City of Winnipeg

Advanced Water Metering Solution Business Case

Findings and Recommendations Report

Diameter Services

Submission 1

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TABLE OF CONTENTS

Acronyms and Terms

Acronym or Term	Expansion	Definition
A.M.R.	Automated Meter Reading	Typically refers to a drive-by meter reading system to automate “on foot” meter reading.
A.M.I.	Advanced Metering Infrastructure	A network of fixed based equipment that captures detailed consumption information from the metering population that is retrieved by data collection software on at least a daily basis.
ANSI	American National Standards Institute	A private non-profit organization that oversees the development of voluntary consensus standards for products, services, processes, systems, and personnel in the United States. These standards ensure that the characteristics and performance of products are consistent and are tested the same way.
AWWA	American Water Works Association	Established in 1881, the AWWA is an international association founded to improve water quality and supply. Members include: water utilities, treatment plant operators and managers, scientists, environmentalists, manufacturers, academics, regulators and consultants.
BCV	Building Control Valve	A water shut-off valve installed before the meter so the water entering the building can be shut-off.
CCB	Customer Care and Billing	Oracle water billing software application.
C/I	Cut-In	Where a meter has never been installed and the plumbing requires modification to allow for the installation of a water meter.
C/O	Change-out	Used in connection with either a large or small meter change-out/replacement.
FN	Fixed Network	See A.M.I. definition.
IM	Intermediate Meters	Meters that are sized 1.5” (37mm) and 2” (50mm).
IVR	Interactive Voice Response	In an automated telephone system, IVR interacts with callers, gathers information and route calls to the appropriate recipients.
LM	Large Meter(s)	Meters that are sized 3” (80mm) and larger.
LOS	Level of Service	Refers to defined service delivery requirements

M.D.M.	Meter Data Management	Software application that helps manage and ensure the accuracy and completeness of the volumes of data provided by a fixed network for billing, analysis, reporting and presentment.
M.I.S.	Meter Installation Software	Software that captures the details of the installation including meter serial #, transmitter identification #, account information of where the equipment was installed.
NSF	National Sanitation Foundation	An accredited, independent third-party certification body that tests and certifies products to verify they meet public health and safety standards.
SM	Small Meters	Water meters with sizes smaller than 1” (37mm).
Transmitter	Transmitter	A radio device connected to the water meter to provide meter readings for either a mobile or fixed network meter reading system.
UME	Unitized Measuring Element	The field replaceable measuring chamber used in conjunction with the City’s LM meters.

Table 1 - Summary of Acronyms and Terms

1. ORGANIZATIONAL GOALS & NEEDS

1.1. Introduction

The City of Winnipeg engaged Diameter Services to provide professional consulting services for an advanced water metering solution business case. The purpose of this engagement as stated in the City's RFP No. 801-2020 included "…compiling information and preparation of a business case for the implementation of an advanced metering solution for the City of Winnipeg" as well as evaluating the City of Winnipeg's readiness from an asset, systems, and business process perspective.

As a part of this exercise, the City of Winnipeg and Diameter Services looked beyond the meter reading and billing functions to discover some of the broader opportunities and challenges faced by the City. This process provided the opportunity to address how an Automated Meter Reading (AMR) or Advanced Metering Infrastructure (AMI) will help the City address these challenges.

Some of the challenges or opportunities the City of Winnipeg is looking to address through this project include:

- Increased confidence in the data associated with water planning and modelling.
- More in-depth view into the City's water consumption and water losses. This requires addressing the City's aging meter population.
- Wastewater and land drainage can become a bottleneck to development (opportunities to better understand demand and profiles).
- Reduced estimated billing and related customer complaints.
- Minimizing negative media coverage because of customer issues.
- Providing customers with an understanding of their usage.
- Data driven communication with customers on billing issues.
- Enhancing the City's image and reputation.
- Improved meter sizing.
- Reducing the burden on the leak credit program.
- Increasing the protection of the potable system through increased backflow monitoring
- Lowering non-revenue to the extent possible especially in the areas of unauthorized consumption, data errors due to erroneous meter readings and better water consumption monitoring at splash pads, arenas, and pools.

The challenges and opportunities identified at the onset of the project carried through as underlining themes in ongoing discussions with the City. These themes, either directly or indirectly, impact virtually every aspect of this project including customer service, operational efficiencies, and system management activities to name just a few examples.

A business case of this nature is most successful when:

1. **The goals identified in the business case align with the City of Winnipeg's goals:** The City of Winnipeg has stated goals that can specifically align with the results of this project including aspects of the City's 2021-2023 Corporate Strategic Plan, OurWinnipeg 2045 Development Plan, Winnipeg's Climate Action Plan, and Complete Communities 2.0, An

OurWinnipeg Direction Strategy. Furthermore, the Business Drivers outlined herein and their respective rankings will reflect the role of AMI/AMR technology in addressing those Business Drivers defined as priorities.

2. **Functionality of the system meets the needs of the Water and Waste Department and the communities and citizens it serves:** Just because a technology allows for certain functionality does not necessarily mean it addresses the needs of a utility and the communities it serves. The AMI/AMR business drivers assessment (ranking) allows the City of Winnipeg to hone in on those technology features that address the specific utility needs. Both AMR and AMI are assessed to show how well each technology meets the functional need.

3. **Capital cost estimate should match the real costs:** The capital costs used in the business case should include the full scope to successfully implement the recommended approach. This cost should be revisited as the City progresses through the technology upgrade process (i.e., after procurement and at key milestones during installation phase).

4. **Benefits should extend outside just the meter to cash process:** The business drivers need to look beyond the meter to cash process. This may include benefits to the City and to the customer that may be more difficult to calculate but offer improved efficiencies or service levels.

Understanding existing challenges and establishing priorities is fundamental to benchmarking the success of any water meter replacement and meter reading technology review. It is important that the business case clearly show the expected impact to the customer as well as to the City of Winnipeg.

1.2. Connections to Existing City Goals

2021-2023 Corporate Strategic Plan: This water meter replacement and AMI/AMR project also aligns with Winnipeg's existing 2021-2023 Corporate Strategic Plan which includes four strategic directions: (1) Culture, (2) Continuous Improvement and Innovation, (3) Communication and Engagement, and (4) Customer Service as summarized below based on the following ranking criteria:

Adherence to Goal	Definition
Not applicable	This goal does not apply
Low	There are few elements of this goal that align to this project AND/OR the technology considered may not fully support this goal.
Medium	There are some elements of this goal that may align to this project AND/OR the technology considered may support this goal.
High	Yes, this goal aligns well with this project AND/OR the technology strongly supports this goal.

Table 2 – Definition of Adherence to Goal Rankings

Through workshop discussions, the City identified those strategic goals whereby AMR or AMI technology could support that corporate strategy. A total of 16 strategic goals were examined:

- AMR could support 14 goals (10 ranked as medium, 4 ranked as low).
- AMI could support 14 goals (8 ranked as high, 5 ranked as medium, 1 ranked as low).

Strategic Direction	Strategic Goals	AMR	AMI*
CULTURE foster a collaborative, engaged, and value-driven organizational culture embodying reconciliation, diversity, and inclusion	1.1 – Measure & increase employee engagement	Low	Medium
	1.2 – Embody reconciliation	N/A	N/A
	1.3 – Increase diversity, inclusion, & employment equity	N/A	N/A
	1.4 – Improve safety & health	Medium	Medium
	1.5 – Strengthen financial management & accountability	Medium	High
	1.6 – Expand risk management framework	Medium	Medium
	1.7 – Enhance employee development & performance	Low	Medium

Strategic Direction	Strategic Goals	AMR	AMI*
CONTINUOUS IMPROVEMENT & INNOVATION Drive continuous improvement and performance measurement in processes and procedures across the organization	2.1 – Identify, review, and improve key city processes across the public service	Medium	High
	2.2 – Strengthen linkages between service level goals and their measurements to help communicate and drive performance	Medium	High
Strategic Direction	**Strategic Goals**	**AMR**	**AMI***
COMMUNICATION AND ENGAGEMENT collaborate to improve internal and external communication with elected officials, residents, employees, and businesses.	3.1 – Improve communication with elected officials across departments	Medium	High
	3.2 – Improve communication with residents across departments	Medium	High
	3.3 – Improve communication with businesses across departments	Low	Medium
	3.4 – Improve communication with employees across departments	Low	Low
Strategic Direction	**Strategic Goals**	**AMR**	**AMI***
CUSTOMER SERVICE Improve the efficiency, effectiveness, and responsiveness of city services.	4.1 – Identify and define customer level of service (LOS) for existing city services	Medium	High
	4.2 – Increase understanding and transparency of service costs relative to LOS	Medium	High
	4.3 – Maintain customer service satisfaction levels	Medium	High

Table 3 – Technology's ability to Support City Strategies
** often includes the implementation of a customer portal*

OurWinnipeg 2045 Development Plan: The City has defined six goals for Winnipeg localized from the United Nations Sustainable Development goals as outlined in the document OurWinnipeg 2045 Development Plan, Appendix 1 including: (1) Leadership and Good Governance, (2) Environmental Resilience, (3) Economic Prosperity, (4) Good Health and Well-being, (5) Social Equity, and (6) City Building.

Based on these categories, the City identified seven objectives whereby AMR or AMI technology could support the execution of that objective.

- AMR could support 6 objectives and 1 objective was considered Not Applicable (1 ranked as medium and 5 ranked as low).
- AMI could support 7 objectives (5 ranked as high, 2 ranked as medium).

Category	Objective	AMR	AMI*
LEADERSHIP AND GOOD GOVERNANCE	1. Establish and implement priority actions through evidence-informed decision making processes.	Low	High
	2. Promote trust and government responsiveness through meaningful, inclusive and informed community engagement.	Low	High
	3. Achieve community-responsive service delivery through an aligned, integrated, collaborative and results-orientated organizational culture.	Low	High
Category	**Objective**	**AMR**	**AMI***
ENVIRONMENTAL RESILIENCE	1. Prioritize the transition to a resilient, low-carbon future through demonstrated organizational and community leadership, and collaborative actions that mitigate and adapt to changing climate.	Not Applicable	High
	2.18 Portable Water Conservation	Medium	High
Category	**Objective**	**AMR**	**AMI***
CITY BUILDING	1. Responsibly plan, prioritize and accommodate growth in areas that best support Complete Communities principles, to achieve this Plan's sustainable development goals	Low	Medium
	2. Integrate resilient land use, transportation and infrastructure planning, and investments.	Low	Medium

Table 4 – Technology's ability to Support City Objectives

Climate Action: The team further discussed OurWinnipeg 2045 in terms of the City's climate action goal of net zero by 2050. The team discussed several opportunities where advanced metering technology could potentially support various climate related initiatives:

- Emissions reduction goals could be supported by advanced metering technology where driving is not required while also providing an opportunity for corporate leadership.

