25 per manual meter read down to $0.45 per read for a drive-by remote read system (e.g. 80% saving). This system has the potential to reduce these costs further with the introduction of remote reads via a fixed radio network.

Business Case Lifecycle Assessment

The lifecycle assessment required for a commercial assessment is based on a sophisticated capital budgeting technique and net present value (NPV) determination over their full design life. The smart water metering system recommended requires an estimated capital investment of $2.238 million for replacement of the whole fleet within the first two years of the 15 year investment period (the two-year change-out period could be adjusted to suit DSC requirements). Summary of the NPV analysis results are as follows:

- The smart metering system proposed is estimated to have a payback period of approximately 15 years (e.g. positive NPV) and positive operating profit (e.g. EBIT) in year 3. Taking into account the time value of money these positive results are achieved within the 15-year investment (analysis) period benchmark. These results depict both positive and negative changes in revenue due to introduction of new smart meters and exclude the current revenue stream from the existing mechanical meter fleet.
- The continued operation of the existing fleet of mechanical meters, with or without a mechanical meter replacement program, results in a negative NPV and operating profit over the 15 year investment (analysis) period. Existing constant rate of revenue generated from existing mechanical meters is therefore also excluded from the analysis for comparative purposes.

Proposed Pilot Project

Prior to the full rollout of smart meters a pilot project is proposed in yet to be defined areas. The pilot will consist of installing 800 DN20 smart meters, 6 district meters, installation of a fixed radio network and drive-by remote read system, testing of 350 existing meters at a NATA approved facility and consulting engineering support at an estimated cost of $499k. This pilot will afford an opportunity for DSC to identify the requirements for integration of meter read data that is captured remotely with the Council’s billing system. DSC will also have an opportunity to familiarise itself with the application of the technology for the future roll-out of the whole meter fleet. This is especially relevant as the Shire’s existing financial system is to be changed. A sample of 350 (No.) old DN20 mechanical meters removed for installation of the new smart meters, be tested in a NATA accredited flow laboratory at an estimated cost of $70,000 (excluding GST).

Recommendation

That the Shire implements a pilot project, commences with a procurement process and adopts the smart metering system identified that will provide the greatest benefits and least risks.

Table of contents

Table index

Figure index

Appendices

1. Introduction

1.1 Background

Douglas Shire Council (DSC) is investigating smart metering options for the retail meter fleet in order to derive both servicing efficiencies and customer benefits available through the various technologies. Various Councils and public water utilities around Australia are currently progressing either trials or full roll-outs of smart meter technologies, however it is important the Councils determine what is fit-for-purpose for their systems, customers and service objectives. There is typically potential for efficiency gains in the following areas:

- Reduction in metering (apparent) losses through a critical examination of metrological aspects associated with the various metering technologies, essentially looking for sustained meter accuracy and performance across a wide range of flow rates (Q_1 – Q_4).
- Remote or semi-remote meter read technologies in comparison to existing manual meter reading practices, as well as potential improvement in the measurement and early identification of the various components of water losses, including leakage on the customer property.
- A provisional assessment of the lifecycle costs of the various technological solutions such that efficiency gains and reductions in the lifecycle costs can benefit all stakeholders.

GHD understands that the current per capita water consumption is extremely high at between 1,300 to 1,500 litres per person per day. Residential consumption is estimated at over 600 litres per person per day with over 800 litres attributed to the non-residential sector. The non-residential sector is largely influenced by the high number of tourists with an estimated tourist population of up to 8,000 people on any one night or an estimated one million visitors per year.

The DSC's water meter size distribution is illustrated in Figure 1 of which, the DN20 are the largest proportion of meters (94% of the estimated 4,100 meters).

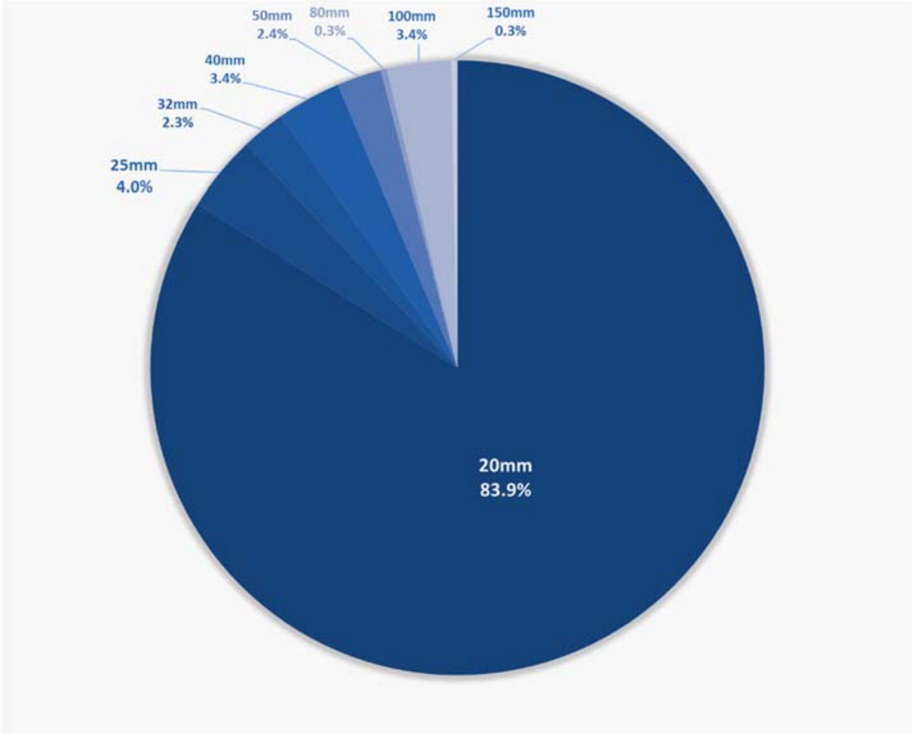

Figure 1 Douglas Shire Council Meter Size Distribution

1.2 Overview and Scope

The aim of this study is to identifyu the most cost effective technology for the implementation of a remotely read smart metering system as well as to provide an overview of the data integration, technical, commercial and implementation timeframe aspects for a smart metering program in the DSC. GHD has relied significantly on its industry knowledge of the technologies, as well as the purpose, objectives and description provided by DSC of the current systems and operations. The purpose of this investigation is to provide DSC with a basis for progressing through to a smart meter trial through the shortlisted technologies, scope of deployment (locality of sites, extent of the cohort) and estimated costs and timeframes.

The investigation will comprise the following tasks:

Task 1 – Technical benchmarking of smart metering technologies

Task 1 addresses the review of the technology available, providing a view of technical approaches to deliver smart water metering. Smart metering systems can include a new meter, a data logger / radio transceiver, gateways, data management systems and all associated firmware and processing software. It is important that any organisation contemplating a move to a smart metering system carefully considers all these elements and what they mean for improving the effectiveness and efficiency of the council. Assessment of the smart water meters with regard to their degree of compliance with metrological regulations (e.g. AS 3565), pattern approvals (e.g. NMI R49), hydraulic performance specifications, environmental robustness, material characteristics and data logging capabilities.

A comparison of the key attributes of a sample of generic traditional and new smart metering communication technologies includes a brief assessment of the effectiveness and dependability of the available solutions against each other and conventional solutions.

Identification of the potential technical and commercial risks associated with these smart metering and communication technologies to various internal and external stakeholders.

Task 2 – Development of possible system scenarios that meet DSC objectives

Guided by DSC's objectives and the technical benchmarking in Task 1, the intention is to develop a preferred scenario using the suitable technology for assessment in Task 3.

Task 3 – Commercial benchmarking of smart metering technologies

Undertake a high-level lifecycle analysis for each system scenario, which will assume a roll-out timeframe and unit benefits typical in similar deployments around Australia. Potential improvements in billed consumptions, water efficiencies, meter reading productivity, potential reduction in the replacement of in-service meters as well as accuracy and timeliness of data will be considered. Billing data for at least 12 months will be used to establish the quantum of billed volume across the DSC.

Lifecycle analysis will be undertaken for the status quo[i] scenario and the selected[ii] smart metering technology scenarios for a 15 year investment period.

Task 4 – Interfacing with Shire's existing communication, billing and associated IT systems

Brief views will be provided of the need, ability and high-level requirements for the preferred solutions to interface with DSC's existing communication, billing and other IT systems. Provisional outcomes of this task are also required in order to establish the technical and cost implications of integrating the new systems. This is reliant upon DSC's supporting information in respect of the existing systems and the meter reading and data processing operation.

Throughout, indicative costs will be provided for the establishment of proposed or alternative technologies.

Task 5 – Development of Framework for a Pilot Project

The provisional identification of the criteria for a pilot project will be developed, in line with the technologies selected for trial, together with the associated current and future data requirements to correctly evaluate the results of the pilot.

Task 6 – Reporting

Preparation of a draft report and undertake a presentation of the project outline and key findings to key internal stakeholders.

NOTES

i. The status quo scenario is defined as the Council's existing mechanical meter replacement program and associated costs of a manual meter read system.

ii. Pragmatic smart metering technology is to be based on GHD's experience of a technology that will most likely result in a successful smart metering solution for DSC.

1.3 Corporate Intent

At the project commencement meeting of 14 February 2018, DSC representatives indicated that the key objective of this project was the identification of a business case to upgrade the Shire's water meters in light of their revenue requirements and stressed water resources of the region. The current low water charges and cost recovery are at odds with the requirements to conserve water resources. The current system of manually read mechanical meters is costly and introduces inaccuracies. A new paradigm in water metering is required and DSC requirements includes the following outcomes:

- A concise executive summary (e.g. 2 pages) of which smart meter(s) to select for future fleet.
- Details of the benefits of the selected smart water meters.
- Cognisance of the existing financial system which, is to be changed.
- Consideration of the range of different users.
- Consideration for the big water users.
- Capital cost of the proposed smart meter roll-out together with an associated programme for next 5 to 10 years.

It was further noted that the existing mechanical meter fleet consists predominantly of Elster meters and previous trails with Itron hybrid mechanical-electronic meters were not successful. DSC have a small operations crew and ad hoc meter reads are labour intensive. DSC do not have a rebate policy for rebates for leakage within properties.

1.4 Qualifications

This report has been prepared by GHD for DSC and may only be used and relied on by DSC for the purpose agreed between GHD and DSC as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than DSC arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described below. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by DSC, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

Cost estimates for current technologies are based upon information provided by DSC and costs for other technologies are based on current rates and do not allow for inflation or price changes (such as those resulting from currency exchange rate variations etc.). Actual prices, costs and other variables may be different to those used to prepare the cost estimates and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the works can or will be undertaken at a cost which is the same or less than the cost estimates.

As risk is proportional to the dependency that a utility/council has on sophisticated metering systems, the complexities of these systems hide dependencies and hence, also mask the risks. Although GHD's risk assessment facilitates prioritisation of the risks and provide an indication what key aspects should be focussed upon, the limitations of investigation(s) could restrict the extent to which risks are uncovered and, hence clearly identified in advance.

Assumptions:

- The information supplied by the meter suppliers/manufacturers is correct and accurate.
- Where a reputable independent source has contradicted the manufacturer's claims, the independent source's findings are assumed correct.
- The status or level of development of the technology considered is as at the date of this report.
- Where a combination of different technologies and systems are required to present a comprehensive solution for a particular metering option, it is assumed that the combination of these various components will function correctly (other than where particular anomalies have been readily identified).
- An assumed level of meter non-registration and under-registration due to a lack of regulatory in-service tests.
- The information supplied by DSC and other sources is correct and accurate.
- Assessment of possible other metering technologies in future will be based on the current data, similar conditions and the same assumptions used in this report.
- The intent is to provide an objective and impartial assessment of information by applying this assessment approach such that that there is a fair and equitable outcome for DSC's customers and stakeholders.
- Although there is a possibility that the Shire derives income from the scrap value for existing mechanical meters and would improve the final benefit cost results, these benefits are considered minor and have been excluded from further analysis as it will not have a significant influence on the preferred customer group to focus upon.
- The implications of tax are excluded from commercial modelling.
- The assumption that pipework, valves and fittings for the existing meter connections can generally be reused without modification for the installation of the new smart water meters.
- Estimates exclude any ongoing annual license and software support costs.

1.5 This Report

This investigation has been undertaken in various stages and this report details the following:

- Task 1 – Technical benchmarking of smart metering technologies.
- Task 2 - Commercial benchmarking of smart metering technologies (all scenarios).
- Task 3 – Interfacing with Shire's existing systems.
- Task 4 – Reporting.

This draft report covers all these tasks.

2. Methodology for Assessment of Smart Water Metering Systems

2.1 General Framework

The general framework adopted that facilitated the identification and objective assessment of smart water metering technologies are those associated with the lifecycle of the assets and with data errors. The assessment of various metering technologies are undertaken in terms of a quality assurance approach as well as potential errors that could be introduced during the acquisition and transmission of data.

This generic framework is flexible enough to be used to assess differing metering technologies and in different environments.

2.1.1 Metrological Assurance Framework (MAF)

A Metrological Assurance Framework (MAF) is an objective quality assurance approach that covers a comprehensive assessment of the specification, procurement, selection, installation, maintenance, auditing and reporting of water meters and their associated data (Johnson, 2013). The MAF provides a standardised approach for the managing of metering assets from inception to disposal under a risk assessment framework.

Implementation of a MAF that considers the full lifecycle of a meter provides confidence that the meters operate within their error and reliability limits stipulated by applicable metrological legislation and regulations. A quality assurance approach is necessary for each process within the meter’s lifecycle if this confidence is to be maintained throughout the meter’s design life. The MAF therefore influences every aspect of a meter’s lifecycle as the cause and effect of any anomalies in one part of the lifecycle will have an adverse influence on the meter in subsequent stages of its lifecycle. This targeted metrological based assessment framework is therefore a differentiator from other non-metering multi-criteria and risk assessments.

2.1.2 Data Pathway

Errors are introduced through the various stages of the data pathway (e.g. chain) from its capture, transmission, conversion, manipulation and reporting as illustrated in Figure 2.

Identification of error sources and their influence on the uncertainty of the data used for billing, management and planning purposes is required. A common source of data anomalies are at interfaces between different systems, technologies and processes. A detailed guide to minimising the errors introduced data at various stages of the data pathway is described by Johnson (2009).

There is a symbiotic type relationship between the life cycle of a metering asset and that of its associated data pathway. Hence the accuracy of the data is influenced by the condition of the meter and its associated metering systems throughout its life.

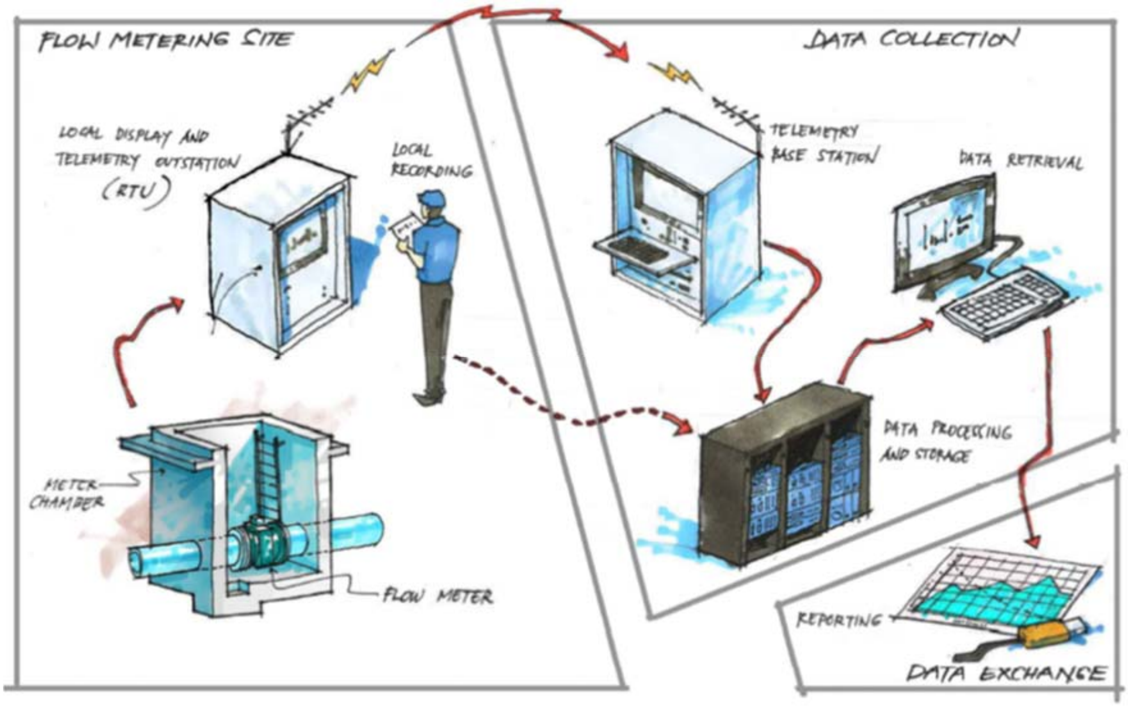

Figure 2 Data Pathway/Chain

2.1.3 Technology and Improved Efficiencies

An overall driver for investigating smart metering technologies is to understand opportunities for efficiency gains in service delivery as well as compliance, and in turn, customer benefits. By implication, this will also require assessing how the metering assets and their data can be managed in an integrated way that improves the accuracy of billed volumes and reduces operating costs to benefit all stakeholders. The success of the particular advanced metering technology in meeting the project's objective is related to the degree with which errors can be minimised at the monitoring source, at interfaces within the various stages of the asset's lifecycle and data cycle as well as at the interfaces between the asset's lifecycle, the data cycle and the stakeholder.