- Support the City's existing project to update green building policies as well as the City's Building Energy Disclosure project which is currently focused on energy and emissions but is looking to broaden its scope to include water use under the climate action plan.
- The Community Energy Investment Roadmap model includes energy and emissions to 2050 with a focus on how to transition energy systems and reduce overall energy use – alignment with advanced metering can also make connections with this initiative by reducing energy usage as part of the water distribution system and at city facilities such as pools and splashpads.

Complete Communities 2.0, An OurWinnipeg Direction Strategy: The City's Complete Communities 2.0, An OurWinnipeg Direction Strategy includes a focus on Financial Growth (itemized at B2) with a vision that "the City will integrate land use and infrastructure planning with capital budgeting to achieve long term financial sustainability". Specifically this document describes Goal 2.0 Strive for financial sustainable city infrastructure, capital assets, and Services.

Based on this category, the City identified a connection to the area referred to as Policies Capital Projects and its accompanying sub-actions:

- AMR could support 4 objectives (4 ranked as medium).
- AMI could support 4 objectives (4 ranked as high).

Category	Goal	AMR	AMI*
B2 FINANCIAL GROWTH Vision: The City will integrate land use and infrastructure planning with capital budgeting to achieve long term financial sustainability.	Goal 2.0 - Strive for financially sustainable city infrastructure, capital assets, and services. Policies Capital Projects		
	2.1 Understand and plan for the full lifecycle cost of capital investments and services in advance of development approval and capital procurement.	Medium	High
	2.1.1 Align and prioritize City investment in capital projects based on the strategic priorities of the City as outlined in *OurWinnipeg*, this By-law, the *Infrastructure Plan*, the capital budget, and on the overall fiscal realities identified through the budget process.	Medium	High
	2.1.2 Align capital project planning with the development priorities and phasing policies of this By-law.	Medium	High
	2.1.3 Identify and evaluate each capital project to determine its growth-related components and the City's share of costs.	Medium	High

Table 5 – Technology's ability to Support Goal 2.0: Strive for financial sustainable city infrastructure, capital assets, and Services

2. AMI/AMR BUSINESS DRIVERS

2.1. Connecting Project Goals with AMI/AMR Business Drivers

In collaboration with the City of Winnipeg, the Diameter Services team reviewed, assessed and ranked 38 different AMI/AMR business drivers. To frame the overall analysis, Diameter Services has identified six categories where AMI/AMR technology offer benefits:

1. **Revenue Protection (RP)**
   Ability to identify areas of revenue improvement, reduce theft and tampering, respond quicker to stopped meters, and an improved ability to apply the right meter technology to customer applications.

2. **Operational Efficiency (OE)**
   Improvements in response time to maintenance issues; reduced meter reading costs and hazards; reduced exceptions, effort to bill and additional trips into the field to collect data.

3. **Improved Distribution System Management (DS)**
   Improvements in the utility's ability to manage its distribution system through district leak detection, dynamic water balance, system wide leak detection, discrete water quality monitoring and more efficient code enforcement.

4. **Enhanced Customer Service (CS)**
   Improvements in customer service through the ability to provide customers' consumption information, online access to consumption, alerts to avoid high water bills or damage, and customer leak detection.

5. **Societal Benefits (SB)**
   Improvements in water conservation and carbon emissions.

6. **Smart Utility/Smart City (SC)**
   Improvements to areas beyond water consumption by leveraging the network for other organizational needs.

2.2. Evaluating Business Drivers

AMI and AMR technology have different features and functionality. The movement to a specific technology should be driven by looking at the importance of various business drivers and selecting the technology that best addresses those drivers. When features or functionality within the AMI/AMR technology address a challenge or improve delivery of water service, it is considered a business driver.

The Diameter Services team reviewed 39 different business drivers with the City of Winnipeg's staff to determine the organization's needs and identify the best technology fit. The development and assessment of the business drivers provides a definition of the actions Winnipeg should expect to implement, first by identifying what is important to the Utility followed by matching the technology that supports these actions.

A business driver may have a financial or non-financial impact (benefit or cost). For the purposes of this report, they have been separated. If a business driver has both a financial and non-financial impact, it will show up accordingly. Only those financial business drivers that were defined by the City of Winnipeg as important or essential have been quantified in terms of financial benefit or cost. *See Table 6 for definitions of important or essential*.

AMI/AMR technology will improve a water utility's operations in several areas; some can be easily calculated, while others will show a qualitative improvement in a respective area. AMI/AMR technology should be considered a tool that the utility uses to improve how the utility operates. The areas of improvement often do not have a direct financial improvement but are still critical to the utility achieving the broader goals of the organization.

To evaluate business drivers, Diameter developed a scoring system that allowed Winnipeg to establish the importance of each business driver and by extension the goals of the project.

Importance to the water utility is defined and scored using the table below.

Score	Importance	Description
0	Not Important	The City will not implement the business driver in the future
1	Future	The City may implement the business driver
2	Important	The City will implement the business driver immediately
3	Essential	The City will implement the business driver immediately and it is critical to the project

Table 6 – Business Drivers Score and Importance to the City

AMI/AMR technologies function differently, have different operational impacts on the utility and provide different benefits partially due to the differences in data each provides. Depending on the technology, the City of Winnipeg will be able to either fully achieve, partially achieve, or not achieve specific business drivers. This system of scoring is designed to accomplish two things. First it prioritizes those business drivers that are most important to the City of Winnipeg and secondly, it helps to define the technology alternatives that provide required functionality, which is key to developing cost/benefit results. The following criteria is used in this determination:

Score	Ability to Support the Business Driver	Description
 (ZERO)	Does not support a Driver. In the Technology Assessment Column in Appendix A, this is referred to as (ZERO).	The business driver as described cannot be implemented using this technology.
 (PART)	Partially supports a Driver. In the Technology Assessment Column in Appendix A, this is referred to as (PART).	The business driver as described can be partially implemented using the technology.
 (FULL)	Fully supports a Driver. In the Technology Assessment Column in Appendix A, this is referred to as (FULL).	The business driver as described can be fully implemented using the technology.

Table 7 – Scoring: Ability to Support the Business Driver

2.3. Business Driver Assessment Summary

A complete list of the business drivers and recommendation rationale are detailed later in this section which will describe the business drivers along with each technology's ability to achieve the goals of the driver.

As a preface to that in-depth discussion, and to provide a high-level overview of the workshop findings, an overview is provided below, which is designed to provide a quick snapshot of the business drivers and related priorities for the AMI/AMR project.

ID	Revenue Protections (RP)	Score
RP 1	Zero Consumption – Tampering / Stopped Meter	3
RP 2	Zero Consumption - Turned off for Non-payment	3
RP 3	Zero Consumption - Empty Pipe Alert	1
RP 4	Detect Misapplied meters	0
RP 5	Support for Leak forgiveness Program	2
	Operational Efficiency (OE)	
OE 1	Reduce Regular Meter Reading Costs	3
OE 2	Same Day Final Reads	2
OE 3	Improve Meter Reading Safety	3
OE 4	Meter Reading Reliability – (Incorrect Reads Provided by Customer)	3
OE 5	Meter Reading Estimation	3
OE 6	Remote Turn-off / Turn-on	2
OE 7	Reduced Customer Inquiries	3
OE 8	Monthly Billing	2
	Improved System Distribution Management (DS)	
DS 1	District Metering	0
DS 2	Water Balance Calculation Frequency	2
DS 3	Acoustics Leak Detection (ALD) - Main Break Monitoring - Drop and Place	1
DS 4	Acoustics Leak Detection (ALD) - Main Break Monitoring - Entire System	0
DS 5	Acoustics Leak Detection (ALD) - Hydrant Monitoring	0
DS 6	Detect Backflow Events	2
DS 7	By law Enforcement	0
DS 8	Pressure Monitoring (targeted locations)	1
DS 9	Temperature Monitoring - Frozen Services (specific areas)	3
DS 10	Peak Demand Monitoring / Planning	0
DS 11	Hydraulic Monitoring	1
	Customer Service Enhancements (CS)	
CS 1	Current City Customer Engagement	Not Scored
CS 2	Not applicable and was not included	n/a
CS 3	Customer Engagement – Passive	3
CS 4	Customer Engagement – Interactive	3
CS 5	Customer Engagement – Progressive	3
CS 6	Leak Detection - Small	2
CS 7	Leak Detection - Broken Pipe	1
CS 8	Vacation Monitoring	1
CS 9	Seamless Customer Experience	2
CS 10	Program Enrollment	1
CS 11	Online Bill Payments	0
	Societal Benefits (SB)	
SB 1	Conservation Program Support	0
SB 2	Climate Change - Reduced CO2	1
	Smart Cities (SC)	
SC 1	Smart Cities - Smart Lighting	0
SC 2	Smart Cities – Transportation	0
SC 3	Smart Cities - Public Safety (Gun shots, earthquakes)	0
SC 4	Smart Cities – Wastewater Monitoring	1
SC 5	Smart Cities – Water Quality Monitoring	1

SC 6	Smart Cities - Garbage Monitoring	0

Table 8: Business Driver Assessment (higher score is more important)

The following provides a summary of the business driver assessment summarizing only those ranked as Essential (Score of 3) or Important (Score of 2).

ID	Revenue Protections (RP)	Score	AMR	AMI
RP 1	Zero Consumption – Tampering / Stopped Meter	3		
RP 2	Zero Consumption - (Turned off for Non-payment)	3		
RP 5	Support for Leak forgiveness Program	2		
	Operational Efficiency (OE)			
OE 1	Reduce Regular Meter Reading Costs	3		
OE 2	Same Day Final Reads	2		
OE 3	Improve Meter Reading Safety	3		
OE 4	Meter Reading Reliability – (Reduce Incorrect Reads)	3		
OE 5	Meter Reading Estimation	3		
OE 6	Remote Turn-off/Turn-on	2		
OE 7	Better Data for Customer Inquiries	3		
OE 8	Monthly Billing	2		
	Improved System Distribution Management (DS)			
DS 2	Water Balance Calculation Frequency	2		
DS 6	Detect Backflow Events	2		
DS 9	Temperature Monitoring – Frozen Services	3		
	Customer Service Enhancements (CS)			
CS 3	Customer Engagement – Passive	3		
CS 4	Customer Engagement – Interactive	3		
CS 5	Customer Engagement – Progressive	3		
CS 6	Leak Detection - Small	2		
CS 9	Seamless Customer Experience	2		

Table 9: Business Driver Assessment (Essential or Important Ranking)

2.4. Detailed Business Driver Assessment

A complete list of all business drivers, how they were scored in terms of importance to the City and technology's ability to support the driver is listed in Appendix A. Table 10 below focusses only on business drivers that were deemed Important or Essential to the Project.

The detailed assessment includes:

- a reference number for each business driver.
- a description/definition of the business driver.
- how the business driver applies to the City based on workshop discussions.
- technology implications.
- the benefits to the City of Winnipeg.
- rank of importance.

The table immediately below summarizes the information in Appendix A and focusses on the Business Drivers that the City of Winnipeg ranked as Important or Critical

Table 10: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Relevance to Winnipeg**	**Technology Assessment**
Revenue Protection (RP)					
RP1	**(3) Critical**	**Zero Consumption** **Stopped Meter/Tamper Protection**	Residential customers may remove the register head or meter resulting in zero consumption for full days in the middle of a billing period. Commercial customers may turn on bypasses resulting in zero or reduced consumption compared to other similar industries.	A goal at Winnipeg is to identify tamper or stopped meter situations The City averages greater than 1,600 per year in known tampers but believes the real number of tampers could be substantially more.	With AMR, the time lapse between meter readings means tampers could go on for some time before being exposed. AMI's ability to receive hourly information on a daily basis can flag these occurrences virtually immediately.
RP2	**(3) Critical**	**Zero Consumption** **Turned off for non-payment**	The Opportunity to monitor customers that were turned off for non-payment to ensure the water was not turned back on without authorization.	It can/does happen where customers will turn the water back on. The City will roll a truck to make sure the water remains off on approximately 10% of the occurrences.	AMR's ability to monitor for unauthorized consumption is dependent on read frequency (i.e., monthly or bi-monthly). With AMI, customers can be to put into a "virtual" shut off group and the utility will receive notification if there was unsuspected consumption
RP5	**(2) Important**	**Support for Leak Forgiveness Program**	The ability to pin-point a leak to a specific event or date. (customer side leak) can support the justification of leak forgiveness or may lead to fewer people qualifying by catching leaks sooner.	The City spends $110,000 on average/year for leak forgiveness	The opportunity for customers to be notified of leaks is limited to meter reading frequency and is simply a "yes/no" flag. Interval data can be captured by most AMR systems as requested on a limited number of meters which can help pinpoint start of the event. AMI captures hourly consumption information daily, and would help the utility calculate how long and how much water leaked on a customer's service. It also allows the leak to captured and the customer to be notified much quicker. .
Operational Efficiency (OE)					
OE1	**(3) Critical**	**Reduce Regular**	Reduces the need to collect meter readings in the field.	The City's Current meter Reading costs are ~ $927,000	AMR reduces meter reading costs but meter readers in the field are still required.

Table 10: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Relevance to Winnipeg**	**Technology Assessment**
		Meter Reading Cost			**AMI**. AMI eliminates virtually all meter readings performed in the field.
OE2	**(2) Important**	**Same Day Final Reads**	Technology provides the ability to collect off cycle meter readings to facilitate Move In / Move Outs	Reads are currently phoned in for move in or move out. If a read is not received, the bill is estimated or prorated. Media situations and legal issues can happen due to discrepancies (b/w move-out read and the move-in read)	AMR requires a field visit to collect the data. Certain types of system may be able to produce a daily read through Mobile No field visit is required with AMI since Daily register reads and/or On-demand readings are available. Also, with AMI the Utility can be alerted about water use prior to a customer setting up an account with the Utility.
OE3	**(3) Critical**	**Improve Meter Reading Safety**	The goal is to Reduce lost time Injuries related to meter reading. Examples include slips and falls, dog bites	Safety takes priority for the City.	AMR reduces the number of meter readers in the field and decreases some safety aspects of manual meter reading (slips and falls, dog bites). However, it increases vehicle safety risks to meter readers and citizens. AMI virtually eliminates all meter readers in the field aside from exceptions such as a non-communicating meter where a meter reading may be manually read.
OE4	**(3) Critical**	**Meter Reading Reliability (Incorrect Reads Provided)**	Electronic meter readings reduce the time and work associated with customers delivering inaccurate reads	Incorrect meter reads creates billing issues and an avoidable burden on the customer service department. For example, there is extra effort on the Utility Billing Centre to make calls for bills over a particular amount some of which are due to incorrect reads provided by customers.	Both AMR and AMI radio transmitters receive electronic (i.e., encoded) readings from the water meter register greatly reducing the likelihood of incorrect meter readings being processed for billing.
OE5	**(3) Critical**	**Water Bill Estimates**	Meter reading technology provides the opportunity to reduce both the number of estimates that need to be calculated and the staff time associated with the estimates.	The City of Winnipeg provides ~270,000 estimates per year. ~20,000 of the estimates are manually generated.	Both AMR and AMI receive radio transmitters received encoder reads provided that are generally reliable and successful.

Table 10: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Relevance to Winnipeg**	**Technology Assessment**
					With AMI, usually meter reading exceeds 99.5% Read Success Rate. AMR read success rate may be equally as high but sometimes requires additional truck rolls to capture missed reads.
OE6	**(2) Important (in targeted accounts)**	**Remote Turn-off / Turn-on**	Greatly reduce the time, effort and cost (i.e., truck rolls) associated with turning off and subsequently turning backing on water.	There were 2,200 shut-offs in 2019 for non-payment. Also in 2019 there were 250 truck rolls to confirm water remained off. The City believed that the opportunity to turn off/turn on water remotely would be of particular benefit to landlord accounts.	AMR does not offer the opportunity to remotely turn water off or on. A two-way AMI technology can allow a water utility to remotely shut off valves or valve enabled water meters. This would eliminate the need to send a technician out to shut off the water. Throttling the water is also possible with some technology options.
OE7	**(3) Critical**	**Better Data for (Reduced) Customer Inquiries**	More accurate meter reading data is expected to reduce customer inquiries and help CSRs with the inquiries they do receive – especially if they have hourly, daily and monthly information available.	The City sees this opportunity as critical. Having more reliable information is proven to solve issues. The City is not seeing issues from radio read meters - issues are completely focused on areas without technology.	AMR meter reading is generally very reliable and will result in better data to reduce inquiries and help CSRs better respond to inquiries. However, AMI provides hourly, daily, monthly consumption information and make it available to customer service reps and customers through a Customer Portal.
OE8	**(2) Important**	**Ability to Perform Monthly Billing**	Meter Reads provided in a timely fashion enable more frequent billing and will allow the City to move to monthly billing as opposed to quarterly.	Moving to monthly billing has been a discussion point at the City this year.	AMR and AMI can help the City move to monthly billing. The estimate is for 3.5 FTE Meter Readers using AMR to provide these readings. AMI provides hourly, daily and monthly consumption information to bill as required.

Table 10: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Relevance to Winnipeg**	**Technology Assessment**
Improved System Distribution (DS)					
DS2	**(2) Important**	**Water Balance Calculation Frequency**	The opportunity for water utilities to perform a water balance more frequently and accurately to calculate non-revenue water across their system.	The City of Winnipeg does a water audit once a year and since a significant portion of the consumption is estimated the City lacks confidence in the numbers (and therefore the audit).	AMR does not allow all customers to be read on the same day and does not enable this type of program to be implemented without estimation. AMI provides actual meter readings from all meters on the same day. This consumption information can be summed and monitored on a frequency of the utility's choosing (monthly, weekly, daily) and compared to water input into the system during the same time period.
DS6	**(2) Important** ***Specific for commercial meters***	**Detect Backflow Events**	The use of certain meter reading technology can alert of backflow events and help protect the water system.	The City of Winnipeg has a Backflow program for all "moderate and severe" hazard premises. Technology would help to identify failures in backflow prevention devices. For DCVA devices for example, it's currently not known that they failed until there's inspection. 2/3 of backflow prevention devices are DCVA devices • Could also help identify locations that do not have a prevention device	AMR could allow for reverse flow to be flagged if provided by the meter register or radio transmitter. It is unlikely the timing of the event will be determined and the extent of the backflow. AMI enables a utility to set up reports based on hourly consumption information to monitor the backflow. Some meters enable forward flow measurement to be separated from backward flow through the meter and both can be measured. In this case and if an event occurred, they would be able to tell when and how much water came back into the system and detect a backflow problem relatively quickly. Where forward and reverse flow can't be separated, an AMI system can be setup with short intervals and can monitor that reverse

Table 10: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Relevance to Winnipeg**	**Technology Assessment**
					flow does not exceed forward flow, indicating a backflow device is not operating correctly. These alerts/alarms then allow a water utility to monitor and respond quickly to backflow events. Often 5% to 10% of backflow devices can fail per year. Helps validate property owner testing programs and reduces cross contamination risks.
DS9	**(3) Critical**	**Temperature Monitoring**	Water temperature monitoring provided by some metering technologies can help utilities/customers proactively respond to freezing temperatures and avoid frozen services.	In some years, the City has had thousands of frozen services and thousands of households running water. In 2014, there were 6884 accounts frozen on City-side and 636 accounts frozen on property-side. The City has ranked Temperature Monitoring as Critical contingent on the data quality/applicability.	AMR does not provide temperature monitoring. AMI requires a water meter that monitors and transmits temperature (C715) and generally requires the meter and AMI manufacture to be the same.
Enhanced Customer Service (CS)					
CS3	**3**	**Customer Engagement** **Passive**	Customer Engagement – Passive - A customer facing business process that provides limited information in a paper format for the single purpose of water billing.	Utilities often start with lower levels of customer engagement usually defined as reactive responses to customer complaints or passive notices included on water bills. The utility is reliant on the customer to initiate the engagement. The City of Winnipeg is already at this level of customer engagement.	Both AMR and AMI support Passive Customer Engagement.
CS4	**3**	**Customer Engagement** **Interactive**	Customer Engagement – Interactive. A customer facing business process that provides information in a paper and digital format for the purposes of water billing, bill comparison to previous periods and payments data.	As a utility applies meter reading technology that includes a customer portal, the customer engagement becomes more interactive. Better access to consumption information, proactive notification of leaks would be examples. The City of Winnipeg has some interactive features such as:	AMR readings will support a passive engagement where the customer can decide to view their billable consumption.