2.2 Metrological Regulations and Guidelines

2.2.1 Legal and Regulatory Framework

The Australian legal and regulatory framework is key consideration in assessing various water metering technologies, from a perspective of the selection of a metering technology through to its control and accuracy performance compliance while in-service.

Australian Metrological Requirements

Meters that are 'used for trade' (e.g. custody transfer) are required to comply with the provisions and requirements of the *National Measurement Act (1960)*, as administered by the *National Measurement Institute specifications (NMI-R 49, 2009)*, in conjunction with *Australian Standards AS3565*. Exemptions for certain classes of meters from pattern approval requirements are allowed for in accordance with the *National Trade Measurement Regulations 2009*.

Guidelines and Codes

Guidelines and Codes facilitate consistent approaches for the applicable environment in which they are developed for however, while they are useful their adoption is voluntary. Water

Services Association of Australia (WSAA) Codes of Practice are examples of these non-mandatory guidelines.

2.2.2 Pattern Approval Requirements

The implementation of Australian metrological requirements with respect to meter capacity is guided by the following criteria, where Q_3 is the Permanent Flow Rate that is the highest flow rate within the rated operating conditions at which the meter is to operate within the maximum permissible error

- All cold water meters installed on or after 1 July 2004 with $Q_3 \leq 4$ kL/h shall be pattern approved and verified.
- All cold water meters installed on or after 1 July 2014 with $Q_3 \leq 16$ kL/h shall be pattern approved and verified.
- All cold water meters with a Q_3 greater than 4 kL/h, but equal to or less than 16 kL/h (i.e. 4 kL < $Q_3 \leq 16$ kL), and installed before 1 July 2014 will remain exempt.
- All cold water meters installed before 1 July 2004 will remain exempt.
- All new cold water meters with a Q_3 > 16 kL/h will remain exempt from pattern approved and verification in terms of Australian metrological requirements. To minimise DSC's risks a requirement for these larger meters it is recommended that these larger meters be OIML R49 pattern approved in terms of one or more the following organisations:
  - European Measuring Instruments Directive (MID).
  - National Measurement Office, UK

The practicality of focussing on the European OIML R49 and not on the Australian NMI R49 for the larger meters, is that currently that these meters generally do not have Australian Pattern Approvals because it is not a requirement stipulated by the local metrological regulations.

Different meter data collection, conversion, transmittal and storage systems introduce errors of differing magnitudes. The extent of these errors is dependent upon the type of systems that could distort original measurements to such an extent that they exceed the regulatory set limits. Hence it is important to note that generally pattern approval relates to the measuring device itself and not necessarily the associated data conversion and transmission systems with their respective data transfer interfaces.

Australian pattern approval requirements for meters with $Q_3 \leq$ 16kL/h means that different makes and types of meters could have the same diameter (DN) but due to improved performance of some types of meters it would exclude them from requiring local pattern approval. The older mechanical meters smaller or equal to DN 40 would generally fall within this category and require pattern approval and hence also be applicable to any regulatory in-service requirements. Approximately 93.6% of DSC's meter fleet are DN 40 or smaller which represents approximately 3,868 meters.

2.2.3 In-service Compliance

Australian Standard AS3565.4 implemented in 2007 requires that meters installed prior to 2007 require testing within 5 years of the Standard's implementation to ensure ongoing compliance. Meters installed after 2007 are required to undergo compliance testing within a period of at least 1 and up to 3 years of being placed into service.

2.2.4 Limitations in Current Regulations

Identification of potential anomalies and limitations in the current regulatory framework provide an important direction for the development of any meter replacement strategy and program. These limitations include the following:

a. In-service compliance requirement for the 'Four-Flow' testing method specified in AS 3565.4 is less accurate in estimating the weighted relative error than the WSA 11 (2012) 'Six-Flow' testing method for DN 20 meters that gives a more accurate estimate of weighted relative error.

b. AS 3565.4 and WSA 11 require data logging end-use surveys to establish the water demand (usage) patterns for the larger meters in order to correctly determine the weighted relative error.

c. AS 3565.4 procedures for grouping of meters for sampling (Clause 8.3) have potential onerous data requirements for typical information systems such billing systems and the sampling requirements (Clause 8.4) can incur high testing costs.

d. The methodologies adopted to estimate the error degradation/decay relationship of the sample of meters removed and tested in accordance with AS 3665.4 as well as establishing its statistical significance are not detailed in the Standards.

e. AS3565.4 was developed based on data derived from using and testing mechanical meters over many years. Time periods, test flowrates, weightings and decision rules are intended to apply to mechanical meters based on reasonably well known and predictable failure modes and performance deterioration. As such, these aspects of the standard may not be appropriate for statistically monitoring the performance of a population of non-mechanical meters. (Alex Winchester,2015).

f. Metrological compliance and certification of the measuring device itself does not necessarily imply that the data conversion and transfer system will achieve the specified level of accuracy.

g. Pattern approval is an essential requirement, however in itself this certification does not necessarily account for, nor convey all the benefits and limitations of a particular meter or its related systems.

In spite of these limitation, it should be noted that Section 109 of the Constitution, the States and Territories cannot pass laws that are inconsistent with Commonwealth law such as the *National Measurement Act (1960)*. As such, it is improbable that states could pass laws exempting themselves from the requirements to used pattern approval and verified meters (where not subject to exemption under the Act). (Alex Winchester, 2015).

3. Criteria and their Rationale

3.1 Compendium of Smart Metering Assessment Criteria

Criteria were selected to facilitate assessing various smart metering technologies as to their propensity to or not to achieve efficiency gains in service delivery and other customer benefits. However, there are some criteria that could be argued as 'non-negotiable' if assurance is required that good quality data is derived from the metering system for whatever purpose. The reliability and quality of this data is of paramount importance if confidence is to be obtained from and maintained by the stakeholders, whether the data is used to convey pricing or non-pricing signals.

Evaluating metering technologies in terms of a MAF and its related data pathway provides the necessary lens to examine the various technologies and systems. Metrological requirements for and interfaces between the various systems provide a useful guide for the identification of these criteria. The various criteria have been identified for their relevance in assessing key components of smart water metering technologies such that the degree with which these components impact efficiencies as well as compliance, and in turn, customers, as described in Table 1.

The following key categories are used in the assessment process, are summarised in Table 1 and described further the subsequent text:

- **Metrology and measurement**: The specific criteria within this category include those related to metrological regulations, pattern approvals and specifications required continuously and accurately monitor a wide range of customer water usages.
- **Operation, environment and materials**: This category relates to selected parts of the data pathway/chain which are potentially susceptible to introduction of data anomalies and failures. Includes the potential susceptibility of the meter technology to damage and/or under-performance through normal operating and extreme environmental conditions.
- **Data conversion, logging & radio communications:** Ability of the system to accurately, efficiently, effectively and securely record, cipher, transmit and receive data. Aspects related to obtaining the assurance necessary for investing in battery powered technologies is also provided.

These categories also provide the necessary information for the subsequent development of comprehensive specifications and expanded assessment criteria to be an integral part of a future procurement process.

This investigation places emphasis on using these criteria to establish the overall risk assessment for each technology in terms of their likelihood and consequences of achieving efficiency gains in service delivery and improve levels of compliance. The output that is provided in Chapter 5 is a general risk assessment continuum relating to the whole metering system and not just the meter itself. It must be noted that the level of this investigation dictates that a pragmatic risk assessment approach is adopted that excludes a more detailed and complicated weighting/rating of individual items.

Table 1 Criteria and Impacts for Comparison of Smart Water Metering

Key Criteria	Sub-criteria	Decision	Efficiency Impacts/Reference	Compliance/Customer Impacts/Reference
Metrology and Measurement	Pattern Approval	$Q_3 \leq 16$ kL/h (Y/N)	Assurance of 'at least' or minimum accuracy performance in accordance with AS 3565	Design and associated performance of meter complies with the mandatory Australian requirements of NMI R-49.
	Specification	$Q_3 > 16$ kL/h (Y/N)	Lack of assurance that minimum accuracy performance will be achieved unless R-49 requirements are specified as part of the procurement process.	Design and associated performance complies with the non-mandatory Australian requirements of OIML R-49.
	Standards	R Ratio and Q_{Start} values	The degree with which the meter can accurately measure both low and high flows in minimising apparent losses (e.g. non-registration).	Assurance that quoted R-Ratio is achievable & sustainable can only be done through R-49 compliance &in-service testing.
Operation, Environment and Materials	Error decay	Susceptible to mechanical wear & tear (Y/N)	Accuracy degradation rate facilitates determination of meter under- or over-registration	AS 3565.4 and WSA 11
	Electronic 'add-on' emitter or meter sampling frequency	>3 scans/sec @ max. specified battery life	The greater the frequency of the measurement of flow rates to establish the volumetric amount the less variability in the results and the greater the accuracy.	The degree with which apparent losses (non-and under-registration) will be minimised in solid state electronic meters.
	Electronic bias error	In-built self-checking capability for solid state or error correction of 'add-on electronics	Susceptibility of electric meters to sudden ad hoc changes in the meter accuracy	Customer fairness and equity in the design of their water tariffs/charges through improvements in efficiencies.
	Susceptible to external influences	Environmental class	The ability of the meter to withstand the extremes of the weather without failing.	NMI R49-2 Outdoor environment class.
		ECM	The resistance of the electronics to interference from radiated electromagnetic fields generated by other devices.	NMI R49-2 electromagnetic environment class (IEC 61000-4).
		IP rating	Equipment enclosures protection level against ingress of dust and immersion in water.	IEC 60529.
		Ultraviolet light	Longevity of materials	AS3565.1 Appendix C.
		Vibration & Shock	Degradation in performance/accuracy	IEC 60068-2-64.

Data Conversion, Logging & Radio Communications	Conversion method	Data errors	e.g. Mechanical totaliser value not corresponding to the electronic value received.	Missed or loss data could prejudice the customer while reliability of data enhances confidence of stakeholders.
	Data storage	1 hour logging of 12 values (alarms and flows) at least 60 days data storage or equivalent (as an example)	Electronic data logger as integral part of the meter with sufficient storage prevents loss of data	Missed or loss data could prejudice the customer while reliability of data enhances confidence of stakeholders.
		Non-volatile memory back-up	Safety of data	Missed or loss data could prejudice the customer while reliability of data enhances confidence of stakeholders.
	Data security encryption at meter (source)	≥ AES128 encryption	Susceptibility and disruption of system from computer hacking	Privacy & confidentiality of data through application of the Advanced Encryption Standard (AES).
	Integration of communications module	Does it have an 'add-on' communication modules or is it fully integrated and sealed meter?	Potential for introduction of data transfer errors or weakness in its physical integrity at interfaces.	Compromise of metrological (Pattern Approval) certification
	Power source	Battery life ≥ 15 years	Related to meter's sampling (scanning) rate, radio transmission power, frequency of transmissions and extent of communication overhearing.	Missed or loss data could prejudice the customer while reliability of data enhances confidence of stakeholders. Procurement contracts with warranties/guarantees of achieving specified battery life and financial penalties for manufactures not achieving these design lives provide the necessary assurance for stakeholders/owners.
	Frequency	Licenced	Cost implications	Specific frequency allocation/approved by ACMA.
		Unlicensed	Free	Potential congested & noisier (e.g. interference and reliability issues).
		Spectrum	Higher frequency has greater range however, lower frequency with smaller data transmission packages are efficient at lower power	Clear specification of data requirements
	Power	Signal	High power achieves greater signal penetration & lower power, less penetration (of obstacles)	AS/NZS 4268.
		Coverage	High power - greater coverage (e.g. more meters)	AS/NZS 4268 limits power to ≤ 1W (e.g. 915 to 928 MHz).
	Data package sizes (w.r.t. principle transmission method)	Small	Less power required and greater penetration than large data packages. Lower power - less coverage (e.g. less meters)	AS/NZS 4268
		Large	Greater amount of routine collected data however, more power required	AS/NZS 4268 limits power to ≤ 1W (e.g. 915 to 928 MHz).

	Communication Protocols	Bi-directional (two-way)	Improved synchronisation and ability to interrogate meters however, greater power requirements and subject to communication overhearing (Spreading Factor)	Relates to compliance in achieving the specified battery life.
		Uni-directional (one-way)	Greater range & penetration however, synchronisation and interrogation issues. Cannot undertake ad hoc interrogations remotely.	Missed or distorted data could prejudice the customer while reliability of data enhances confidence of stakeholders.
		Combination of both one- and two-way systems (e.g. Listen Before/After Talk)	Less power requirements, improved penetration and elimination of communication overhearing (Spreading Factor)	Generally proprietary systems

3.2 Details of Smart Metering Assessment Criteria

3.2.1 Metrology and measurement

This criterion relates to Australian and international metrological regulations and standards. The importance of this criterion is that when a metering technology complies with these requirements it provides the necessary confidence before and after their procurement. It is important to note that although there are potential anomalies and limitations in the current metrological regulations they still have to be complied within terms of pattern approval, however in itself this certification does not necessarily account for, nor convey all the benefits and limitations of a particular meter or its related systems.

An important aspect to consider when examining the metrology is the difference between the meter's measurement error envelope and its error curve as illustrated in Figure 3 The error envelope relates to metrological standards and specifies the 'accuracy' limits within which the pattern approved meter must operate. However, the shape the error curve within and outside this envelope is defined by the particular type of meter and has an impact on volumetric measurements, whether positive or negative.

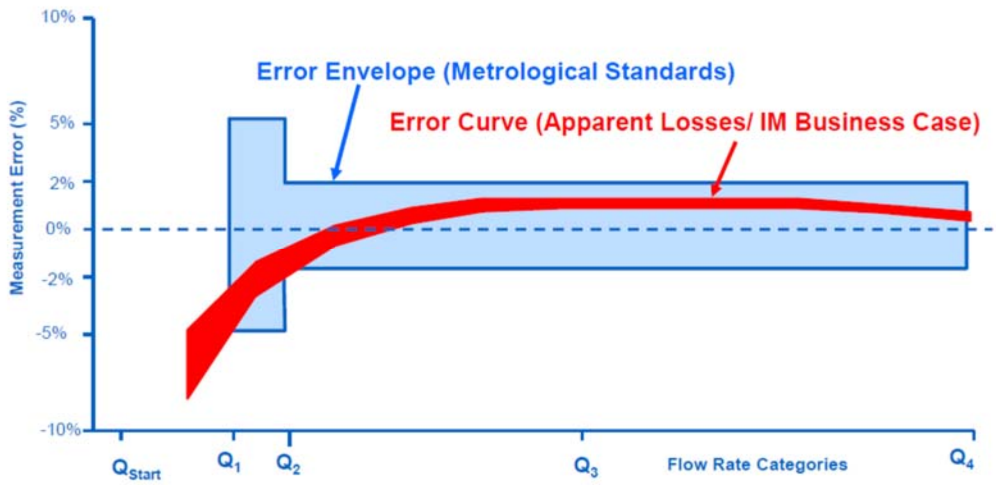

Figure 3 Meter Measurement Error Curve & Envelope

The data required to assess the specific criteria are generally available from National Measurement Institute's (NMI) Certificate of Approval (e.g. pattern approval) for the meter. Further details of these factors are provided in the applicable Australian Standards (AS3565, 2010) and National Measurement Institute R49 (2009) documents.