Table 10: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Relevance to Winnipeg**	**Technology Assessment**
				• bill presentment • Credit Card payments • Financial Institutions (online/in person) • submit and track requests through 311 • IVR	Displaying consumption flags could enhance the level of engagement especially when a continuous leak flag could be displayed for a customer complaining of a high bill. Some interactive engagement but likely would fall short in several areas. Requires a portal. AMI technology would allow customers to view hourly consumption through a customer portal to better understand their consumption behavior. Portals generally include some global consumption alerts and are more interactive.
CS5	**3**	**Customer Engagement** **Progressive**	Customer Engagement - Progressive A customer facing business process that provides paperless information to customers regarding water billing, bill comparison to previous periods, payments data, online payment, setting consumption alerts/alarms, consumption behavior analytics, and potentially online service requests.	This “best in class” customer engagement requires a fully functional customer portal to handles proactive communications with customers but also program management (i.e., conservations) as well. This engagement builds on the functionality provided by the City today for additional and proactive alarms (leaks), bill comparisons (similar households, previous periods), requests for shut-offs (snow-birds).	AMR readings system would have limited capabilities. Would not achieve a progressive engagement even with a customer portal. AMI technology and a best-in-class customer engagement platform would provide the “personalized” service through customize alerts, and resolution workflows.
CS6	**(2) Important**	**Leak Detection – Small**	This functionality provides the opportunity for a utility to set a leak threshold, so it is proactively notified of a customer leak. Customers can set their own separate threshold which may be different than the utility threshold to receive proactive notifications from a customer portal.	This type of customer side leak detection would help customers avoid large bills and could help reduce leak forgiveness dollars provided by the utility, payment deferrals and high bill complaints.	AMR would only provide a utility set leak flag and either a bill print adjustment or a portal to display the flag would be required. AMI technology in conjunction with a customer portal will achieve this.

Table 10: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Relevance to Winnipeg**	**Technology Assessment**
CS9	**(2) Important**	**Seamless Customer Experience**	A Seamless Customer Experience refers to a single web application that allows customers access, or provides information, to all City services including water utility information. Through the Seamless Customer Experience, the customer could see payment history, consumption history, outstanding payables, make payments online, view (and sign up to) City programs, pay taxes etc.	The City of Winnipeg does not want 2 portals or a different look and feel for the AMI portal. There is a significant initiative within the City to have everything “look and feel” the same. The City wants a single sign on that would provide consumption and payment balance/history. The city is in early discussions on a Citizen portal which will be the main portal.	With AMR, Customer Portal Technology typically not provided as part of an AMR implementation. AMI vendor provided Customer Portals generally focus on consumption data without the ability to deal with payments and payment history. It will not be a “seamless customer experience. A Fully Functional Portal allows for the seamless customer experience with its customizable branding and single sign on capabilities.

3. WATER METER ASSESSMENT

3.1. Introduction

At the onset of this study, Diameter requested that the City of Winnipeg provide a database with specific information pertaining to all the active water accounts. In preparation for the workshops, an analysis of this information was conducted to identify: Customer Class, Age and Size of meter population, Meter Type, Register Type, Number of Dials being read and Read Frequency. During Workshop 1, this information was presented to Winnipeg's Core Project Team to validate for accuracy and minimize assumptions going forward. The information provided below is a result of Diameter's analysis in December 2021 and the subsequent workshop conducted.

3.2. Customer Classes

Winnipeg's water customer population is made up of seven Customer Classes – Government, Industrial, Landlord, Large Commercial, Multi-Family Residential, Single Family Residential, Small Commercial. The total number of meters by Account Class is detailed in Table 11 below.

Customer Class	Total
Government	774
Industrial	384
Landlord Account	4,793
Large Commercial	1,885
Multi-Family Residential	11,119
Single Family Residential	187,642
Small Commercial	10,554
Grand Total	217,151

Table 11 – Total number of meters by Account Class as of December 2021

A further breakdown of the various sized meters in each Customer Class is provided below in Table 12.

	Meter Size					
Account Class	5/8”	3/4”	1”	1.5”	2”	Total
Government	111	83	117	199	233	**743**
Industrial	125	51	80	45	45	**346**
Landlord Account	4,501	126	97	38	30	**4,792**
Large Commercial	52	36	808	458	388	**1,742**
Multi-Family Residential	8,570	586	1,253	493	194	**11,096**
Single Family Residential	185,743	1,671	205	15	8	**187,642**
Small Commercial	6,967	1486	1094	492	453	**10,492**
Total	**206,069**	**4,039**	**3,654**	**1,740**	**1,351**	**216,853**

Table 12 - Meter Size by Customer Class

	Meter Size						
Account Class	3”	4”	6”	8”	10”	Wtr Mtr Private	Total
Government	18	7	3	2	1	5	**36**
Industrial	24	7	7	0	0	6	**44**
Landlord Account	1	0	0	0	0	0	**1**
Large Commercial	85	37	16	4	1	2	**145**
Multi-Family Residential	19	3	1	0	0	0	**23**
Single Family Residential	0	0	0	0	0	0	**0**
Small Commercial	49	10	3	0	0	1	**63**
Total	**196**	**64**	**30**	**6**	**2**	**14**	**312**

Table 12 Continued - Meter Size by Customer Class

3.3. Water Meter Age

In order to move to AMR or AMI, the City of Winnipeg will need to change the majority of its meters because the meter registers are not compatible with radio transmitter technology. Therefore, the age of the City’s meters is not as relevant to move to AMR or AMI as is the functionality of the meter’s register.

Where age is relevant in Winnipeg’s case, is from a standpoint of helping to determine potential revenue increases once the City changes out its meter population. Below is a break-out of the City’s meter population by size and age category which will, along with consumption information, be used in the revenue gain calculations.

Meter Size	0-4 Years Old	5-9 Years Old	10-14 Years Old	15 - 19 Years Old	> 20 Years Old	Total
5/8"	29,948	26,911	24,065	19,269	105,876	**206,069**
3/4"	554	506	471	371	2,137	**4,039**
1"	520	415	290	517	1,912	**3,654**
1 ½"	175	164	263	355	783	**1,740**
2"	286	219	130	233	483	**1,351**
3"	53	38	18	14	73	**196**
4"	7	24	8	4	21	**64**
6"	17	4	3	0	6	**30**
8"	1	1	1	0	3	**6**
10"	0	0	1	0	1	**2**
Total	**31,561**	**28,282**	**25,250**	**20,763**	**111,295**	**217,151**

Table 13 – Water Meters broken out by Age

From the table above, over 60% of the City of Winnipeg's meters are over 15 years old and over 72% are older than 10 years. The water meter industry uses age to help determine accuracy and revenue loss. Age is generally reflective of consumption and as consumption increases so too does meter wear and accuracy decline. Water quality, such as "hardness", also impacts meter accuracy from the standpoint that harder water negatively impacts meter accuracy to a greater extent than softer water. Winnipeg has an average calcium carbonate concentration of 80.5 mg/L according to the City's website (https://winnipeg.ca/waterandwaste/water/testresults/winnipeg.stm) which is equal to the median value found in Canada. "A survey of municipal water supplies in Canada showed that half of all Canadian municipalities had hardness levels below 80 mg/L, and 20% had levels greater than 180 mg/L. (https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-drinking-water-quality-guideline-technical-document-hardness.html). As a result, no special consideration will be given to additional accuracy loss because of the hardness levels in the City's water.

The City of Winnipeg has done meter accuracy testing on meters removed from River Heights and compared revenue changes at these locations. There were 494 meters removed although some meters were not tested, or no data was provided. Comparing average consumption/day between the meters removed from service with the new meters on 474 meters indicates a ~7% increase in consumption for the year.

The breakdown of revenue increase from meters removed as compared to replacement meters for specific age categories is shown below.

River Heights Meter Accuracy Revenue Changes by Meter Age Category		
Age Category	**Increase In Revenue**	**Number of Meters in Sample**
0-5 Years	6.60%	77
6-10 Years	5.50%	53
11-15 Years	15.42%	36
16-20 Years	0.37%	35
21-25 Years	17.30%	22
26-30 Years	3.70%	145
31-40 Years	9.07%	106
Expected Revenue Increase from Meter Changes (Total Weighted Average)	6.85%	

Table 14 – Expected Revenue Increase from Meter Changes using River Heights meter change-outs as a Sample.

Understanding the true state of the City's entire meter population is difficult as evidenced in the chart above. Note the revenue increases over one year in the 11-15 year range is 15.42% while in the 16-20 year range is only .37%. Small sample sizes can obviously account for some of that variation when looking at individual age categories but looking at the entire sample provides an approximate expectation of revenue increases with a complete meter change-out considering that the average age of the City's meters is 20 years old.

While a much larger sample of meters can be sent out for testing across the flow range, it is a costly and lengthy process. An alternative to large scale and lengthy test procedures is to estimate revenue improvement using Neptune's SEER® Program which provides an estimated accuracy based on the water meter size, age, and manufacturer.

Estimated Accuracy (SEER)	
Age	Meter Accuracy
1	99.66%
2	99.32%
3	98.98%
4	98.64%
5	98.30%
6	98.00%
7	97.70%
8	97.10%
9	97.10%
10	96.80%
11	96.45%
12	96.10%
13	95.75%
14	95.40%
15	95.12%
16	94.80%
17	94.48%
18	94.16%
19	93.83%
20 or greater	93.51%

Table 15 - Neptune SEER Water Meter Accuracy Estimate by Age

The chart represents an average meter accuracy across age category and meter size. Neptune's SEER® (Statistical Evaluation for the Enhancement of Revenue) analysis tool was specifically designed to identify Non-Revenue Water at the water meter level. SEER Model can determine meter accuracy within a 95% confidence interval. Because this accuracy data has been provided by the manufacturer, we recommend taking a conservative approach to these expected accuracy improvements. When calculating revenue loss in the Financial Model, we will only include a percentage of the expected accuracy loss based on additional factors such as water quality.