Aspects also related to this criteria are summarised as follows:

- Whether the meter is NMI pattern approved and verification in terms of Australian metrological requirements. It is a regulatory requirement that all new customer meters that are used for billing purposes and have a $Q_3 \leq 16$ kL/h must have pattern approval.
- Minimum flow rate Q_1 relates to the capability of meter to accurately measure the low flows so that possible leakage and wastage can be detected.
- Metrological Quality Description Ratio (R) that describes the flow range capability of the meter as a ratio (R) which is the permanent flowrate (Q_3) divided by the minimum flow rate (Q_1) (e.g. R= Q_3 / Q_1). This is specified in the particular meters NMI certificate and provides the only verifiable assurance that this performance will be achieved during the design life of the meter.

- Starting flow rate (Q_{Start}) is not specified in the NMI certificate. This is the flow rate that first generates motion of the meter mechanism from when the mechanical mechanism is initially at rest or first generates an electronic signal in the case of electronic meters starting from the zero flow rate condition. As Q_{Start} values are not a compulsory reporting requirement for pattern approvals and therefore do require confirmation from an independent source/witness for verification.

3.2.2 Operational Efficiency and Effectiveness

Meter non-registration and under-registration

Non-registration is the volume of water passing through the meter at flow rates less than the starting flow rate (Q_{Start}) and is not recorded by the meter. Under-registration is the volume of water passing through the meter that is partially recorded by the meter due to mechanical wear and tear resulting from increased age and/or increased volumetric throughput. Deposits in some types of mechanical meters (e.g. single- & multi-jet) can result in over-registration where recorded volumes exceed the true amount passing through the meter. Some digital solid state electronic meters can also be subject to the ad hoc occurrence of bias (systematic) measurement errors resulting in either under- or over-registration.

Non-, under-and over-registration have an impact on the accuracy of data provided for both billing and end-use applications. When used for billing it provides an important input for the financial assessment and justification for advanced metering. When required for end use assessments in the monitoring of demand patterns and assisting in motivating for water use behaviour changes, it is important in providing confidence in the results produced. Another important application of the data derived from meters is undertaking a water balance for the water system to identify water losses. The difference between the volumes of water supplied less the sum of the various customers' usage is deemed to be leakage however, metering errors are included as losses and efficiencies of the system. Minimisation of these metering errors improves the accuracy of the leakage estimates and hence, their correct valuation and identification of optimal strategies to address these losses.

An increase in meter non- and under-registration due to shifting of the error curve is illustrated in Figure 4.

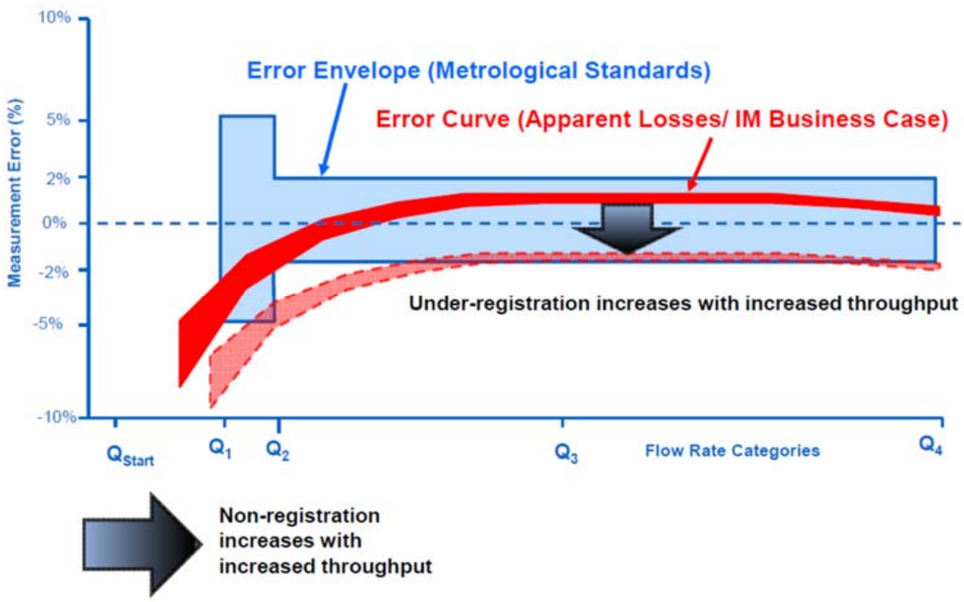

Figure 4 Meter Non- and Under-registration

Measurement error degradation

The negative impact that mechanical wear and tear caused by increased volumetric throughput has on measurement error is illustrated in Figure 5 for a sample of 285 piston/volumetric meters tested in an urban environment for Tasmania. The ‘six-flow’ testing method recommended by WSA 11 (2012) was specified for testing these meters. The tests indicate an average error degradation of -2.7% per 1,000 kL throughput. This approximates to an increase in measurement error of -0.76% every year for an average consumption of 280kL/year for the mixture of various types of mechanical meters. As the decay model is based upon a linear regression, the testing of the hypothesis about the correlation coefficient was required. This measured the ‘goodness of fit’ of the linear equation for the sample size, and was found to be statistically significant for the 95% confidence level and therefore the error decay model was adopted. This translated to apparent (metering) losses, for categories of various volumetric throughputs, equivalent to approximately 10.2% of the billed volume for that particular cohort of meters.

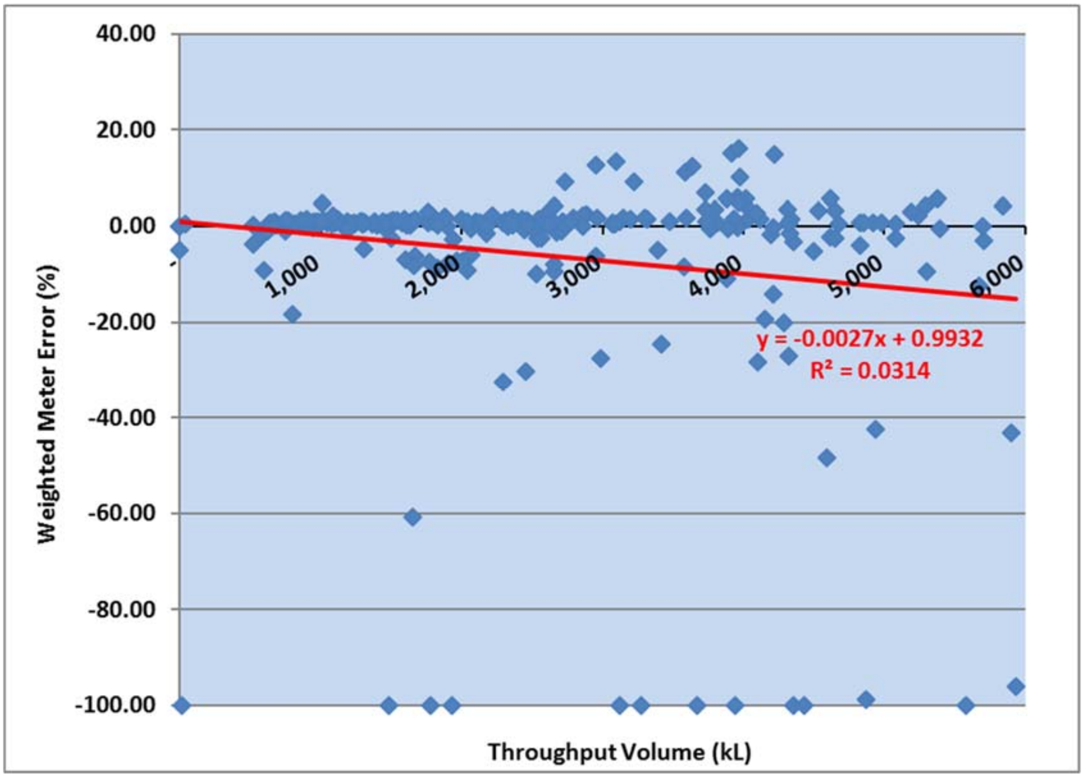

Figure 5 Example of Meter Measurement Error Decay

Noting that in-service testing and the subsequent estimation of error decay relate to a meter’s under-registration only. Non-registration of mechanical meters can be between 5% and 10% of the total daily water used by a residential customer (Mukheiber et al, 2012).

Other related aspects

Aspects also related to this criteria are summarised as follows:

- Meter’s principle of flow measurement to establish the degree with which it is influenced by the phenomenon of non-, under- and over-registration as illustrated in Figure 4. This relates to the meter type offered by the vendor/manufacturer.
- The meter’s starting (Q_{Start}) or minimum flow (Q_{min}) where it will be first capable of maintaining error of measurement within ± 5% error. This relates to the capability of meter to accurately measure the low flows so that low flow leakage and wastage can be detected such as a dripping tap or a toilet cistern’s faulty float valve.

- Continuous flow measurement capability of solid-state electronic meters are specified by the frequency with which flow rate measurements are taken by the meter to derive the registered volumes displayed and stored by the meter (e.g. number of measurements per second). The data resolution of add-on Emitters (e.g. interfaces/loggers/transmitters) for mechanical meters is also related to the working frequency of these interface units. The meter's battery life is related to the flow sampling frequency whether an 'add-on' device for mechanical meters or solid-state electronic meters.
- It is probably appropriate for an in-service compliance standard for electronic-type meters to include different requirements based performance and failure modes such as battery life, but potentially also calibration (bias error) drift, sensor deterioration or contamination as well as other in-use and temperature dependent effects. (Alex Winchester, 2015). Some digital/electronic meters that have in-built self-checking capability that prevents bias (systematic) measurement errors. This relates to the susceptibility of electronic meters to have sudden ad hoc changes in the meter accuracy that is not always immediately apparent to the operator/customer.
- The NMI R49-2 Outdoor environment class (electronics) identifies whether the meter has the capability to withstand the extremes of the weather that includes testing under conditions of varying humidity and temperatures.
- NMI R49-2 electromagnetic environment class identifies whether the meter's electronics is resistant to interference from radiated electromagnetic fields generated by other devices.
- IP Rating require specifying to ensure protection of equipment within enclosures against ingress of dust and water.
- As with the other items the degree with the meter and its electronics (whether integral or an add-on attachment) has the ability to continue performing according to specified accuracies after exposure to vibration and mechanical shock is relevant to the metering system's achieving its specified design life. Reliance on the vendor's assurances in this regard requires the backing of contractual warranties for the meter's design life to be relevant.
- Meter body and add-on loggers require the material resistance to exposure ultraviolet light to be certified through application of AS 3565.1 (Appendix C).

3.2.3 Data Conversion, Logging and Communications

This criterion relates to the current and ongoing performance of both the equipment and associated systems. Interfaces between the various systems potentially are the greatest sources of errors for data derived from the whole system. These errors not only fail to replicate actual water use conditions they also contribute to inefficiencies in the misinterpretation of data as well as in additional ongoing operating costs not initially budgeted for by the organisation. The ability of the meter to monitor water use events, store and catalogue the data, transmit the data and present the data to accurately replicate water usage patterns as well as accurately report total volumetric usage on an ongoing basis for the life of the system, is a key consideration (and indicator).

Data conversion errors

An example of error introduced from the conversion of mechanical meter totaliser to an electronic reading by means of a reed switch pulser is illustrated in Figure 6. This phenomenon is known as reed-switch bounce and is documented in related literature (Arregui, et al, 2006). A similar finding was for a Sydney Water AMR pilot found that 57% of AMR reads were greater than 4% above manual reads and 5% AMR reads were less than 4% below manual reads

(Doolan, 2011). Some vendors attempt to minimise reed switch bounce errors through the use of electronic noise filters however, this still fails to recognise which is the false signal and which is the real signal for inclusion in the flow calculation.

Figure 6 Example of Meter Read Errors due to Reed Switch/MIU Errors (Comparison of mechanical meter totaliser on left with electronic read on right)

Data storage

The meter's internal data storage capacity is relevant as failures in communications links do occur such as during extreme climatic events or random communication failures. There are two distinct components for data storage, one the data logger and the other Fixed Date Readings for billing management. Data logger that can be adjusted to record from 1 minute to 120 minutes, its capacity is also related to the electronic logger interval which is illustrated in Figure 7 for the logging of 12 alarms, flow values and status flags. For example logging every 60 minutes this will allow for storage of 9.4 weeks of data. It therefore relates to the type of data collected by the particular metering technology. The data logger is useful for ad hoc water end-use investigation as it records the Alarm State, Counter reading, Maximum Flow and Minimum Flow.

Fixed Date Readings which are adjustable by the day of the month The other components of the memory, a key requirement for billing and operational management, is the Fixed Date Reading which has 23 month's capacity and records are taken at the 1st of the month at midnight and include records of the following data:

- Alarm State
- Counter
- Backward Volume
- Maximum Flow
- Time of Maximum Flow
- Peak Flow
- Time of Peak Flow
- Current Flow
- Broken Pipe Flow

- Time of Broken Pipe Flow
- Minimum Flow
- Time of Minimum Flow

Alarms are an integral part of the data package recorded and transmitted with alarm states including backflow, tamper, broken pipe, etc.

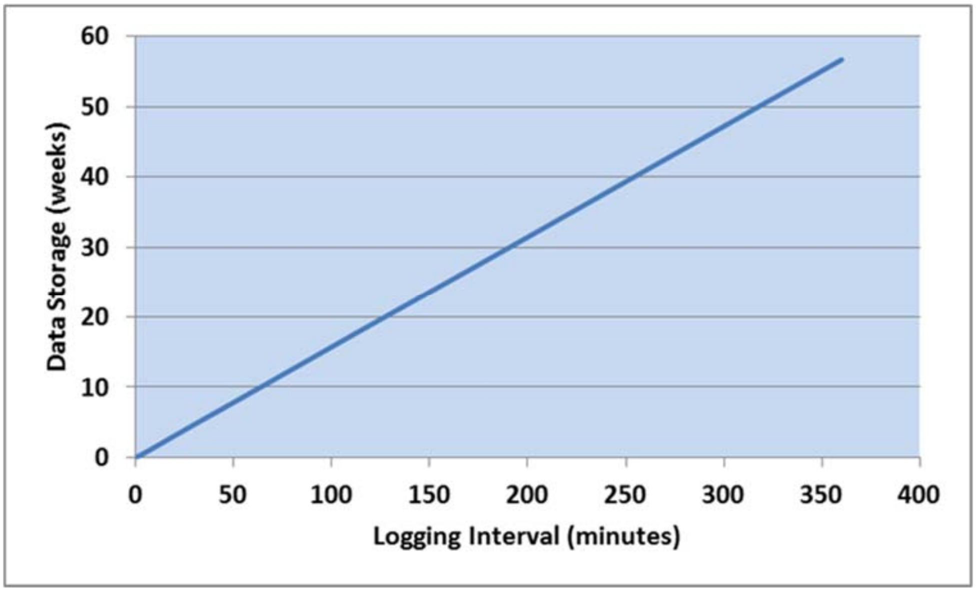

Figure 7 Example of Electronic Logging Interval versus Data Storage Capacity (source Xylem/Sensus)

Data is stored within the memory of the meter and transmitted via a fixed radio system (e.g. GatewayLite-3G link) when the grid power is restored. The GatewayLite relay can be powered either by 240Vac mains or 12-24V solar panel (8.2 W consumption). The drive-by read system is not dependent on mains power and the data is stored within the App in the tablet or a Hand Held Device (HHD) linked to the drive-by read system in the vehicle (e.g. SIRT and car antenna). The drive-by system reads all meters within range when the vehicle is travelling at 50km/hr and is efficient when operating as the principal remote read system or providing the necessary backup for fixed radio systems. When the fixed radio network is working, a GatewayLite-3G link sends a CSV file from the gateway daily or for whatever period is selected by the client.

Encryption

The level and type of data security provided related to the particular meter's encryption method/standard. Advanced Encryption Standard AES, is a cipher used to protect classified information and is generally implemented in software and hardware throughout the world to encrypt sensitive data. Metering and communication systems that provide a level of data security that equals or preferably exceeds that of the standard AES128 encryption method is required to prevent unauthorised accessing, modifying or altering software and hardware. The encryption key should be valid throughout the whole data chain ensuring data security and customers' privacy is maintained. Some meter makes do not provide encryption at the meter which, introduces a 'weak link' into the data chain and only provide data security further along the data chain, such as using VPN (Virtual Private Network) and/or other firewalls associated with off-site data storage.

Battery Life

Smart water meters installed in geographically dispersed environments such as those associated with urban water supply and distribution systems are dependent on batteries for their power source. Battery lives are relevant whether they are required to power loggers/transmitters affixed to mechanical meters or solid state electronic meters with integral loggers/transmitters. Hence, the design life of a particular smart water metering system is dominated by its battery life. Battery life is obviously dependent upon the power requirements of particular device and in the case of smart meters its scanning rate of the flowing water, the radio transmission power, frequency of transmissions and type of communication protocol.

Claims by manufactures/vendors that specified battery lives will be achieved are a challenge to verify especially as smart metering is a relative new technology that do not have lengthy operational records to substantiate these claims. Procurement contracts that provide the necessary assurances through warranties/guarantees of achieving specified battery life together with enforceable financial penalties for manufactures if their products to not achieve these design lives, is the only way of providing necessary assurance for investing in such technologies.

Communication Protocols

Data communication protocols define digital message formats and rules are specified by particular vendors/manufacturers. One-way protocol weaknesses are their smaller data set and inability to be interrogated remotely back to the meter. Two-way protocols allow for remote programming of meters and are more flexible however, they are power hungry that results in reduced meter battery life. Listen before Talk and Listen after Talk protocols (also known as 1.5-way protocol), overcome the weaknesses of the other two protocols. In an urban environment, two-way and 1.5 way protocols could be considered superior for their range of data available than one-way protocols. This is also because their synchronisation of data according to a time stamp ensures improved accuracy of the derived water volumes. The more accurate metering technologies are regularly updating the electronic clocks in the meters and synchronising them to ensure all water volumes are measured according to a specified time (e.g. midnight) while less accurate methods interpolate water volumes from their own ad hoc synchronised time and/or to different time zones (e.g. GMT).

Unaddressed overhearing is a phenomenon of two-way communications with multiple geographically dispersed water meters. When a specific remotely read meter is contacted by a reverse signal via the gateway (e.g. in bi-directional systems), all the other meters in close proximity can be activated to check if they are being addressed. This unnecessary activation of the surrounding meters results in a reduced battery life. Another disadvantage is that there can also contribute to transmission collisions preventing or delaying the delivery of data.

Other related aspects

Aspects also related to this criteria are summarised as follows:

- Radio frequencies are licenced through the Australian Communications and Media Authority (ACMA) technical limitations. The requirements and permanency of a particular radio frequency is done through the ACMA. Frequencies used by some low power long range communication devices have no regulatory protection from interference that is normally associated with other licenced frequencies, hence can be subjected to interference from ISM applications (e.g. microwave ovens, etc.).
- The Australian Standard AS/NZS 4268:2017 digital modulation transmitters operating at 915MHz to 928MHz, typical of low power long-range devices limits its transmission power to a maximum of 1W. The implications of this limit is that the higher-powered devices

required to achieve signal penetration in difficult environmental conditions are limited in Australia to the 1W threshold.

- Transmission of small packets of data that contain the critical flow and alarm status of the meter ensures a large number of meters can be read very quickly without issues of data collisions and ensures connectivity is maintained with meters installed in below ground boxes. Another advantage of small data packages is that a lower transmission power could be sufficient to achieve signal penetration of obstacles. The comprehensive specification of data requirements becomes imperative when selecting a communication technology. Obviously, larger data packages provide more information.

4. Review of Key Drivers and Objective

4.1 Review of Existing Systems

4.1.1 Meter Throughput Analysis

An assessment of the DN20 meter cohort's volumetric throughput, based on the latest totaliser readings provided, is illustrated in Figure 8. The DN20 meter cohort consists of 3,384 with an average cumulative volume (e.g. throughput) of 3,220 kL. With an annual average usage of 418 kL this equates currently to an approximate average age of 7.7 years for the DN20 meters. Compared to the trigger for in-service requirements stipulated by the Australian Standards AS 3565.4 of 1,920 kL throughput (for average annual usage of 240kL/yr) the cohort has, on average, exceeded its volumetric throughput 'life'.

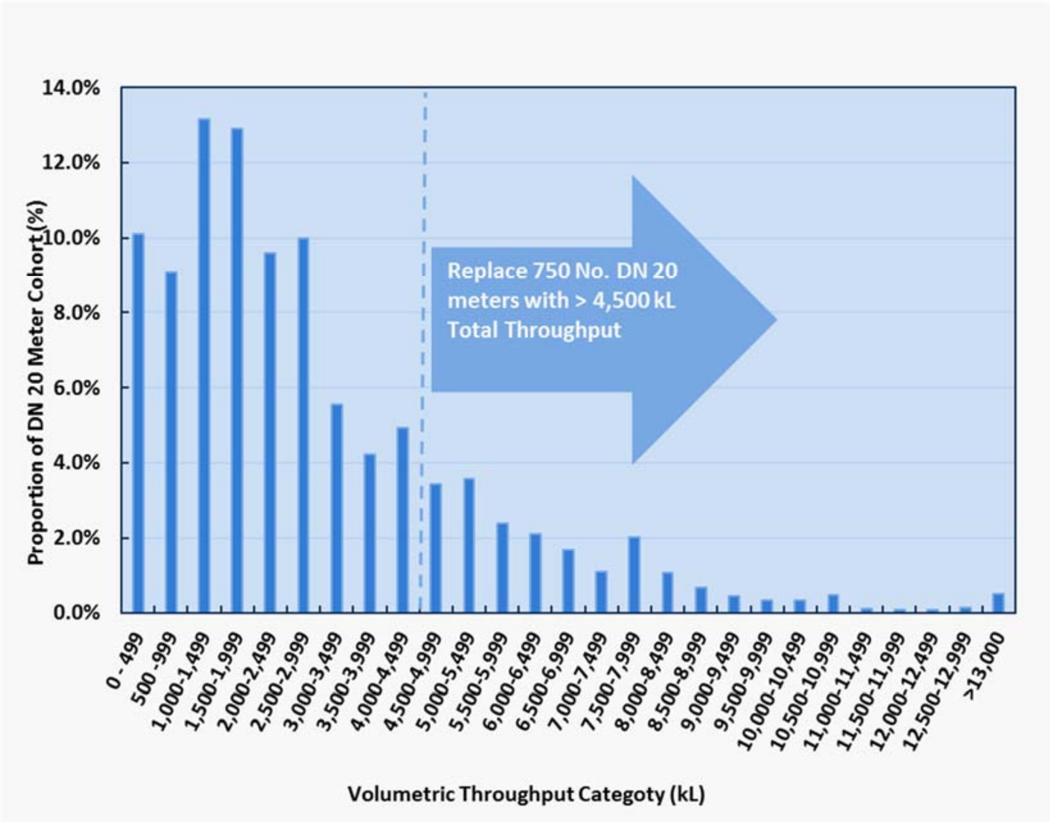

Figure 8 DN 20 Meter Cohort Volumetric Throughput Analysis

Identification as to whether the meters are on average correctly sized for their historic application is detailed in Table 2. The averages historic usage is based on the recent four trimester meter reads (2017/18) where the average daily demands are considered for all trimesters while the maximum demand trimester is used to determine an upper limit. An indication as to the correct sizing of meters can be established by comparing these billed demands to that of the typical Q_3 (permanent flow rate) for a mechanical meter. Indicative results are that the existing DN20 to DN40 plus DN 100 mechanical meters are 'on average' undersized and subject to excessive flows accelerating their wear and tear (e.g. increased degradation in accuracies).

Table 2 Indication of Correct Meter Sizing

Meter Diameter	Mechanical Meter Specification Q_3 (kL/hr)	Ave usage expressed as % of Q_3(i)	Max usage expressed as % of Q_3(ii)	Correct meter sizing ranges based on billed usage as % of Q_3 (Arregui, et al, 2006 & Canal de Isabel II, 2010)
20mm	4	1.19%	37.47%	Ave. ≥1% & ≤7%
25mm	6.3	1.55%	24.32%	Ave. ≥1% & ≤7%
32mm	10	2.14%	9.31%	Ave. ≥1% & ≤7%
40mm	10	3.36%	36.25%	Ave. ≥1% & ≤7%
50mm	50	1.19%	5.84%	Ave. ≥1% & ≤9%
80mm	120	1.07%	4.28%	Ave. ≥1% & ≤12%
100mm	160	1.54%	38.73%	Ave. ≥1% & ≤12%
150mm	160	2.97%	11.20%	Ave. ≥1% & ≤12%

Notes : (i) Average usage measured by meters for all billing periods (e.g. trimesters).

(ii) Maximum usage determined from the billing period (e.g. trimester) with the highest recorded usage.

4.1.2 Meter Measurement Errors

The increase in mechanical meter's measurement error (e.g. accuracy) has been estimated from GHD's previous experience in assessing meter fleets that includes the example in Figure 5 for a mechanical meter fleet with large volumetric throughputs. In the absence of in-service "six flow' tests for the Douglas Shire meter fleet, the following error degradation models have been adopted:

- DN20 cohort of mechanical meters are estimated to have an error decay of -1.5% per 1,000 kL throughput for totalised volumes > 1,750 kL as illustrated in Figure 9. The decay rate is weighted per throughput category to establish the overall volumetric losses detailed in Table 3. The weightings relate to the number of meters in each volumetric throughput category as a proportion of the total (as illustrated in Figure 8) and the respective measurement error determined from the model (as illustrated in Figure 9). Reiterating that the error decay model relates to the meter's under-registration only and does not estimate the volume of meter non-registration.
- DN25 to DN100 mechanical meters have an estimated error decay of 1.50% per 1,000 kL throughput adjusted as a proportion of their specified permanent flow rate (Q3) when compared to that of a DN20 meter (e.g. for DN25 the proportion is 4/6.3) to establish their weighted error and hence volumetric losses as given in Table 3.
- DN150 mechanical meters have an estimated 0.75% per 1,000kL throughput adjusted as a proportion of their specified flow rate (Q3) compared to that of a DN20 meter (e.g.4/160) to establish their weighted error and hence volumetric losses as given in Table 3.

The annual volume of apparent losses (e.g. due to meter under-registration) is estimated as 413,369 kL valued at approximately $0.413 million per year in lost water sales. This equates to an overall apparent loss for DSC's 4031 meters of 4.73% (based on average daily demand of 17.11 ML/d). Regulatory in-service testing of a representative sample of mechanical meters on a NATA accredited laboratory will improve the estimates of under-registration. Non-registration can generally only be established from a comparison of the customer's water usage history as recorded by an old mechanical meter with that of the usage of the same customer recorded by a new smart meter with a large R-ratio (e.g. flow range) capability.

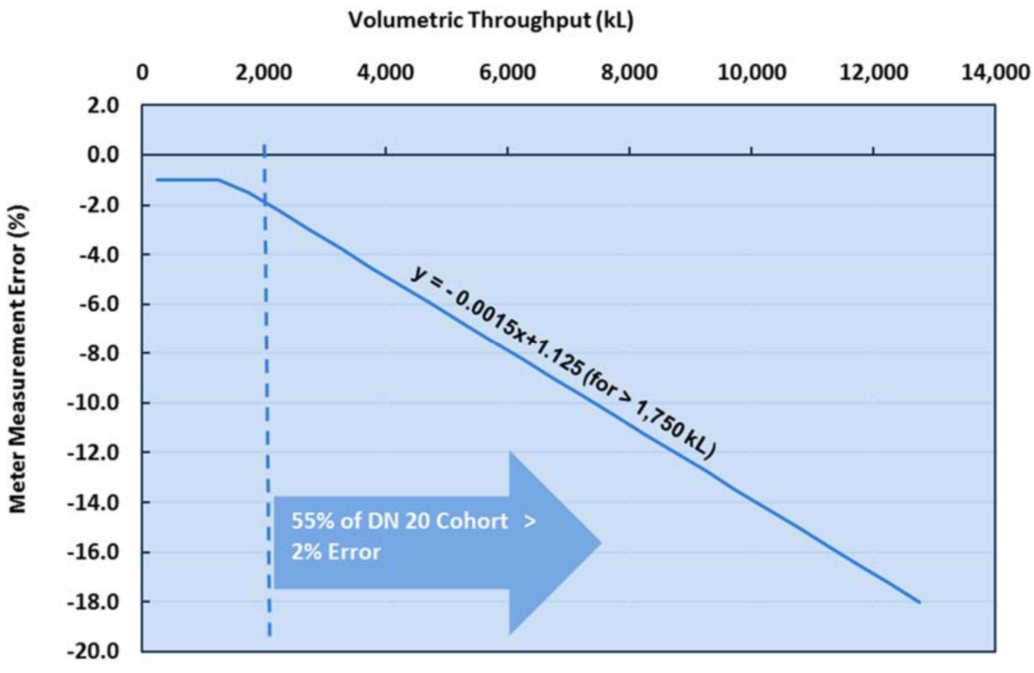

Figure 9 DN 20 Meter Cohort Measurement Error Model

Table 3 Estimated Metering (Apparent) Losses of Current Fleet

Meter Diameter	Overall Error (%)	Quantity	Annual Volume of Losses (kL/y)	Annual Cost of Losses($/y)	Annual Cost of losses per meter ($)
20mm	-4.43%	3,384	-50,004	-$70,005	-$20.69
25mm	-5.07%	161	-6,973	-$9,762	-$60.63
32mm	-7.16%	93	-12,497	-$17,496	-$188.13
40mm	-9.93%	136	-39,701	-$55,582	-$408.69
50mm	-3.62%	95	-17,890	-$25,045	-$263.64
80mm	-3.04%	13	-4,432	-$6,204.	-$477.27
100mm	-4.30%	136	-126,261	-$176,765	-$1,299.75
150mm	-6.92%	13	-37,506	-$52,507	-$4,039.06
Totals		4,031	-295,263	-$413,369	

4.2 Objectives for Future Systems

4.2.1 Existing DN20 Mechanical Meters

The optimal level of apparent losses due to mechanical water meter inaccuracies (e.g. measurement errors) can be established through the application of optimisation theory developed by Arregui (2010) and checked with net present value (NPV) analysis. As an initial optimal replacement assessment using an estimated real discount rate of 3.2% (e.g. allowing for inflation), an error degradation of -1.5% per 1,000 kL throughput and an average annual usage of 418kL for DN mechanical meters, is illustrated in Figure 10. The optimal replacement period for Douglas Shire's DN20 mechanical meters is 11 years which, equates to a volumetric throughput ‘trigger’ of 4,598 kL. According to these current estimates approximately 750 meters will require replacing if the DN20 cohort are to be retained as mechanical meters.

This optimal replacement period ‘trigger’ of 11 years also provides a useful upper limit for further analysis of smart water meters. Noting that this theoretically derived upper limit ignores the requirements of Australian in-service metering standards and is established solely from the perspective of loss in revenue due to meter measurement decay. However, it does highlight the financial disadvantage of not implementing a meter replacement program.

Noting that the optimisation theory does not supersede the regulatory requirements of in-service sampling and testing. This implies that if the sample of meters fail the regulatory in-service tests the meter population they represent must be removed even if their theoretical determined optimal period has not been exceeded.