It is interesting to note that the overall age of the River Heights meters tested is just over 21 years and the revenue gain experienced by the City after changing these meters is roughly in line with the SEER meter accuracy shown above for meters aged 20 years or greater.

3.4. Meters by Size and Consumption

The table below shows the percentage of the City's meter population by size and the amount of total consumption provided by each meter size. While 5/8" meters account for nearly 95% of the City's entire population, they only account for 52% of the City's total consumption. Conversely, 1" to 6" meters only account for 3.2% of the City's meter population with nearly 44% of the total water consumed underscoring the need for continued meter accuracy at these meter sizes.

			Consumption by Size (m3)			
Meter Size	Quantity	Percentage of Meters	2018	2019	2020	Percentage of Total Consumption (2020)
5/8	206,069	94.97%	30,030,736	29,654,584	31,436,020	52.05%
3/4	4,039	1.83%	1,831,892	1,803,372	1,729,472	2.86%
1"	3,654	1.66%	6,051,708	5,974,356	5,819,292	9.63%
1.5	1,740	0.80%	6,098,552	6,025,468	5,905,092	9.78%
2	1,351	0.61%	8,140,752	8,182,880	7,807,340	12.93%
3	196	0.09%	3,984,076	3,765,128	3,228,320	5.34%
4	64	0.03%	2,178,572	2,177,376	1,918,828	3.18%
6	30	0.01%	2,490,540	2,350,000	1,860,924	3.08%
8	6	0.00%	165,041	614,184	599,076	0.99%
10	2	0.00%	134,572	129,224	97,192	0.16%
Grand Total	217,151	100%	61,106,441	60,676,572	60,401,556	100%

Table 16 – Meters By Size and Consumption

3.5. Meters with Encoder Registers

Only meters with encoder registers can be used with either AMR or AMI meter reading systems. However, most of the City of Winnipeg's meters are direct read registers which are not compatible with radio transmitter technology.

The City does have some encoder registers in service already that are being used with the Itron AMR meter reading system. The number of meters that can be retained by the City will depend on whether AMR or AMI is selected, the vendor chosen, and the size of the meter. That is, in some cases, meters can be retained and only the meter register will be changed but in other cases, this approach is not cost-effective.

On smaller meters (5/8" and 3/4"), the cost of the meter register alone is about 75% the cost of a completely new meter leading utilities to replace entire meters, as opposed to registers only, at these sizes. For this reason, this document will assume 5/8" and 3/4" meters will not receive new registers and only encoder meters can potentially be retained. All direct read '5/8 and 3/4" meters will need to be changed. However, meters that are 1" and larger can receive a register upgrade where appropriate and avoid unnecessary costs of meter change-outs. These encoder meters can also be retained depending on the factors mentioned in the previous paragraph.

Below is a breakdown of meters with encoder registers broken out by size and age category.

	Encoder Register Meters – Meter Size by Age Category				
Meter Size	**0-4 Years**	**5-9 Years**	**10-14 Years**	**15 - 19 Years**	**Total**
5/8	3720	1875	699	5	**6299**
3/4	66	30	9		**105**
1"	133	56	7		**196**
1.5	11	17	5		**33**
2	123	50	8		**181**
3	52	32			**84**
4	6	21			**27**
6	14	3			**17**
8	1				**1**
Grand Total	**4126**	**2084**	**728**	**5**	**6943**

Table 17 – Encoder Meters by Size

3.6. AMR Capable Meters

The City has deployed Itron's AMR walk-by system for just over 6,500 meters but is expecting delivery of Itron's MC4Max in 2022 to move these meters to drive-by. For the most part, the Itron radio transmitter **(called the ERT)** is integrally mounted on the meter register forming a completely contained unit. Considering re-usability of the meter only, we previously established that it is not practical to replace meter registers on 5/8" and 3/4" meters due to the cost of the register is very close to that of the entire meter. However, integrally mounted ERTs pose additional challenges which need to be addressed.

3.6.1. 5/8" and 3/4" Encoder Meters that can be Retained with an AMR Solution

Assuming the City replaces meters 10 years and older, there are 5,691 5/8" and 3/4" meters that can be retained IF the City chooses Itron's AMR system as shown in the green highlighted column in Table 18. These meters can continue to operate as they are today and be replaced at the appropriate time in the future.

If another AMR System is chosen (anything other than Itron), all 5/8" and 3/4" mechanical meters with encoder registers would need to be changed. There is a total of 4,790 5/8" meters and 3/4" mechanical meters with encoder registers that would need to be changed because the integrally mounted ERTs make it impractical to retrofit these registers with a new radio transmitter in the field. 807 5/8" and 94 3/4" meters are non-mechanical and could be retained and retrofit with a new radio transmitter assuming there is a length of wire coming from the register making this possible or if the existing radio transmitters are connected to the register using Nicor connections for example.

5/8" and 3/4" Re-Usable Encoder Water Meters for an AMR Solution					
Meter Size	0-4 Years	5-9 Years	Total	Retained Meters	
				Itron AMR	Other AMR
5/8	3720	1875	**5,595**	**5,595**	**807**
3/4	65	31	**96**	**96**	**94**

Table 18 – 5/8" and '3/4" Encoder Meters that can utilized in an AMR Deployment

3.6.2. 1" and Larger Encoder Meters that Can be Retained with an AMR Solution

Different than 5/8" and ¾" meters, Intermediate and Large Meters can have their registers replaced cost effectively. For Meters 1" and Larger, table 19 shows the total number of 1" and larger meters

that can be retained when deploying an AMR solution. Separately, in the green highlighted column, we have indicated the number of meters and radio transmitters that can be retained "as is" when deploying an Itron AMR. The work types for both an Itron AMR deployment and a non-Itron AMR deployment are shown below in Tables 15 - 18.

While register replacements can be justified on larger meters for the most part, further discussions with the City will be warranted for AquaMaster Transmitter replacements since the AquaMaster register (or Transmitter) replacement for these meters is quite expensive. Table 19 assumes the City will proceed with AquaMaster Transmitter replacements on AquaMaster meters.

1" and Larger Re-Usable Water Meters				
Meter Size	**0-4 Years**	**5-9 Years**	**Total**	**Re-usable and with no Modification required to Meter or Radio if using Itron**
1"	520	415	**934**	**188**
1.5"	175	164	**338**	**27**
2"	286	219	**505**	**173**
3"	53	38	**91**	**84**
4"	7	24	**31**	**27**
6"	17	4	**21**	**17**
8"	1	1	**2**	**1**
10"			**0**	**0**
Grand Total	**1,059**	**865**	**1,924**	**517**

Table 19 – 1" and Larger Encoder Meters that can utilized in an Itron AMR Deployment

3.7. AMR Work Types

In the tables below, Work Types have been provided for the City's entire meter inventory, anticipating 2 possible AMR scenarios. The first is an AMR solution using Itron which is currently

deployed in a limited fashion at the City of Winnipeg. The second AMR scenario anticipates a solution other than Itron and outlines the implications on Work Types if this is the chosen path.

Work Types make the following Assumptions:

- No 5/8" and 3/4" meters will be retrofit with Registers only.
- 1" and Larger meters will be changed if they are 10 years or older.
- Direct Read Meters 1" or larger that are under 10 years old will be retrofit with a new Register
- AquaMaster Transmitters will require changing for a "non-Itron" solution since the encoder protocol is not supported by vendors other than Itron.
- There is 1 3" Turbine meter and 1 3" Compound meter which are under 10 years old and included in meter changes.

	5/8" and 3/4" AMR Work Types (Itron AMR)				
Meter Size	**Replace Meter / Install Transmitter**	**Retrofit Register / Install Transmitter**	**Retain Meter / Install Transmitter**	**No Work Required**	**Total**
5/8"	200,474			5,595	**206,069**
'3/4"	3,943			96	**4,039**
Total	**204,417**			**5,691**	**210,108**

Table 20 – 5/8" and '3/4" Meter Work Types (Itron AMR)

	1" and Larger AMR Work Types (Itron AMR)				
Meter Size	**Replace Meter / Install Transmitter**	**Retrofit Register / Install Transmitter**	**Retain Meter / Install Transmitter**	**No Work Required**	**Total**
1"	2,719	747		188	**3,654**
1.5"	1,401	311		28	**1,740**
2"	846	330	2	173	**1,351**
3"	102	6	4	84	**196**

	1" and Larger AMR Work Types (Itron AMR)				
Meter Size	**Replace Meter / Install Transmitter**	**Retrofit Register / Install Transmitter**	**Retain Meter / Install Transmitter**	**No Work Required**	**Total**
4"	**30**	**1**	6	27	**64**
6"	**9**		4	17	**30**
8"	**3**		2	1	**6**
10"	1		1	0	**2**
Total	**5,111**	**1,394**	**19**	**518**	**7,043**

Table 21 – 1" and Larger Meter Work Types (Itron AMR deployment)

	5/8" and 3/4" AMR Work Types (non-Itron AMR)			
Meter Size	**Replace Meter / Install Transmitter**	**Retrofit Register / Install Transmitter**	**Retain Meter / Install Transmitter**	**Total**
5/8"	205,262	0	807	206,069
'3/4"	3,945	0	94	4,039
Total	**209,207**	**0**	**901**	**210,108**

Table 22 – 5/8" and '3/4" Meter Work Types (non-Itron AMR deployment)

	1" and Larger AMR Work Types (non-Itron AMR)			
Meter Size	**Replace Meter / Install Transmitter**	**Retrofit Register / Install Transmitter**	**Retain Meter / Install Transmitter**	**Total**
1"	2,719	753	182	3,654

	1" and Larger AMR Work Types (non-Itron AMR)			
Meter Size	**Replace Meter / Install Transmitter**	**Retrofit Register / Install Transmitter**	**Retain Meter / Install Transmitter**	**Total**
1.5"	1,401	331	8	1,740
2"	846	437	68	1,351
3"	108	23	65	196
4"	33	19	12	64
6"	10	13	7	30
8"	4	2	0	6
10"	2	0	0	2
Total	**5,123**	**1,578**	**342**	**7,043**

Table 23 - 1" and Larger Meter Work Types (non-Itron AMR deployment)

Note: Of the 1,578 Register Retrofits mentioned above, 76 are AquaMaster Transmitter Replacements that are required when moving to an AMR/AMI system other than Itron. Only Itron supports the Elster protocol which is the protocol provided by the current AquaMaster Transmitters in place by at the City.

3.7.1. Itron vs. Non-Itron Work Types (AMR Deployment)

The difference in work types in an Itron AMR deployment vs. a non-Itron AMR deployment is for two reasons. The first is the fact that the City already has Itron AMR deployed in some areas and those ERT enabled meters under 10 years old can continue to be utilized with no modification. Secondly, AquaMaster Transmitters will not need changing with an Itron AMR deployment since the Itron ERT will read the Elster protocol that is output by these meters.

With a non-Itron AMR deployment, mechanical meters 1" and larger that have an Itron ERT attached will need a new meter Register and 76 AquaMaster Transmitters will need to be replaced. It is assumed that non-mechanical meters (not including Aquamasters) provide the opportunity to remove the ERT and install a new radio transmitter. These meters have length of wire available that attaches to the radio transmitter via the Itron "quick connector" or are otherwise hard wired.

It an Itron AMR deployment, it is also notable that the City has already invested in the MC4 drive-by mobile data collector, MV-RS and FCS provided by Itron which will contribute to savings. However, it is expected the City would need at least 2 additional mobile data collection units should a full Itron AMR deployment be pursued.

3.8. AMI Considerations

3.8.1. Meter Resolution

As with AMR, AMI requires encoder meters at a minimum to provide a digital data read to the radio transmitter.

High resolution registers are essential to provide meaningful data since the meter is read at least every hour. In the case of residential meters, litre resolution is needed to provide meaningful interval data. If, for example, only cubic meter data was provided to the transmitter the residential customer would have to consume 1000 litres of water before any change was seen in the data. Given average daily household consumption is approximately 0.3 m3 for a two-person household, days might pass before any change in consumption was provided by the transmitter.

Table 24 below outlines the expected meter resolution for various sized meters when using AMI. As is shown below, high resolution meter registers encode - and therefore provide to the transmitter - 8 digits of resolution. In a 5/8", '3/4", 1"and 1.5" meter, these registers measure cubic meters to the left of the decimal and down to the litre to the right of the decimal. 5 digits to the left of the decimal and 3 to the right of the decimal are typically encoded as shown below by the green boxes in the table below. The red box appears on the register for visual display but is not encoded and therefore this digit is not provided to a transmitter.

Meter Size	Expected Minimum Resolution	Example – Cubic Meter Registers
5/8" – 1.5"	.001 m3 (litre)	x x x x x | x x x [red] 10K 1K 100s 10s 1 | .1 .01 .001 .0001
2" – 4"	.01 m3 (tens of litres)	x x x x x x | x x [red] 100K 10K 1K 100s 10s 1 | .1 .01 .001

Meter Size	Expected Minimum Resolution	Example – Cubic Meter Registers								
6" – 12"	.1 m3	x	x	x	x	x	x	x	x	
		1M	100K	10K	1K	100s	10s	1	.1	.01

Table 24 – Meter Register Resolutions for AMI deployments

Any of Winnipeg's meters that are to be retained as part of an AMI deployment are required to have the resolution outlined above. Work Types expressed below allow for meters to be retained that meet these standards while others will need to be changed. Since the majority of Winnipeg's meters are direct read meters, this is not a huge implication to the overall budget.

3.8.2. Radio Transmitter Location

To limit the amount of infrastructure required in a fixed network environment while maintaining daily read success rates, Diameter recommends fixed network radio transmitters be located on the outside of the premises. Less infrastructure generally translates to less maintenance over the life of the system. Outside radio transmitters have the added benefit of avoiding appointments when/if a visit to the radio transmitter is required in the future for a firmware upgrade to reprogram as examples. Locating radio transmitters on the outside does not eliminate all potential issues. Vandalism, cut wires, and temperature extremes can cause issues. Some radio transmitters are rated to operate as low as -40C although most are rated to -30C. Below this threshold, the radio transmitter may stop transmitting temporarily and until the unit comes back into operating range upon which time it will start to transmit again. Generally, storage is rated for 10 degrees colder than the operating temperature. At the high end of the temperature scale, radio transmitters are rated to operate to + 70C and even as high as + 85C in some cases.

The Financial Model will assume that the radio transmitters will be located on the outside of premises.

3.9. AMI Work Types

As discussed above, AMI requires the appropriate resolution at the meter. The 809 5/8" and '3/4" meters that can be retained are non-mechanical meters (ultrasonics) that already provide high resolution and will only require the appropriate radio transmitter. Also as indicated earlier, it is not cost-effective to retrofit any of these meters with new registers. Therefore, all the remaining that cannot be retained "as is", are scheduled for replacement as part of an AMI project.

	5/8” and ‘3/4” AMI Work Types			
Meter Size	**Replace Meter / Install Transmitter**	**Retrofit Register / Install Transmitter**	**Retain Meter / Install Transmitter**	**Total**
5/8”	205,262	0	807	**206,069**
‘3/4”	3,945	0	94	**4,039**
Total	**209,207**		**901**	**210,108**

Table 25 – Small Meter AMI Work Types

This is not the case with 1” and larger meters in an AMI deployment. In these cases, mechanical meters under 10 years old can be retrofit with new registers cost-effectively as opposed to changing the entire meter. Meters that provide the appropriate resolution AND the appropriate protocol can be retained. Generally, these are non-mechanical meters such as ultrasonics or evo Q4000s. However, all AquaMaster meters will require new meter transmitters (not to be confused with AMI/AMR radio transmitters) that provide the meter reading in the appropriate protocol to the radio transmitter. Currently, the AquaMaster Transmitters installed at the City of Winnipeg only provide the Elster protocol output which is no longer supported by manufacturers other than Itron.

	1” and Larger AMI Work Types			
Meter Size	**Replace Meter / Install Transmitter**	**Retrofit Register / Install Transmitter**	**Retain Meter / Install Transmitter**	**Total**
1”	2,719	753	182	**3,654**
1.5”	1,401	331	8	**1,740**
2”	846	437	68	**1,351**
3”	108	23	65	**196**
4”	33	19	12	**64**
6”	10	13	7	**30**
8”	4	2	0	**6**

	1" and Larger AMI Work Types			
Meter Size	Replace Meter / Install Transmitter	Retrofit Register / Install Transmitter	Retain Meter / Install Transmitter	Total
10"	2	0	0	**2**
Total	**5,123**	**1,578**	**342**	**7,043**

Table 26 – Large Meter AMI Work Types

	AMI Work Type Summary			
	Replace Meter / Install Transmitter	Retrofit Register / Install Transmitter	Retain Meter / Install Transmitter	Total
Total	**214,330**	**1,578**	**1,243**	**217,151**

Table 27 –AMI Work Type Summary

3.9.1. Options to Reduce Costs in an AMI Deployment

The work types presented above for AMI reflect Winnipeg's situation for the majority of AMI vendors. There are opportunities however to potentially mitigate some of the AMI costs. Examples include:

18(1)(c)(i) [redacted]

3.10. 23(1)(a) [redacted]

23(1)(a) [redacted]


23(1)(a)

4. AMI/AMR AND METER TECHNOLOGIES

4.1. Introduction

This meter reading technology overview will provide a detailed review of the functionality, benefits and City's implications relating to Automated Meter Reading (AMR) and Advanced Metering Infrastructure (AMI) technologies. Although touch pad meter reading is an available technology and may be used on an exception basis on the rare occasion a customer refuses a radio transmitter this option would not achieve the advancements the City is looking to achieve, so they have been omitted from this write up.

Meter Reading Technology Alternatives: Meter reading technology is discussed in more detail below and includes the following:

- Walk-by AMR Technology
- Mobile AMR Technology
- Fixed Base AMI Technology
- Water Meter Technology
- Water Meter Register Technology
- Other Devices

Note that this section is a general overview of the types of technology available on the market today and not a vendor review of their individual technology. The latter will be conducted as part of the Procurement process. As such, vendor specific items such as radio transmitter safety – which varies vendor to vendor because of different transmission power and the amount of radio "noise" produced by that particular vendor will be discussed in the RFP. So too will Security as security approaches differ based on the vendor, whether their system is one-way or two-way and the technology being deployed. However, it should be noted all radio transmitters that will be bid into Winnipeg will comply with Industry Canada Requirements and while they do emit radio frequency energy it is less than commonly-used wireless devices such as cell phones, baby monitors and microwave ovens. Unlicensed frequency devices have a power limitation of 1W per transmission while licensed frequency radio transmitters can provide up to 2W of power. In addition, depending on the technology, AMI radio transmissions can be less frequent and on a scheduled basis vs. AMR since AMI transmissions are not constantly broadcasting.

The Health Canada website states the following regarding "smart meters":

"There are no health risks from exposure to radiofrequency EMF from smart meters. These devices must meet standards to ensure they do not exceed radiofrequency EMF exposure limits.

As with any device that emits radiofrequency EMF, you will absorb some of the energy emitted by smart meters if you are nearby. The amount of energy you absorb depends largely on how close your body is to a smart meter.

Your exposure to radiofrequency EMF from smart meters is very low. This is because:

- smart meters emit relatively low power signals
- there is distance between your body and smart meters
- smart meters transmit data in short bursts, not continuously
- when smart meters are not transmitting a signal, they do not emit radiofrequency “EMF”

The following link contains further information from Heath Canada as it relates to Smart Meters:

https://www.canada.ca/en/health-canada/services/health-risks-safety/radiation/everyday-things-emit-radiation/smart-meters.html.

- It should also be noted that Diameter recommends installing radio transmitters outdoors. And while the reason for this recommendation is not radio transmission safety, it will help limit exposure to customers.

4.2. Walk-by AMR Technology

4.2.1. Walk-by AMR Technology Overview

The diagram below shows the critical pieces of a walk-by system.