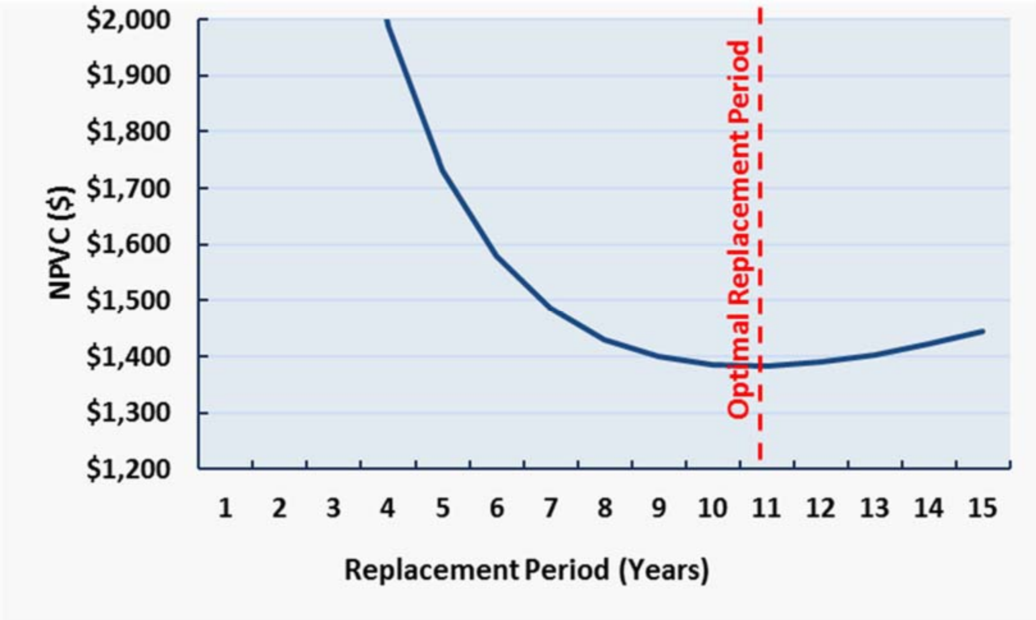

Figure 10 DN 20 Meter Cohort Theoretical Optimal Replacement Period

5. Matching Smart Metering Technologies to DSC Objectives

5.1 Risk Considerations

Potential technical and commercial risks associated with smart metering and communication technologies are generally related. Under or non-registration of water usage, for example, can be identified as a technical issue because it is defined by the particular meter's performance specifications. However, this results in reduced billed volumes and reduction in revenue collection which, is a commercial risk linked to a technical aspect. Ongoing software license and telecommunication costs also relate to specific technologies but could be largely classified as commercial risks. Some technical risks are inter-related such as communication protocol, data package size, transmission power and battery life and therefore the combined risk requires to be considered in terms of its influence on battery life. The high procurement cost of a technology is not necessary an unacceptable commercial risk especially if the particular technology can off-set its purchase costs against ongoing benefits of improved efficiency gains through increased billed volumes and cost effective remote reads.

The risk matrix provided in Table 2 is viewed from the perspective of categorising a particular smart water metering technology of not achieving efficiency gains and/or not improving levels of compliance.

Table 4 Efficiency and Compliance Risk Matrix

	Consequences (e.g. of not achieving efficiency gains or improving levels compliance)		
Likelihood (e.g. of occurring)	Major	Moderate	Minor
Likely	• Under-estimating of under-registration and non-registration errors. • Not complying with metrological regulations/ standards for ≥ DN50. • Two-way protocols causing premature power failures (e.g. due to overhearing). • Transmission failures caused by low power and large data sets.	• Incorrect or no measurement error decay/ degradation allowance for mechanical meters. • Premature battery failures. • Mechanical-electronic signal conversion errors. • Meter read inefficiencies. • Data storage limitations at the meter.	
Possible	• Premature failure of technology. • Inadequate data security.	• Incorrect throughput volumes.	• Random bias errors for mechanical meters.

	Consequences (e.g. of not achieving efficiency gains or improving levels compliance)		
	• Ongoing software license costs associated with fixed radio networks. • Averaging errors for electronic meters (e.g. related to the scanning frequency of flowing water). • Random bias errors in solid state electronic meters	• Ongoing telecommunication costs • In-service non-compliance • One-way protocol synchronisation data errors	
	• Not complying with metrological regulations/ standards for ≤ DN50 • Averaging errors for mechanical meters. • Transmission failures caused by lower power and small data sets	• Listen Before/After Talk protocols data errors and/or power failures • Ongoing software license costs associated with drive-by remote read systems.	

This assessment process facilitates prioritisation of the risks and provides an indication what key aspects should be focussed upon when undertaking assessment of smart metering technologies. The risks are extracted from Table 4 and ranked as follows:

High Risk

a. Under-estimating of under-registration and non-registration errors.

b. Not complying with metrological regulations/ standards for ≥ DN50.

c. Two-way protocols causing premature power failures (e.g. due to overhearing).

d. Transmission failures caused by low power and large data sets.

e. Incorrect or no measurement error decay/ degradation allowance for mechanical meters.

f. Premature battery failures.

g. Mechanical-electronic signal conversion errors.

h. Meter read inefficiencies.

i. Data storage limitations at the meter.

j. Premature failure of technology.

k. Inadequate data security.

l. Ongoing software license costs associated with fixed radio networks.

m. Averaging errors for electronic meters (e.g. related to the scanning frequency of flowing water).

n. Random bias errors in solid state electronic meters.

Medium Risks

o. Incorrect throughput volumes.

p. Ongoing telecommunication costs.

q. In-service non-compliance.

r. One-way protocol synchronisation data errors.

s. Not complying with metrological regulations/ standards for ≤ DN50.

t. Averaging errors for mechanical meters.

u. Transmission failures caused by lower power and small data sets.

Low Risk

v. Random bias errors for mechanical meters.

w. Listen Before/After Talk protocols data errors and/or power failures.

x. Ongoing software license costs associated with drive-by remote read systems.

This prioritised list of risks therefore provides important input for comparing a sample of smart metering technologies detailed in the next section.

5.2 Smart Metering Comparison

A selected sample of six smart water metering technologies have been assessed according to two categories, one that uses add-on electronic devices together with conventional mechanical meters and other solid state electronic meters with either integral electronic transmitters/loggers or combined with add-on transmitters. The assessment process can be applied to all makes and types of meters that are 'used for trade' (e.g. custody transfer) and comply with the provisions and requirements of the Australian National Measurement Act (1960).

5.2.1 Mechanical Water Meters with 'add-on' electronic transmitters/ loggers

- ***Elster V100 & Coronis Waveflow***

  Elster Metering Pty Ltd in Australia is part of the Water Metering Business Unit of the Elster Group, which has a global metering business encompassing water, gas and electricity. The 20 mm diameter V100 Model mechanical piston meter has Australian pattern approval. Remote reads are through add-on Coronis Waveflow electronic transmitter and Wavenis transmission protocol.

- ***Elster V200 & Taggle***

  Taggle Systems, in operation in Australia since 2007, manufacturers, owns, operates and maintains a network of radio receivers which are deployed in various parts of Australia. Taggle is in the process of collaborating with Elster to equip the V-200 meter with an integrated Taggle transmitter.

- ***Itron TD8 & EverBlu Cyble***

Itron Australasia Pty Ltd is a wholly subsidiary of Itron Incorporated, a publicly listed US based company with 30 years history of serving the meter data collection and management sector. The Actaris Model TD8 20 mm diameter meter has Australian pattern approval. Remote reads are through add-on Itron Cyble EverBlu and Radian transmission protocol.

5.2.2 Static Solid State Electronic Flow Meters with integral transmitters/loggers

- ***Enware (Diehl) Hydrus Model171 & Taggle***

The Hydrus meter is manufactured by the German Diehl company and distributed in Australia by Enware, an owned and operated manufacturer and distributer of commercial and industrial plumbing and safety products. In Australia, Diehl Hydrus meter sizes available are for DN20, DN25, DN32 and DN40.

Taggle, indicate that they can externally fitted their ADC1 remote read transmitters to the Enware Hydrus Meters.

- ***Kamstrup FlowIQ 2102 & READy***

Smart Building Services Pty Ltd operates nationally as the sole Australian distributor of Kamstrup, a Danish company that manufactures digital water metering systems since 1991.The Kamstrup READy is a remote system for reading water their meters. Their system is flexible to be either read as a drive-by application or over a fixed radio network. In Australia, Kamstrup meter sizes available are for DN20, DN25 and DN40.

- ***Sensus (Xylem) iPerl & Sensus RF***

A truly advanced smart meter that demonstrates a quantum leap in technology, is the Sensus iPerl RF and the importance of this meter is not only its technology but the heritage of the company that has translated this technology into a device that can be successfully implemented within the environment of a water utility. Sensus (Xylem), Germany have been manufacturing water meters since the 1800's and are one of the largest manufacturers of large diameter Woltmann meters. They have supplied over 5 million composite body meters and already have over 3 million iPerls installed world-wide. In Australia, iPerls meter available are for sizes DN20, DN25, DN32 and DN40.

Bermad Water Technologies are the Australian distributors of the Sensus iPerl RF and have been operating for over 26 years. As a national company Bermad supply and support a range of products into many of the major water companies and water infrastructure projects. The SensusREAD system is flexible to be either read as a drive-by application or over a fixed radio network.

5.3 Technology Assessment

The assessment of the six smart water metering technologies are detailed in Table 5 and although some data relates to 20 mm diameter meters, the assessment is also applicable to the range of meter sizes that are of the same model/type. An overall risk assessment for each technology is also provided in terms of potential efficiency gains in service delivery and improve levels of compliance and is illustrated in the form of a colour graded continuum from high risk through to low risk for DSC. Noting that this risk assessment continuum relates to the whole metering system and not just the meter itself. This technology benchmarking is a prerequisite for commercial benchmarking as it identifies the smart metering technology that should be included in further financial analysis because of its lowest risk.

Based on the assessment in Table 5, the recommended smart metering technology to meet the DSC objectives is the Sensus iPerl.

Table 5 Smart Metering Technology Comparison Summary

Smart Water Metering Technology		Mechanical Water Meters with ‘add-on’ electronic transmitters/loggers			Static Solid State Electronic Flow Meters with integral transmitters/loggers		
Key Criteria	**Sub- criteria**	**Elster V100 & Coronis Waveflow**	**Elster V200 & Taggle *(Taggle add-on not shown)**	**Itron TD8 & EverBlu Cyble**	**Enware Hydrus Model171 & Taggle *(Taggle add-on not shown)**	**Kamstrup FlowIQ 2102 & READy**	**Sensus iPerl & Sensus RF (Xylem)**
Illustration							
Meter’s principle of flow measurement		Volumetric/ Piston	Volumetric/ Piston	Volumetric/ Piston	Ultrasonic	Ultrasonic	Remnant Magnetic
Metrology and Measurement	Pattern Approval (NMI Certificate)	NMI 14/3/1	NMI 14/3/1	NMI 14/3/26	NMI 14/3/15	NMI 14/3/23	NMI 14/3/28
	Standards (R Ratio and Q_{Start} @ approximately ±5%) flows relate to DN20	R 200 Q_{Start} 13 litres per hour	R 200 Q_{Start} 13 litres per hour	R 200 Q_{Start} 10 litres per hour	R 200 Q_{Start} 5 litres per hour	R 250 Q_{Start} 5 litres per hour	R 800 Q_{Start} 1litres per hour
Operation, Environment and Materials	Error decay (Susceptible to mechanical wear & tear)	Yes	Yes	Yes	No	No	No
	Electronic ‘add-on’ emitter or meter sampling frequency	Emitter working frequency 1 cycle per sec	Emitter working frequency 1 cycle per sec	Emitter working frequency 1 cycle per sec	0.5 scans/sec (e.g. 1 scan every 2 secs)	0.25 scans/sec (e.g. 1 scan every 4 secs)	4 scans/sec (e.g. 1 scan every 0.25 sec)
	In-built self-checking capability for electronic bias error or error correction of ‘add-on electronics	No	No	No	No	Yes	Yes

	Susceptible to external influences – Outdoor environmental requirements (NMI R49-2)	Non-compliant (for add-on)	Complies	Non-compliant (for add-on)	Complies	Complies	Complies
	ECM (resistance of electronics to interference from radiated electromagnetic fields generated by other devices)	Reed switch and Hall effect sensors subject to some external interference (e.g. non-compliant)	Complies	Complies	Complies	Complies	Complies
	IP 68 rating	Complies	Complies	Complies	Complies	Complies	Complies
	Ultraviolet light (compliance with AS 3565.1 - Appendix C)	Non-compliant (for add-on)	Complies	Non-compliant (for add-on)	Non-compliant	Complies	Complies
	Vibration & Shock (IEC 60068-2-64)	Non-compliant (for add-on)	Complies	Non-compliant (for add-on)	Complies	Complies	Complies
Data Conversion, Logging & Radio Communications	Conversion method (susceptibility to introduce data errors)	Data errors	Inductive pulse (minimal errors)	Inductive pulse (minimal errors)	Direct digital (e.g. no conversion errors)	Direct digital (e.g. no conversion errors)	Direct digital (e.g. no conversion errors)
	Data storage	None	3 hours	2 days	3 hours	20 days	60 days of 1 hour logging of 12 values (alarms and flows) data storage or equivalent. Selectable 1 to 120 minutes.
	Non-volatile memory back-up (Y/N)	No	No	No	No	Yes	Yes
	Data security encryption at meter (source)	Proprietary protocol	Proprietary protocol	RADIAN Proprietary protocol	None at the source/meter	AES128 encryption	≥ AES128 encryption
	Power source (Meets specification warranty requirement for battery life ≥ 15 years)	No	No	No	No	Yes	Yes
	Frequency(AS/NZ 4268)	433MHz	915-928MHz	433Mhz	915-928MHz	923 MHz	433MHz

	Power (e.g. AS/NZS 4268 limits power to ≤ 1W for 915 to 928 MHz)	10 mW	25mW or 500mW	≤ 10 mW	25mW or 500mW	10mW in drive-by mode and 25 Mw in fixed network mode	10mW in drive-by mode and 25 Mw in fixed network mode
	Data package sizes (w.r.t. principle transmission method)	Very small	Small	Small	Small	Small	Transmits a small packet of data every 15 seconds BUP (bubble up packet) data of critical flow and alarm status.
	Communication Protocols	Uni-directional (one-way)	Uni-directional (one-way)	Bi-directional (two-way)	Uni-directional (one-way)	Uni-directional (one-way)	Combination of both one-and two-way systems (e.g. Listen Before/After Talk)
<u>RISK CONTINUUM</u>							
Efficiency gains in service delivery	Red = High risk of not achieving efficiency gains Green=Low risks (more likely to achieve efficiency gains)	**High Risk**			**Medium Risk**		**Low Risk**
Potentially improve levels of compliance	Red = High Risk of not improving levels of compliance Green=Low Risks (more likely to improve level of compliance)	**High Risk**			**Medium Risk**		**Low Risk**

6. Benefit Cost Analysis

6.1 Benefits of Implementing Advanced Metering Projects

The generic benefits of implementing advanced smart metering when compared to manually read mechanical meters include the following:

Improved Customer Billing

- Accurate billing
- Savings in manual reads and re-reads
- Reduced number of estimated bills
- Reduced final reads

Enhanced Customer Service

- More frequent billing
- Proactive notification
- Fair & equitable tariffs
- Revenue protection
- Early warning of customer leakage (if using fixed radio network transmissions of interval register readings, e.g. hourly meter read data)

Reduced Non-revenue Water and Apparent Losses

- Reduced meter reading lag errors
- Reduce non- and under-registration errors
- Minimise estimated consumptions
- Improved water balances

Reduced Meter Renewals

Reduced meter testing and renewals costs (if solid state digital electronic meters replace mechanical meters).

6.2 Payback Period Analysis

Payback period is the amount of time required for an organisation to recover its initial investment in a project as calculated from the benefits (or cash flows) derived from these investments. This is an unsophisticated capital budgeting techniques, since it does not actually consider the time value of money by discounting cash flows (e.g. benefits & costs) to determine present value. NPV analysis provides a more accurate determination of payback periods because it considers the time value of money.

The types of benefits and costs considered for the analysis process are listed in Table 6 and described in the subsequent sections. It should also be noted that the analysis includes consideration of positive cash flows that result from revenue from an improvement in billed volumes paid for by customers. Savings to existing committed budgets and improved

Table 6 Benefits and Costs Summary

Benefits	Costs
Reduction in apparent losses due to improvement in measurement accuracies achieved by new smart meters when compared to the old mechanical meters and categorised as an ongoing increase in Revenue	Purchase (e.g. capital) cost of new smart water meters. CAPEX incurred at commencement of investment period (e.g. assumed to be within the first year of the project for analysis purposes)
Savings in the reduction or elimination of in mechanical meter renewals budget due to changed in-service requirements categorised as an ongoing saving in OPEX	Purchase (e.g. capital) cost of remote meter read system. CAPEX incurred at commencement of investment period
Increased revenue from the more efficient remote reads when compared to existing manual meter reads therefore reducing an existing OPEX (e.g. ongoing positive amount)	Cost of removing old meters and installing new meters. CAPEX incurred at commencement of investment period (e.g. within the first year of the project)
	Ongoing meter reading OPEX costs for the new remote read system
	Write-off costs of the existing meters replaced by smart meters that is categorised as single amount in CAPEX incurred at commencement of investment period (An extra option also excluded for sensitivity analysis)
	Ongoing apparent losses of the new smart water meters categorised as OPEX (although at a lower level than the current mechanical meters and constant)

6.3 Benefit Modelling

Examining the previously listed generic benefits of implementing advanced metering through the filter that considers causality for explanatory variables, benefit realisation and the status quo, the following benefits are included in the commercial modelling:

- Reduced apparent losses.
- Increased revenue from savings in manual meter reads.
- Savings from reduction or elimination in renewals.

These benefits are considered adequate for this high-level strategic commercial assessment and because of the data made available by DSC at the time of this investigation.

Benefit in reducing apparent losses.

An example of the improvement in billed volumes resulting from the installation of solid state electronic meters achieve when replacing mechanical meters is illustrated in Figure 11. Although the average rainfall increased in this example by approximately a third after the installation of the solid state electronic meters (e.g. Sensus iPerls), the billed volumes also increased by approximately 8.1% for this pilot study. This is contrary to expectations in that increased rainfall would usually result in a decrease in external water usage which, if this was the actual situation then the improvement in billed volumes would in reality be greater than 8.1%. Understanding that other factors could have influenced changes in usage such as changes in water usage behaviours, unoccupied residences, occupation of new residences, etc.

These factors were however, assumed to have negligible impact on the results because of the context of the particular environment and economic circumstances of the pilot areas.

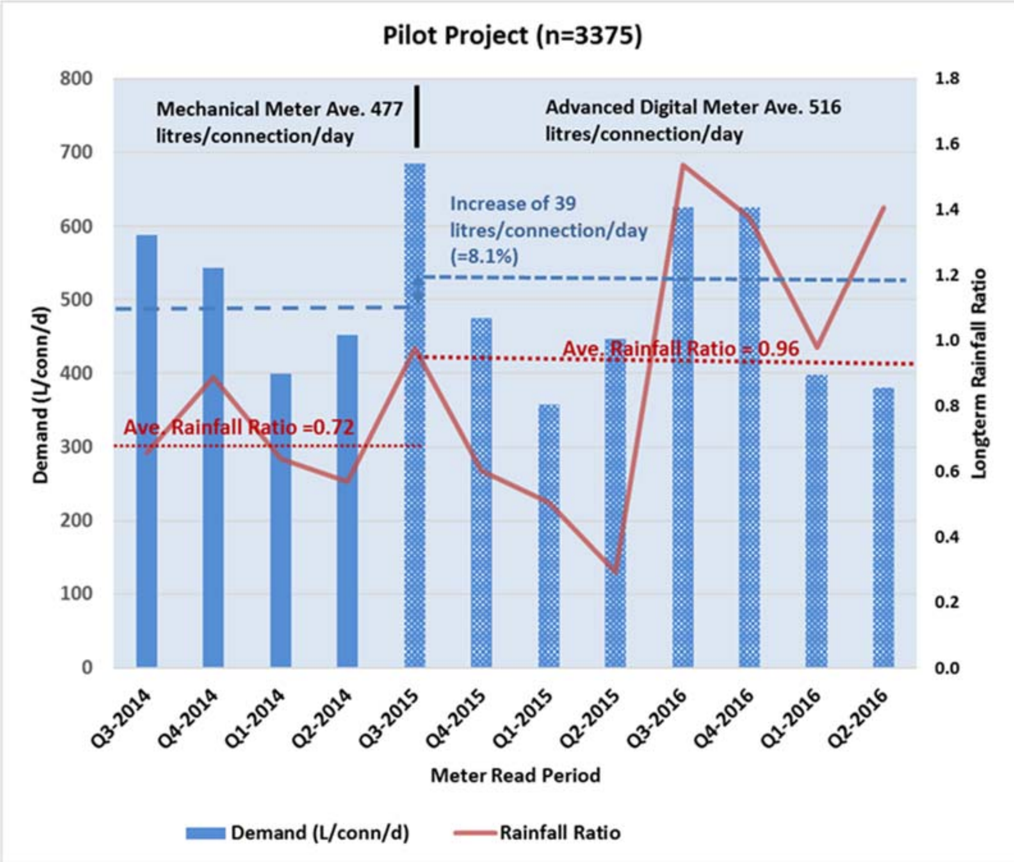

Figure 11 Example of Improved Billed Volumes from Digital Meters

The apparent (metering) losses for DSC have previously been estimated at approximately 295 ML valued at approximately $0.413 million in lost water sales (refer to Table 3). Water quality and demand usage patterns could also differ between that of DSC and the example quoted. It is likely that DSC's current level of apparent losses and growth rate in apparent losses would be larger.

The estimate benefits from installation of the Sensus iPerl RF (DN 20 to DN 40) and Sensus MeiStream Plus RF (DN 50 to DN150) are derived from their ability to measure very low flows and a larger range of demands over their full design lives. This is because their respective R-ratios (e.g. turn-down ratios) of 1:800 and 1:500, currently exceed that of any other types of meter available. The estimated benefits of reduced apparent losses (due to reduced under-registration) are as follows:

- Replacement of existing meters with Sensus iPerls DN20, DN25, DN 32 and DN40 will reduced apparent losses to -1% (e.g. estimated benefit of 4.13% when compared to the apparent loss for this category of meter sizes of 5.13%).
- Replacement of existing meters with Sensus MeiStream Plus DN50, DN85, DN 100 and DN 150 will reduced apparent losses to -1.5 % (e.g. estimated benefit of 3.02% when compared to the apparent loss for this category of meter sizes of 4.52%).

The estimated savings due to the reduction in apparent losses (e.g. through improvement in the meter's registration of flows), when compared the performance of existing mechanical meters with that of newer solid-state digital electronic meters, is summarised in Table 7.

Table 7 Estimated Savings in Apparent Losses (Metering errors)

Meter Size Range	Total Demand (kL/y)	Total Losses (kl/yr)	% Apparent Losses	Estimated Savings (%)	Estimated Savings (kL/yr)	Estimated Savings ($/yr)
DN20 - DN40	2,126,804	-109,175	-5.13%	4.13%	87,907	$123,070
DN50 - DN 150	4,117,591	-186,088	-4.52%	3.02%	124,324	$174,054
Totals	6,244,395	-295,263			212,231	$297,124

Note: The “Estimated Savings” referenced in Table 7 is in effect, an increase in billed revenue for DSC

Increased revenue from savings in manual meter reads.

Current Manual meter reads (MMR) are undertaken by a contractor from Cairns and currently costs $26,507 per year. This translates to approximately $2.25 per manual meter read.

Walk- and drive-by reads are a cost effective remote read system that can be applied either on their own or in conjunction with a fixed radio network (FRN). Walk- and drive-by remote read systems provide a cost effective approach to phasing in a remote reading technology ensuring the successful integration with existing systems and operational of key services such as billing. The reading data can be also exported/ imported to other meter data management databases and integration with other technologies. Walk- and drive-by systems also provide a useful emergency back-up for fixed radio network systems.

Flexibility of drive-by reads for some technologies is demonstrated by their ability to use commercial hand held devices (HHD), a Notebook/ Tablet computer and a USB port. Tablets have the advantage of being inexpensive and readily available consumer products. The latest technologies are user-friendly and can be successfully operated by less skilled personnel from either contractors or the utility. This type of technology lends itself to application in a denser urban environment but does not preclude its use within regional communities if a transmission or internet connection is available to transfer the data remotely back to the ‘office’ after a scheduled drive-by collection activity. The drive-by functionality is not dependent on local mobile phone or radio coverage as it reads the meter directly.

Walk- and drive-by remote read systems usually require at least a data collection and communications interface layer IT software to operate but without the additional ongoing costs generally associated with fixed radio systems.

Application of fixed radio network for the remote read of a whole meter fleet usually incurs ongoing annual license and software support costs of between $2.00 and $15.00 per water meter (e.g. per end point) while that of drive-by generally do not incur ongoing license and software support costs.

The estimated benefit of introducing the newer smart metering technology is in substantially reducing the costs in meter reads. The default base case value adopted is an 80% saving when compared to manual meter reads or $0.45 per read for a drive-by remote read system. This excludes the possible cost of the same personnel’s’ involvement in non-meter read activities.

Savings from reduction in renewals of mechanical meters.

Currently, DSC undertakes approximately 70 ad hoc replacements of meters in a year. The optimal period for replacement of mechanical meters was determined as 11 years (also refer to Figure 10) and together with a macro meter sizing exercise (refer to Table 2) has the following implications:

- An initial urgent replacement of 750 meters with throughputs that exceed 4,598 kL is required (also refer to Figure 8);
- A regular program for the replacement of approximately 330 meters (DN20) with throughputs that have exceed 4,598 kL will require replacing every year;
- Current meters greater than DN20 that are oversized require replacement with a meter one size smaller (also refer to Table 2).

The estimated costs to undertake annual renewal of mechanical meters is approximately $122k and is detailed in Table 8 based on an 11 year replacement period. In addition to this amount, an initial 750 meters with throughputs that exceed 4,598 kL will require immediate replacing at an estimated cost of $95k. Hence, current annual meter replacements are only approximately 20% of what is required to minimise the apparent losses due to measurement error decay of mechanical meters.

Table 8 Estimated Annual Mechanical Meter Replacement Costs

DN	Total (No.)	Annual Replacement (No.)	Approx. Mechanical Meter Purchase Cost ($)(i)	Approx. Installation Cost ($)(ii)	Total Annual Renewals Costs ($) - Mechanical Meters
20mm	3384	308	$49	$78	$38,978
25mm	161	15	$233	$373	$8,859
32mm	93	8	$512	$820	$11,258
40mm	136	12	$535	$857	$17,212
50mm	95	9	$558	$894	$12,546
80mm	13	1	$729	$1,168	$2,241
100mm	136	12	$822	$1,317	$26,441
150mm	13	1	$1,535	$2,459	$4,721
Totals	**4031**	**366**	**$46,992**	**$75,264**	**$122,256**

Notes
(i) DN20 price provided by DSC, larger diameters based on historic costs for other utilities.
(ii**)** Estimated meter change-out costs only, excluding alterations to pipework & fittings and costs of side-walk reinstatement.

6.4 Preferred Option

6.4.1 Estimated Unit Costs of Smart Metering System

The estimated unit cost of the smart water meters previously selected (Also refer to Section 5.3) are given in Table 9. Budget prices for DN20 to DN40 meters are inclusive of internal check valves. These prices are based on the supply of the product from the vendor directly to DSC and not via an implementation contractor.

Table 9 Smart Water Meter Budget Prices

Description	Estimated Price per unit (Excl GST)
Sensus iPerl Smart Water Meters - DN20	$240.00
Sensus iPerl Smart Water Meters - DN25	$370.00
Sensus iPerl Smart Water Meters - DN32	$470.00
Sensus iPerl Smart Water Meters - DN40	$510.00
Sensus MeistreamPlus RF- DN50	$810.00

Sensus MeistreamPlus RF- DN80	$940.00
Sensus MeistreamPlus RF- DN100	$1,010.00
Sensus MeistreamPlus RF -DN150	$1,510.00

The estimated unit cost of the components of smart meter reading system are given in Table 10. Budget prices are provided for components of both drive-by and fixed radio network remote read systems.

Table 10 Remote Reads System Budget Prices

Description	Estimated Price per unit (Excl GST)
Fixed Radio Network - Gateway Lite, 433mHz, 240V or 24 DC powered, includes internal IRIS Light management system	$4,130.00
Fixed Radio Network - Repeaters, 433mHz, Battery powered	$160.00
Sensus Walk-by/Drive-by application remote read software for iPerls and installation on Handheld devices operating on Windows 6.1. (supply, installation and commissioning)	$15,000
Drive-by SIRT (Sensus Interface Radio Tool) Radio Modem	$1,910
Drive-by Car Kit	$700
Drive -by Hand Held Device (HHD)	$4,220
PC Tablet	$500
Training per day	$1,800.00
SensusRead to Billing System Interface Software	$50,000

6.4.2 Business Case Results

6.5 Lifecycle Analysis based on NPV Assessment

As a sophisticated capital budgeting technique, net present value (NPV) considers the time value of money and in the case of smart water meters, this is over their full design life. Decision making criteria for NPV results is that when the resultant NPV value is greater than $0, then that project's scenario is accepted. When the resultant NPV value is less than $0, then that project's scenario is rejected. This presumes an existing base case (e.g. status quo) reference level with which the proposed project can be compared. The more 'accurate' NPV analysis derived payback periods must be used for project go/no-go decision making purposes as it considers the present value of net pre-tax cash flow as well as operating profits. Key considerations in developing a commercial model are that the assumptions regarding causality of the explanatory variables must be clearly articulated, these variables must be measurable and a base case (e.g. status quo) model must facilitate an objective assessment**Error! Reference source not found.**.

The NPV model inputs used are as follows:

- Nominal pre-tax discount rate (WACC) 5.79%
- Growth rate 0.713%
- Expected inflation rate 2.50%
- Revenue growth rate (price - gross) 6.0%
- OPEX growth rate (gross) 1.0%

6.5.1 Status Quo Scenarios

NPV analysis for the existing mechanical meters and associated costs of a manual meter read system has been calculated for the Capex and Opex streams illustrated in Appendix A. The following costs have been considered in the NPV analysis of the existing mechanical meters:

Operating Costs (Opex)

- Manual meter reads.
- Error degradation of mechanical meters (e.g. for under-registration).

Capex/Renewals

- Mechanical meter renewals (budgeted and forecasted) as detailed in Appendix A.
- Allowance for ad hoc (random) failures.

It is important to note when considering these results are that existing revenue generated from the volumes recorded by the existing mechanical meters is excluded from the analysis because it is considered to be the status quo base line (e.g. benchmark). The results therefore show the changes in revenue due to introduction of new smart meters. Existing constant rate of revenue generated from existing mechanical meters is therefore excluded from the analysis. Hence the NPV analysis is assessing the costs of the existing mechanical meter cohorts against any technological improvements that would improve efficiencies, such as an increase in revenues or decrease in operating expenditures as compared to the existing status quo accounting ‘snap shot’. A negative departure from the status quo base line reference is the cost of error measurement decay associated with mechanical meters and is therefore included in the analysis to compare with the reduction in the measurement errors of the smart metering option.

As previously discussed, solid state electronic meters require consideration of different requirements than those of mechanical meters for in-service replacements such as battery life and calibration drift. As some solid state digital electronic meters are more than capable of achieving a useful life of 15 years, this has been selected as the investment period benchmark.

The results of the financial analysis for the existing cohorts of mechanical meters are that the NPV values are negative and the EBIT (Operating Profits) remain negative at the end of the 15 year assessment period.

6.5.2 Smart Water Metering Nett Benefits

Implementation of the smart water metering system recommended will require an estimated capital investment of $2.238 million (excl.GST) within the first two years of the 15 year investment period. These investments costs together with the following benefits have been included in the NPV analysis:

Increased Revenue

- Increased revenue from reductions in non- & under-registration when replacing mechanical meters with smart meters.

Operating Costs (Opex)

- Reduction in Operating Costs from savings in manual reads (+).
- Costs of smart meter drive-by reads (-).
- Mobile data costs between Gateways and office (-).
- Apparent Losses of smart meters (-).

- Reduction on Operating Costs from savings or elimination of mechanical meter renewals budget(+). Noting that this is based on the requirements established from application of optimisation theory and previously summarised in Figure 8 and Figure 10.

Capex

- Supply and installation of smart water meters and associated communication systems as detailed in Appendix B.

The revenue, Capex and Opex streams used in the NPV analysis for the smart metering system these illustrated in Appendix B.

6.5.3 Summary of NPV Analysis Results

The results of the NPV analysis are summarised in Figure 12 that shows the NPV for the smart metering system becomes positive in Year 15 (e.g. payback period is approximately 15 years) and the operating profit (e.g. EBIT) becomes positive within 3 years. As the resultant NPV value is greater than $0 within the 15 year investment period, then that smart metering project should be adopted.