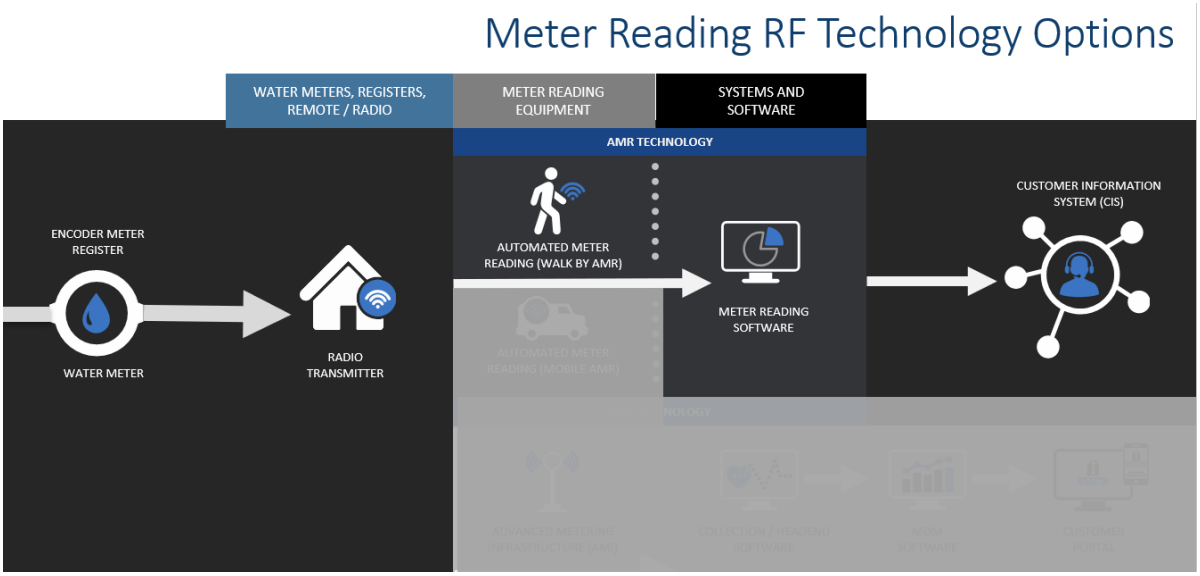

Figure 1 - Walk-by System Diagram

4.2.2. Functionality

Walk-by AMR technology collects meter readings from a radio transmitter that is attached to the water meter register and transmits the readings via RF to the handheld meter receiver. The readings will automatically associate with each property through the radio transmitter identification number. The meter reader is still required to walk the meter reading route but would not have to touch the device on the building itself with the handheld device and in most cases all readings would be read

by just walking by the property. This technology eliminates some of the inherent risks relating to meter reading on private property while increasing reading accuracy. Generally, the handheld device used in walk-by meter reading would not be suitable for mobile data collection.

Regardless of how the readings make it into the handheld, at the end of each day, the readings are uploaded to the utility's Customer Information System (CIS) via manufacturer-specific meter reading/route management software. This software not only collects meter readings to provide to the CIS but receives the meter reading routes assigned to the field devices from the CIS. This same software may have the ability to download and upload reads/routes from the field in some cases.

4.2.3. Features and Benefits

Radio transmitters provide several features and benefits that are not available with direct read or touch pad technology. These features are the same regardless of the device that reads them (AMR walk-by or AMR mobile). The next sections will apply to both types of AMR (walk by and mobile) reading methods.

Radio Transmitter Alerts and Flags

Algorithms that can detect certain consumption patterns can be performed in either the meter register or the radio transmitters. For most walk-by, mobile, and some fixed base radio transmitters, these calculations can determine leak, backflow, or zero consumption conditions. It is important to note that although some manufacturers provide this functionality within the register head, most have moved towards providing this same functionality within the radio transmitter.

Leak Detection Flag

A continuous leak detection flag checks for changes to readings on an hourly or 15-minute interval (depending on the product and manufacturer) and stores a 1 (if the read changed) or a 0 (if the read did not change). At the end of the day, if all periods hold a "1" then it assumes there was continuous (consumption in every time period) consumption for that day. The algorithm will send a flag to the data collection unit once 30 to 45 days are registered with continuous consumption, indicating that there may be a leak occurring at that property. This will allow the utility to either warn the customer via the water bill, a phone call from customer service, or web portal to indicate that a leak may be present at their property and that a higher water bill may be the result. While this flag is better than no flag at all, the leak might be occurring for a considerable time before it is captured because of the time between readings. In addition, the amount of the suspected leak is not captured with the flag just the fact there is a suspected leak.

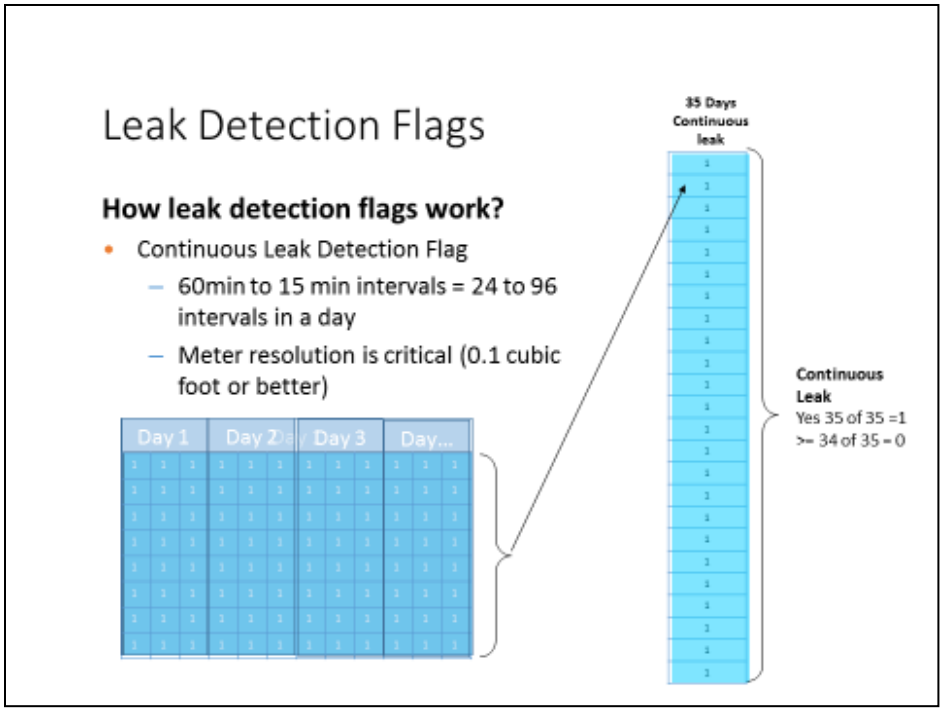

Figure 2 - Leak Detection Flags

These algorithms are highly dependent on the resolution of the water meter. If only a billable unit (for example m3) is being encoded, then only the largest of leaks or backflows would be detected. On a 5/8" meter only large leaks would trigger this flag (i.e., the "leak" would have to be at least 17 litres/minute). On the other hand, if the resolution is very high (.1 litre or .0001m3) then many customers may experience this flag. Some water utilities can experience up to 15% of the population showing this type of leak, some of which might be false positives from multi-family dwellings or industry where continuous consumption might be expected. At times, the volume of these notifications may be difficult to manage.

Reverse Consumption Detection Flag

Like leak detection technology, radio transmitters and certain register heads can detect if reverse consumption has occurred or is occurring at a property. This information is sent through the meter reading equipment in the form of a flag. The water utility can then take corrective action to eliminate this risk to the water system. To be detected by the meter, the backflow event must cause the meter to read negative volume. If the register is read every fifteen minutes, then the volume of reverse flow during this time must exceed the volume of water being consumed in a positive direction. Short, small volume backflow events will not normally be detected by these register heads. This feature is best utilized on those high risk, large sized water meter customers who have backflow prevention devices installed on their property that may or may not be operational.

Zero Consumption Flag

There are radio transmitters and specific register heads that can determine if zero consumption has taken place for an extended period. Zero consumption may be a symptom of water theft. With this information, the water utility can send staff to investigate the situation.

Low Radio Transmitter Battery Flag

Most manufacturers' radio transmitters monitor the voltage level of their own battery and send an alarm a short period of time before it's expected to no longer function (3 to 12 months). This may provide some notice to the utility to initiate a work order to replace the radio transmitter/battery unit before the battery failure, so that fewer readings are missed.

Depending on the manufacturer and product, some radio transmitters do not monitor voltage, there is a time-based flag that is sent 12 to 24 months before the 20-year expected life. This may not be ideal, as depending on the draw on the battery the product may last more or less than this expected 20-year period.

Tamper Flag

Radio transmitters can determine if there is a communication error between the radio transmitter and the encoder register. Some systems can decipher between a cut wire, an incorrectly wired register, and a programming error/issue with the register. In some cases, this flag may alert the utility to a legitimate event of a customer tampering with their meter, but there will be other cases that are unintentional maintenance issues. These flags would initiate a response in the field to investigate and resolve the issue.

Data Logging

Certain manufacturers' radio transmitters store the daily and hourly readings for the last 30 to 90 (dependent on manufacturer) days. This additional information can be used to resolve customer complaints. This data logging feature can provide the same type of hourly reading information a fixed base system produces for individual customers who may request this information.

4.2.4. Implication for the City of Winnipeg

A walk-by RF solution should only be considered if the full AMR or AMI program is not approved. The efficiency gains the City would expect would not off-set the cost to deploy a radio transmitter at 100% of the metered accounts. Instead, a re-evaluation of meter reading data efficiency would need to occur, and targeted radio transmitters would be installed on those most costly or less efficiently read water meters.

Business processes to fully utilize the above flags could be used for any account that has a radio transmitter whether in AMR (drive-by) mode or with an AMI. However, given these flags will only be gathered every 30 days with an AMR system, and therefore "after the fact", most water utilities do not utilize them to a large extent with an AMR meter reading system. And while AMI delivers these

flags daily providing a tremendous opportunity to increase customer service, avoid estimates and potentially water theft, it is important that notification parameters are properly set to avoid “nuisance alarms” and to ensure that the utility reacts appropriately to alarms that are provided by the system

4.3. Mobile AMR Technology

4.3.1. Mobile AMR Technology Overview

The diagram below shows the critical pieces of a Mobile AMR system.