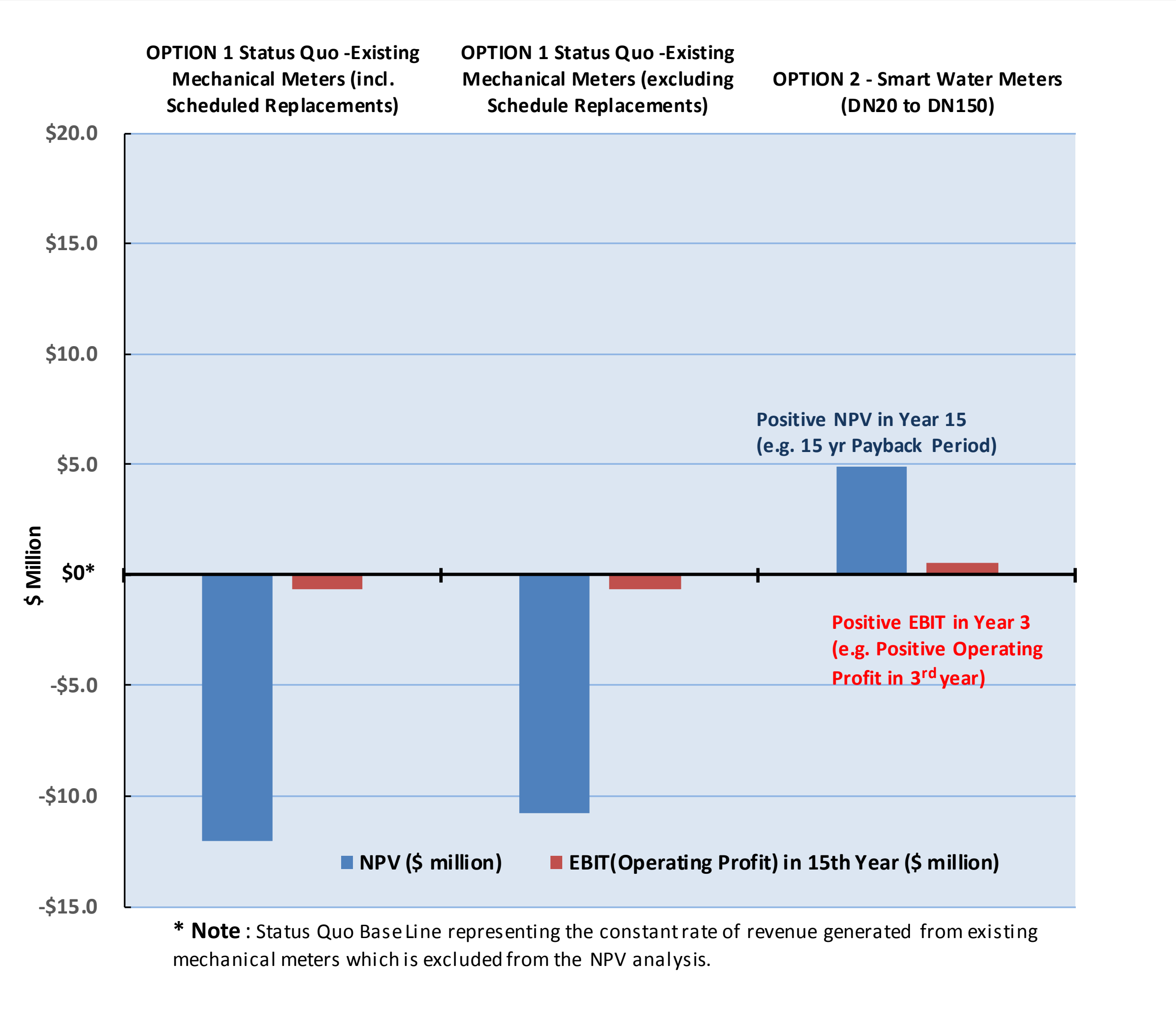

Figure 12 Financial Analysis Comparisons

Summary of the NPV analysis results are:

- The smart metering system proposed is estimated to have a payback period of approximately 9 years (e.g. positive NPV) and positive operating profit (e.g. EBIT) in year 3. Taking into account the time value of money these positive results are achieved within the 15-year investment (analysis) period benchmark. These results depict both positive and negative changes in revenue due to introduction of new smart meters and exclude the current revenue stream from the existing mechanical meter fleet.
- The continued operation of the existing fleet of mechanical meters, with or without a mechanical meter replacement program, results in a negative NPV and operating profit over the 15 year investment (analysis) period. Existing constant rate of revenue generated from existing mechanical meters is therefore excluded from the analysis.

7. Development of Framework for a Pilot Project

7.1 Selection of Smart Metering Trial Customers

7.1.1 Decision Criteria

The following key criteria should be applied to identify areas for inclusion in the smart metering pilot:

- Examination of conveniently located areas for a pilot within range of a 3G telecoms link (e.g. Mobile phone cell/tower):
- The meters within the area are majority DN20;
- The meters are located within a discrete boundary preferably fed by a single water supply main for installation of a smart district meter; and
- The existing meters are located in non-paved sidewalks (e.g. grassed) to minimise reinstatement costs should reconstruction of a connection pipework be required.

The previously defined 'trigger' for the replacement of DN20 mechanical meters was 4,500kL and an initial selection of the pilot area was to consider the proportion of meters in suburbs with meters that equal or exceed this volume are listed in Table 11.

Table 11 Ranked Suburbs with DN20 with High Volumetric Throughputs

Suburb Name	Total Number DN20 Meters	No. Meters with Throughput >4,500kL	% Meters in Suburb with Throughput > 4,500kL
Port Douglas	887	27	3.0%
Mossman	798	51	6.4%
Wonga Beach	416	76	18.3%
Craiglie	286	99	34.6%
Cooya Beach	236	66	28.0%
Newell Beach	189	54	28.6%
Bonnie Doon	102	12	11.8%
Maillo	82	13	15.9%
Rocky Point	67	13	19.4%
Mowbray	53	10	18.9%
Bamboo	46	3	6.5%
Mossman Gorge	46	12	26.1%
Daintree	42	6	14.3%
Killaloe	38	6	15.8%
Cassowary	37	15	40.5%
Whyanbeel	32	5	15.6%
Lower Daintree	14	1	7.1%
Shannonvale	9	5	55.6%
Stewart Creek Valley	2	0	0.0%
Syndicate	1	0	0.0%

Upper Daintree	1	0	0.0%
	3,384	474	

Provision has been made in the trial project budget for up to 800 meters across the DN20 fleet to be replaced.

7.2 Data Integration

The pilot will afford an opportunity for DSC to identify the requirements for integration of meter read data that is captured remotely to be integrated with the Council's billing system. DSC will also have an opportunity to familiarise itself with the application of the technology for the future roll-out of the whole meter fleet. This is especially relevant as the Shire's existing financial system is to be changed.

7.3 Timeframe and Budget

7.3.1 Smart Meter and District Meter Pilot

The estimated costs for a smart water metering pilot is detailed in Table 12. The proposed pilot will consist of remotely read solid state digital electronic meters transmitting directly from a repeaters and Gateways situated on light poles. All smart meters will communicate directly or via repeaters with these Gateways which, will in turn transfer data via mobile phone link to the offices of Douglas Shire Council. A back-up remote drive-by read system is also proposed for trialling to facilitate decision making for the full rollout of the smart water meters.

Table 12 Proposed Smart Water Metering Pilot Project

Description of Smart Metering Component	Qty (No.)	Estimated Purchase Unit Price ($/meter)	Total Purchase Costs ($)	Unit Installation Cost ($/meter)	Total Installation Costs ($)	Total Costs ($)
Sensus iPerl Smart Water Meters - DN20	800	$240	$192,000	$78	$62,400	$254,400
Fixed Radio Network - Gateway Lite, 433mHz, 240V or 24 DC powered, includes internal IRIS Light management system	3	$4,130	$12,390	$1,000	$3,000	$15,390
Fixed Radio Network - Repeaters, 433mHz, Battery powered	25	$160.00	$4,000	$300	$7,500	$11,500
Drive-by SIRT (Sensus Interface Radio Tool) Radio Modem	1	$1,910	$1,910			$1,910
Drive-by Car Kit	1	$700				$700

Sensus Walk-by/Drive-by application remote read software for iPerls and installation on Handheld devices operating on Windows 6.1. (supply, installation and commissioning)	1	$15,000	$15,000			$15,000
District Meters MeistreamPlus RF DN150	4	$1,510	$6,040	$2,459	$9,837	$15,877
District Meters MeistreamPlus RF DN100	2	$1,010	$2,020	$1,317	$2,633	$4,653
Shipping & delivery costs (Sum)	1	$4,000	$4,000			
Set-up & Training per day	5	$2,000	$10,000			$10,000
Sub-Total						$403,430
Add 5% Contingencies						$20,172
Consultancy Services Costs (scope to be confirmed with DSC)						$75,000
TOTAL (Excl GST)						**$498,602**
***Note :** Prices exclude the reconstruction of connection pipework and fittings						

7.3.2 Regulatory In-service Testing of Mechanical Meters

The estimate to undertake tests of a sample of DN20 cohort of meters in a NATA accredited flow laboratory that are compliant with the Australian Standard AS 3565.4 and will cost approximately $200 per meter. A random sample of 350 meters from those removed for the smart metering pilot should tested according to the 6-flow rate test requirements at a total estimated cost of $70,000 (excluding GST). The results of these tests will facilitate establishing the whether the fleet complies with the regulatory in-service requirements as well as indication as to the degree the existing mechanical meter are under-registering.

8. Project Implementation

8.1 Phased Approach

Various actions are required as part of the process to sucessfully implement and commission a universal smart metering program. These actions relate to planning, procuring and implementation of metering projects to minimise the key risks associated with these types of projects.These risks are generally associated with the following project stages:

- Assessment of metering technologies and development of a business case (Addressed in this report).
- Procurement that includes preparation of specifications, development of tender adjudication scoring requirements, undertaking objective assessments of tenders, reporting and preparation of related documentation.
- Planning and implementation of a phased approach with the objective that facilitates a comprehensive ongoing assessments of the outcomes during the roll-out.
- Contract supervision and control of the roll-out of the metering program to facilitate the simultaneous integration into the organisation's existing assets, systems and processes.

8.2 Procurement

General procurement objectives for the metering project include the following:

- To ensure that all project outputs are delivered to the required quality, within the specified timeframe as well as within the project budget;
- To ensure that the stakeholders expectations are met;
- To ensure that the stakeholder requirements are effectively managed;
- To ensure procurement strategy will deliver value-for-money; and
- To ensure optimal risk transfer and that KSC's residual risks are correctly managed.

The independent assessment of procurement will ensure that the project delivered is in accordance with the expected probity standards. Preparation of specifications and defining the tender adjudication scoring requirements are an integral part of the procurement process. Noting that the initial framework for developing these assessment criteria were previously listed in Table 1. However, further definition of procurement objectives, development of the tender adjudication scoring requirements and detailed analysis of procurement options will be required.

A key risk mitigator is that procurement contracts must provide the necessary assurances through warranties/guarantees of achieving specified technical requirements together with enforceable financial penalties for manufactures if their products do not achieve these specified performance requirements. Compliling these warranties/guarantees requires an in-depth understanding of smart water metering systems.

8.3 Implementation

In order to identify a project delivery mode that is best able to meet these objectives, defining project parameters need to be identified. Metering projects are characterised by the following requirements:

- Price certainty;

- Cost expectations of the client versus industry benchmarks for the envisaged activities;
- Ability of market to provide meters in the required quantities and within the relevant timeframes;
- Correctly assess and quantify the various conditions and arrangements of the pipe connection assets to accommodate the new smart meters.
- Customer acceptance of smart meters being installed;
- The client organisation's capacity to undertake the work internally;
- Other considerations such as traffic and public access management, stray electrical currents etc; and
- Public consultation and communication strategy.

Important actions required prior to roll-out of the program include the development of standard designs, specifications for site surveys and assessment of the survey data to ensure that the new metering system can be accomodated on the relative sites.This includes specifying the requirements for rebuilding connecting pipework, siting and affixing communication equipment to existing infrastructure, to name a few examples.

The development and monitoring of quality assurance measures is essential to identify subtle errors in the data obtained during initial roll-out of the project to facilitate accurate and objective assessments so that the necessary modifications to processes required for future universal implementation. This includes the development of standardised data assessment templates and guidance notes. Correct identification and standardisation of the recoding of maintenance activities is required to verify the realisation of the originally envisaged benefits through an independently and thorough assessment process.

The review and assessment of DSC's administrative and organisational processes associated with the recording, processing and reporting of water usage, maintenance and operational data associated with the smart metering projects will also be required.

8.4 Program

Guided by the NPV analysis the sequence for implementation of smart metering technologies would be as follows:

(i) Year 0 – Smart and district metering pilot as well as regulatory in-service testing of a sample of mechanical meters ($ 500k).

(ii) Year 1 - DN20 to DN40 (approximately $1.6 million). Giving higher priority to those suburbs with meters that have the greatest proportion with the largest throughputs. (refer to Table 11).

(iii) Year 2 - DN 50 & DN150 (approximately $0.56 million).

Smart metering technologies should therefore be implemented over a 3-year period for the following reasons:

- To facilitate the process of procuring, supplying, installing as well as integrating the new technologies into the Shire's existing systems.
- The distribution of the Shire's proposed smart metering Capex expenditure.
- After an initial pilot, spreading future replacements over a 2-year period as the asset life (and analysis) has been based on a fixed period (e.g. 15 years) so replacements will be required in approximately 15 years.

- The phasing out of the current manual meter read (MMR) contract and implementation of a replacement contract or engagement of dedicated staff relevant to the needs of the remotely read smart metering technology adopted.

These Capex estimates are for 2018 prices, exclude GST and exclude consultant’s costs.

As DSC’s new billing system has yet to be specified, procured and implemented, the requirements for interfacing the new smart metering remote read system and the new billing system will need to be undertaken during the initial phase of the smart metering roll-out.

9. Concluding Remarks

9.1 Concluding Summary

Implications of In-service Regulatory Requirements

The current widely adopted Australian in-service regulatory requirements were developed based on a history of data for mechanical meters. Current decision rules are intended to apply to mechanical meters and as such, these aspects of the standard are not necessarily appropriate for statistically monitoring the performance of a population of non-mechanical meters. The implication of this is that retaining a mechanical meter fleet will require DSC to continue to incur ongoing expenditure to comply with meter in-service testing and replacements. However, solid-state electronic meters will not necessarily require such high levels of operating expenditures associated with current in-service compliance requirements of mechanical meters.

Technology Benchmarking

A comprehensive, objective and independent evaluation of metering technologies has been undertaken within the context of a data pathway and its asset lifecycle. This framework provides the necessary lens to examine, procure and manage the various complex technologies and systems. The assessment of the six smart water metering technologies was undertaken that included determining the overall risk assessment for each technology in terms of potential efficiency gains in service delivery and improve levels of compliance. The technology benchmarking was a prerequisite for commercial benchmarking as it identified the smart metering technology with the lowest risk which, is the Sensus iPerl RF and Sensus Meistream Plus RF.

Key Benefits

Commercial benchmarking considered the benefits of implementing advanced metering that took into account assumptions regarding causality of the explanatory variables that are clearly articulated and must ultimately be measurable. The base case (e.g. status quo) model developed must also facilitate an objective assessment. The key benefits identified are considered adequate for this high-level strategic commercial assessment and in context with the data made available by DSC at the time of this investigation. Key benefits selected for inclusion in the model are as follows:

- Reduced apparent losses as an ongoing increase in DSC's revenue
- Savings from reduction or elimination in meter renewals as an ongoing saving in operating costs
- Savings in manual meter reads as an ongoing positive operating cost
- Potential savings on customer leakage, if a fixed radio network meter read system is adopted with hourly meter-read data

Existing Mechanical Meter Fleet

Analysis of the existing mechanical meter's throughput (e.g. totalised volume passing) indicates that the 3,384 DN20 meter cohort have an average throughput volume of 3,220 kL. This is relatively high when compared to the trigger for in-service requirements stipulated by the Australian Standards AS 3565.4 of a 1,920 kL throughput The existing DN20 meter cohort has, on average, exceeded its volumetric throughput 'life'. The optimal replacement period for Douglas Shire's DN20 mechanical meters has been calculated as 11 years which, equates to a volumetric throughput 'trigger' of 4,598 kL. According to these current estimates approximately

750 meters will require immediate replacing if the DN20 cohort type are to be retained as mechanical meters. Indicative results are that the existing DN20 to DN40 plus DN 100 mechanical meters are 'on average' undersized and subject to excessive flows accelerating their wear and tear (e.g. increased degradation in accuracies).

Lifecycle Assessment based on NPV Analysis

Lifecycle assessment required for a commercial assessment is based on a sophisticated capital budgeting technique, net present value (NPV) over their full design life. The smart water metering system recommended requires an estimated capital investment of approximately $2.238 million within the first two years of the 15 year investment period. Summary of the NPV analysis results are as follows:

- The smart metering system proposed is estimated to have a payback period of approximately 15 years (e.g. positive NPV) and positive operating profit (e.g. EBIT) in year 3. Taking into account the time value of money these positive results are achieved within the 15-year investment (analysis) period benchmark. These results depict both positive and negative changes in revenue due to introduction of new smart meters and exclude the current revenue stream from the existing mechanical meter fleet.
- The continued operation of the existing fleet of mechanical meters, with or without a mechanical meter replacement program, results in a negative NPV and operating profit over the 15 year investment (analysis) period. Existing constant rate of revenue generated from existing mechanical meters is therefore also excluded from the analysis for comparative purposes.

9.2 Recommendations

It is recommended that:

- A pilot project with 800 (No.) DN20 Sensus iPerls RF, and 6 (No.) Sensus Meistream Plus RF District meters be undertaken in areas yet to be defined at an estimated cost of $498,602 (excl GST). Also that an sample of 350 (No.) DN20 old mechanical meters removed for installation of the new smart meters, be tested in a NATA accredited flow laboratory at an estimated cost of $70,000 (excluding GST).
- Smart metering solution proposed be adopted for the DN20 to DN150 meter fleet however, implementation be spread over a 2-year period.
- The procurement process commences that includes preparation of specifications, development of tender adjudication scoring requirements, undertaking objective assessments of tenders, reporting and preparation of related documentation. The timely implementation of this process is especially relevant as there is a high demand for the technology proposed both in Australia and Internationally, resulting in a lead time from placing an order to delivery of approximately 12 to 18 weeks.
- Commencement with the initial phase of the roll out involving DN 20 to DN40 meters followed by DN50 to DN150 cohorts. Planning of the implementation in concentrated areas is further recommended, as this will facilitate both installation and simplify future renewals at the end of investment period.

References

- Alex Winchester (2015). Policy Officer – Legal Metrology Policy; National Measurement Institute; Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education. Telephone discussion and email with Author, August 2015.
- Arregui, F. Cabrera, E. & Cobacho, R.(2006). *Integrated Water Meter Management.* IWA Publishing.(ISBN:1843390345)
- Australian Government – Water Meters Intended for the Metering of Cold Potable Water and Hot Water. National Measurement Institute NMI R 49 (Second edition, first revision April 2009)

  Part 1: *Metrological and Technical Requirements*

  Part 2: *Test methods*

  Part 3: *Test Report Format*
- Australian Standard AS 4268 (2017). Radio equipment and systems- Short range devices – Limits and methods of measurement.
- Australian Standard AS 4747 Parts 8(2013) Meters for non-urban water supply: In-service compliance for non-urban water meters.
- Australian Standard AS 3565 - Meters for cold and heated drinking and non-drinking water supplies.

  Part 1(2010): *Technical Requirements*

  Part 4 (2007): *In-service compliance testing*
- Canal de Isabel II (2010). Accuracy in the measurement of individual water consumption in Madrid Region. Authored by Guzma, I.D & Cabeza, J.F. (ISBN 978 84 936445 3 6)
- Doolan, C (2011). Sydney Water's Smart Metering Residential Proj+ect. AWA National Water Efficiency Project. Paper EFF16.
- Johnson, E.H. (2009). *Management of Non-revenue and Revenue Water Data*. Engineers Media, Crown Nest NSW, Australia. ISBN 9780858258839 (2nd Edition).
- Johnson, E.H. (2013). *Outcomes from International Projects Lead to an Innovative Meter Management Framework.* IWA Efficient 2013 Conference. Paris, France
- Johnson, E.H. (2014). *Management Framework for Intelligent Metering.* Towards the Digital Water Utility Conference. WSAA. Melbourne 10 &11 September.
- Mukheibir P, Stewart R, Giurco D & O'Halloran K. (2012) Understanding Non-registration in Domestic Water Meters. AWA Water. December. pp 95- 100 .
- National Measurement Institute Web site (http://www.measurement.gov.au)
- WSA 11 (2012). Compliance Testing of In-Service Water Meters – Code of Practice. Water Services Association of Australia.

Appendices

Appendix A –Existing Meter Fleet Costs

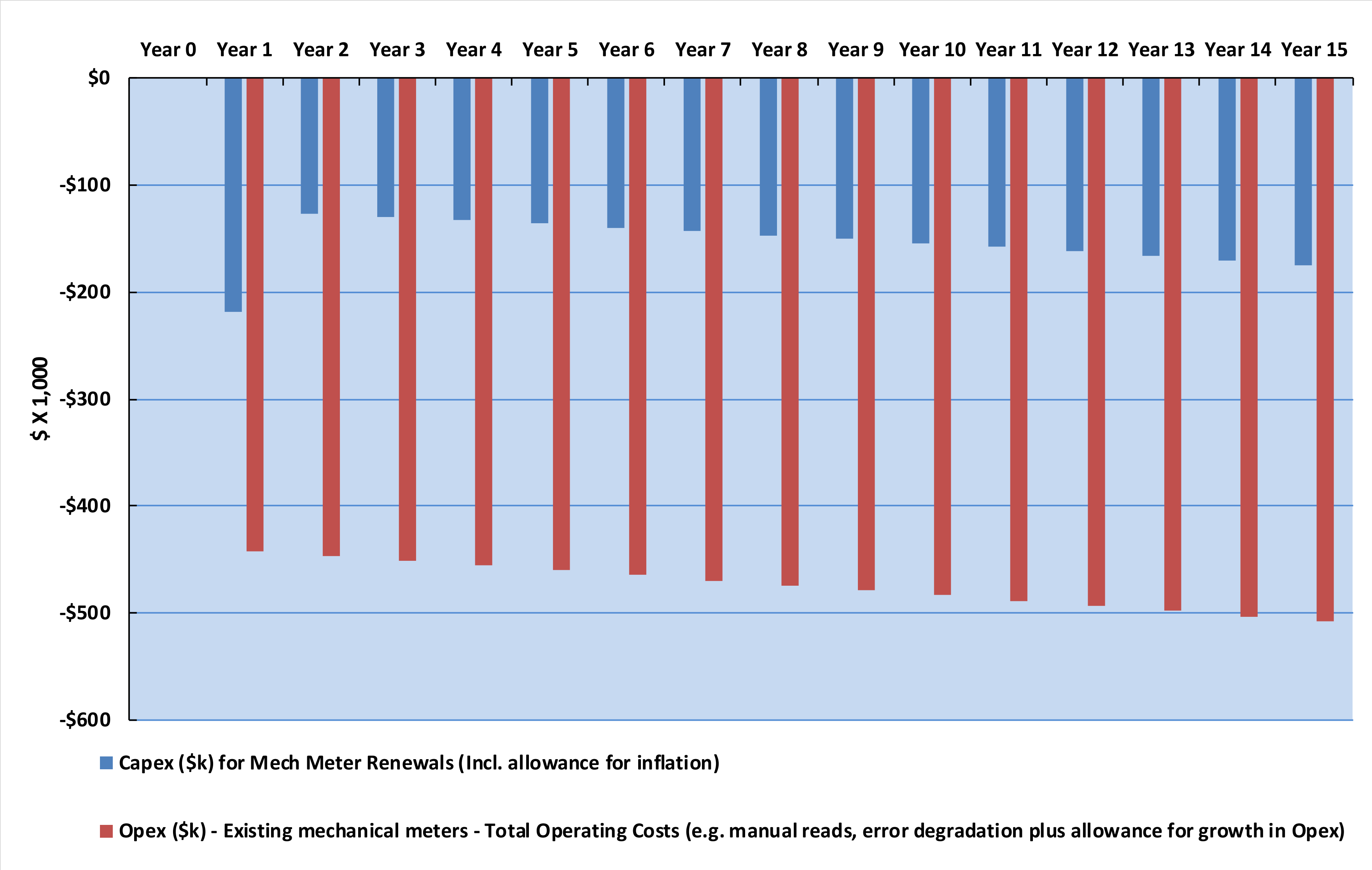

Figure A.1: Estimated Cost Streams for Existing Mechanical Meter Fleet

Table A.1 Estimated Mechanical Meter Renewals Costs (Refer to Table 8)

DN	Total (No.)	Annual Replacement (No.) (approx.. 11-yr cycle)	Mechanical Meter Purchase Cost ($)	Unit Installation Cost ($/meter)	Total Annual Renewals Costs ($) - Mechanical Meters	Once-off Replacement (No.)	Total Once-off Renewals Costs ($) - Mechanical Meters
20mm	3384	308	$49	$78	$38,978	750	$95,025
25mm	161	15	$233	$373	$8,859		
32mm	93	8	$512	$820	$11,258		
40mm	136	12	$535	$857	$17,212		
50mm	95	9	$558	$894	$12,546		
80mm	13	1	$729	$1,168	$2,241		
100mm	136	12	$822	$1,317	$26,441		
150mm	13	1	$1,535	$2,459	$4,721		
Totals	**4031**	**366**	**$46,992**	**$75,264**	**$122,256**		

Table A.2 Summary of Opex Cost

Opex	Volumetric amount (kL/y)	Costs ($/yr)	References
Once-off Renewals	-	-$95,025 (First year only)	Table A.1 & Figure 8
Annual Meter Renewals (Required)	-	-$122,256	Table A.1
Mechanical Meter Error Decay	-295,263	-$413,369	Table 3
Manual meter read costs	-	-$26,507	Section 6.3

Appendix B –Smart Meter Fleet Costs & Nett Benefits

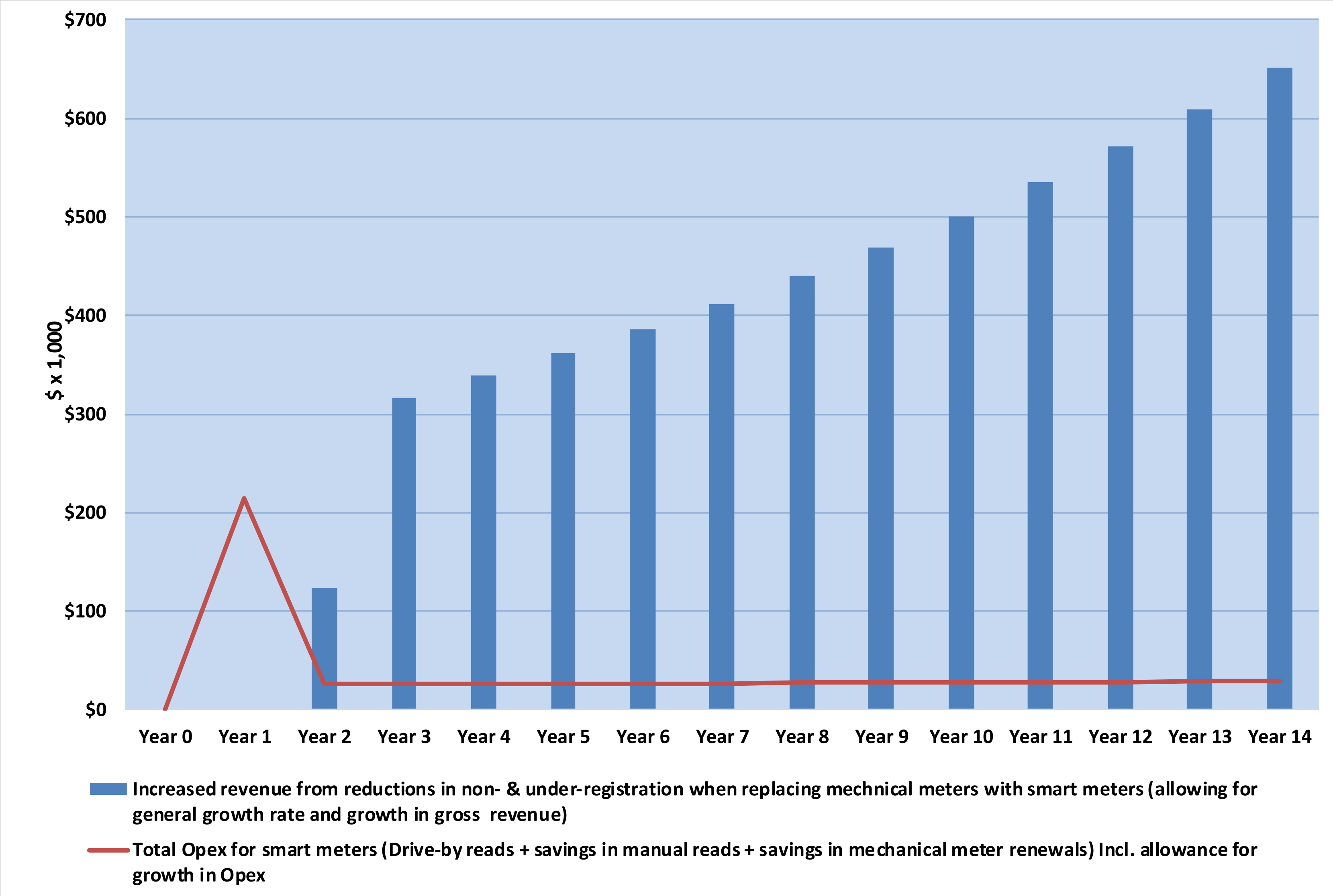

Figure B.1 : Estimated Nett Benefits of Smart Metering System

Table B.1 Estimated Smart Metering System Capital Costs

DN	Quantity (No.)	Description of Smart Metering Component	Estimated Purchase Unit Price ($/meter)	Total Purchase Costs ($)	Unit Installation Cost ($/meter)	Total Installation Costs ($)	Total Costs ($)
20	3384	Sensus iPerl Smart Water Meters - DN20	$240.00	$812,160	$78	$263,952	$1,076,112
25	161	Sensus iPerl Smart Water Meters - DN25	$370.00	$59,570	$373	$59,992	$119,562
32	93	Sensus iPerl Smart Water Meters - DN32	$470.00	$43,710	$820	$76,238	$119,948
40	136	Sensus iPerl Smart Water Meters - DN40	$510.00	$69,360	$857	$116,556	$185,916
50	95	Sensus MeistreamPlus RF- DN50 (electronic)	$810.00	$76,950	$894	$84,958	$161,908
80	13	Sensus MeistreamPlus RF- DN80	$940.00	$12,220	$1,168	$15,178	$27,398
100	136	Sensus MeistreamPlus RF- DN100	$1,010.00	$137,360	$1,317	$179,057	$316,417
150	13	Sensus MeistreamPlus RF -DN150	$1,510.00	$19,630	$2,459	$31,971	$51,601
		Sub-Totals (Meters)		**$1,230,960**		**$827,903**	**$2,058,863**
	10	Fixed Radio Network - Gateway Lite, 433mHz, 240V or 24 DC powered, includes internal IRIS Light management system	$4,130.00	$41,300	$1,000	$10,000	$51,300
	30	Fixed Radio Network - Repeaters, 433mHz, Battery powered	$160.00	$4,800	$300	$9,000	$13,800
	1	Sensus Walk-by/Drive-by application remote read software for iPerls and installation on Handheld devices operating on Windows 6.1. (supply, installation and commissioning)	$15,000.00	$15,000			$15,000

	2	Drive-by SIRT (Sensus Interface Radio Tool) Radio Modem	$1,910.00	$3,820			$3,820
	2	Drive-by Car Kit	$700.00	$1,400			$1,400
	2	Drive -by Hand Held Device (HHD)	$4,220.00	$8,440			$8,440
	2	PC Tablet	$500.00	$1,000			$1,000
	5	Set-up & Training per day	$2,000.00	$10,000			$10,000
	1	SensusRead to Billing System Interface Software	$50,000.00	$50,000			$50,000
	Lump Sum	Shipping & Delivery Costs		$5,000.00			$5,000
	Lump Sum	Radio survey costs		$20,000.00			$20,000
Sub-Totals (Comms and Reading System)							**$179,760**
GRAND TOTAL (Excl GST)							**$2,238,623**

GHD

Level 1 85 Spence Street Cairns Queensland 4870

42/20467

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	E. Johnson	R Savage		R Savage		9/2/2018
B	E. Johnson	R Savage		R Savage		12/4/2018
01	E. Johnson	R Savage		R Savage		8/6/2018
01	E. Johnson	R Savage	RHSavage	R Savage	RHSavage	18/6/2018

www.ghd.com