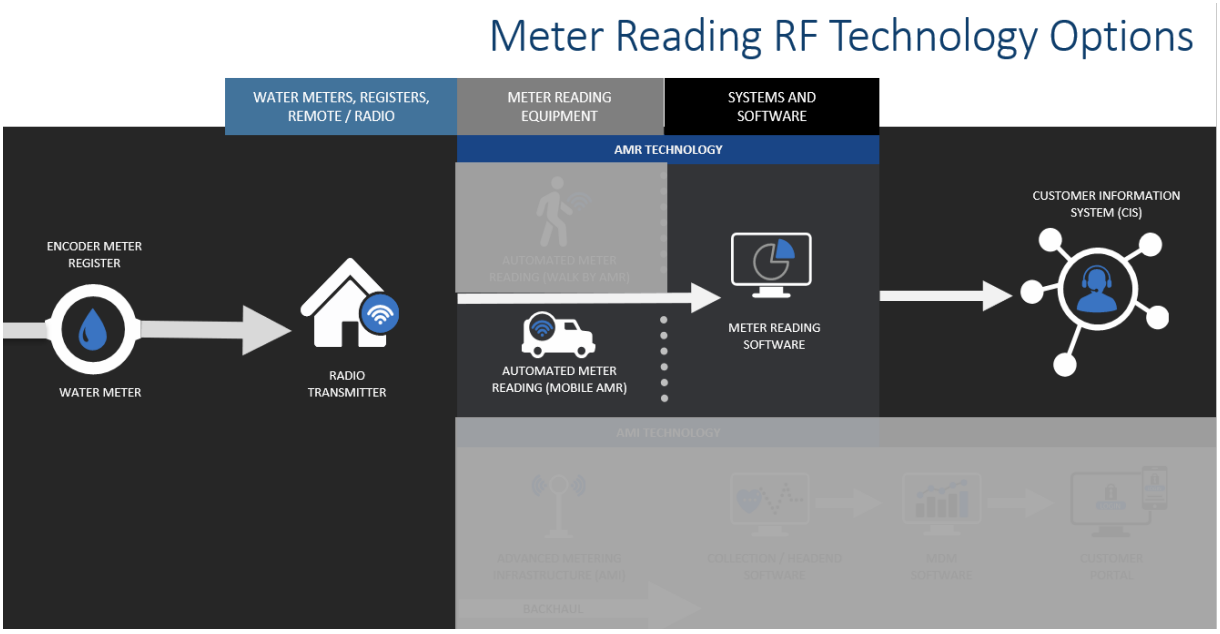

Figure 3 - Mobile AMR System Diagram

4.3.2. Functionality

Mobile meter reading systems are comprised of a laptop computer which is connected to a radio receiver that is in turn connected to an antenna mounted on the outside of a vehicle. This system has a more powerful radio receiver than the typical handheld and can pick up multiple readings from several radio transmitters by driving past the metered properties. A mobile reading system often has multiple receiver channels that enables the system to do this very efficiently.

The laptop comes with mapping software that allows the meter reader to easily track progress and identifies where to drive to collect any readings not yet captured. The map display often has different colored dots to show if the meter at a property has been read, not read, or has an alert (leak, tamper, backflow, etc.)

While AMR mobile eliminates risks associated with walking meter readers (i.e., slips/falls, inclement weather, interaction with the public) and decreases the time and resources required to collect meter readings, it does come with risks associated with vehicle operation and potentially distracted driving.

4.3.3. Features and Benefits

Radio Transmitter Alerts and Flags

The radio transmitter for a mobile AMR system is the same as the one provided for a walk-by AMR system, so all the same alerts and flags are provided to the mobile data collector that were discussed in the walk-by AMR section.

Many of the flags that are discussed in the Radio Transmitter features and benefits section of the report are dependent on reading the meters in the population every 30 days. This can only be accomplished in a cost-effective manner using AMR mobile technology at a minimum.

Datalogging Collection during Regular Reading Route

As discussed in the walk-by AMR system, many radio transmitters can provide hourly reading information for the previous 30 to 96 days (dependent on the manufacturer product design). This is usually performed outside the normal meter reading process, but some manufacturers (Itron with 100W+) have incorporated this feature into the normal reading process. The utility would indicate for a specific account if daily or hourly consumption information is required. When the meter reader passes the address the additional reading interval data is collected automatically. This would help the utility in a couple ways. First, if a customer complained of a high bill the utility could get hourly information to help the customer understand their consumption pattern. Second, if a customer sells their house and it requires a reading on a specific day, the meter reading could collect the daily reads for the meter so the bill could be closed out properly. This would eliminate a meter reader from making a special trip. Finally, hourly consumption data can also be used to help determine the proper meter size for an individual location ensuring the meter isn't too large and avoiding revenue loss for the City.

It should be noted that collecting hourly data for all meters would lead to significant meter reading delays using mobile AMR. Because of the increased volume of data coming from each meter, the meter reader would likely be required to sit on the side of the road while the AMR mobile collector is collecting the data from the radio transmitter. For this reason, AMR mobile is not recommended for collecting hourly data from each meter.

4.3.4. Implications for the City of Winnipeg

The City of Winnipeg's current residential meter reading process relies on customers to phone in three quarterly readings while a single summertime meter reading by City staff is attempted which requires access to the basement of each property. Apart from approximately 6,000 water meters with Itron ERT's, all commercial water meters are also read by visually meter reading from the water meter itself.

If AMR Mobile were selected, the City would be able to collect actual quarterly meter reads which will be used to accurately bill for water. The City could also consider moving to a monthly meter reading and billing process making water bills smaller and easier for customers to manage. Even

with monthly meter reading it is expected the annual meter reading costs would still be significantly reduced.

Should the City decide to continue with quarterly billing, it is recommended to read its meters monthly if using drive-by technology. This would enable the City to capture alert flags such as leaks, reverse flow or zero consumption and is a process the city of Winnipeg has already implemented with their current AMR pilot areas.

4.4. AMI Technology

4.4.1. AMI Technology – Overview

The diagram below shows the critical pieces of a Proprietary RF AMI system.

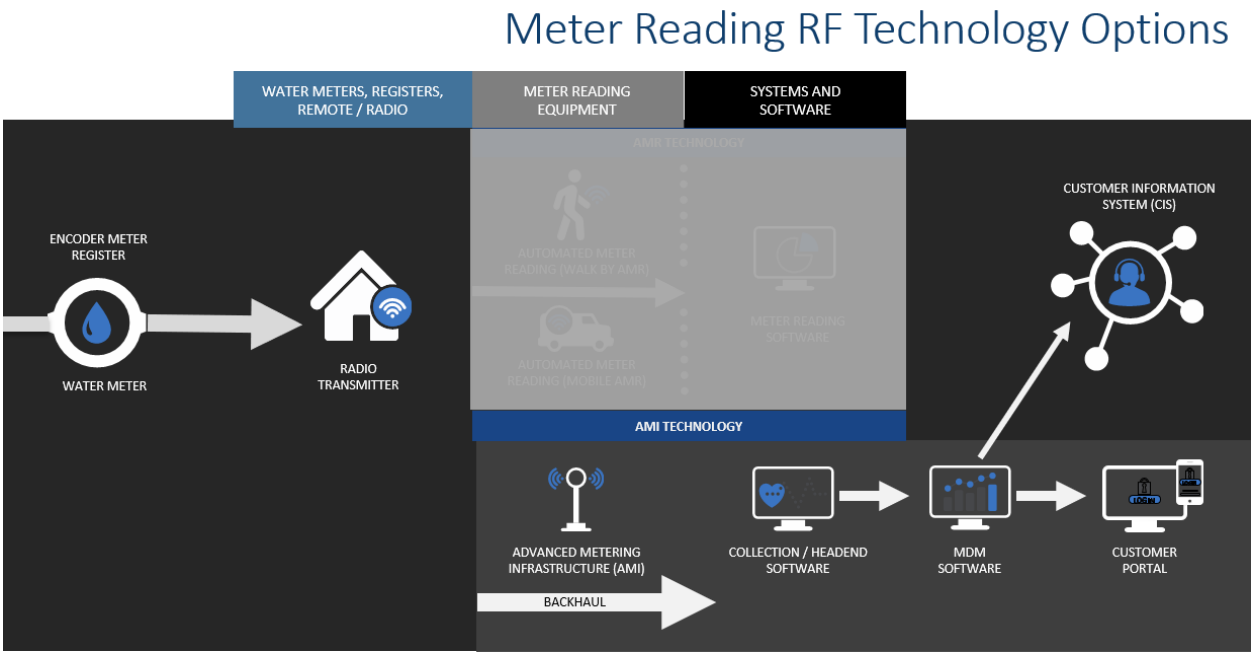

Figure 4 - Fixed Base AMI System Diagram

In a fixed area network (FAN) configuration, radio transmitters are attached via a length of wire to each water meter and are generally located on the outside of the premises. The radio transmitters are read by permanently installed radio collectors (receivers) or “data collection units (DCUs)” These radio transmitters are based on similar proprietary technology that is prevalent in AMR mobile radio transmitters. All currently marketed AMR technologies have a path to AMI.

These data collectors are strategically deployed in the geographic area by mounting them on poles, towers, or utility owned buildings. The data collectors are connected to the collection software using a wide area network (WAN). The type of WAN varies depending on what the data collector location has available: directly to the City network, fiber, or cellular would-be typical examples. The collectors are constantly receiving data from the radio transmitters in the population and providing the information to the head-end collection software.

The big difference between AMR mobile technology and AMI technology is in the amount of information provided and the timeliness of the information provided. For example, an AMI radio transmitter reads the water meter register on an hourly basis (720 reads / month) compared to just once (1 / month) with AMR mobile technology. And with AMI, these hourly readings are received daily along with relevant flags as opposed to every 30 or 60 days with AMR mobile. Clock time in the radio transmitter is maintained by the network whereby the network management software will provide the appropriate time to the data collector which in turn synchronizes with the radio transmitter when out of tolerance. Day light savings time is handled in the same manner.

Interestingly, while AMI provides volumes of data compared to AMR, AMI networks typically have less radio noise that does AMR. This stems from the fact AMR radios are constantly broadcasting a meter reading (roughly every 8 – 12 seconds) in case the mobile collector is in the vicinity. In order to preserve battery life, AMI radio transmitters are programmed to transmit data daily or perhaps a few times per day and AMI radio transmitters are generally located outside as opposed to AMR radio transmitters which are mostly indoors.

4.4.2. Functionality

Like an AMR system, AMI requires a radio transmitter connected to each water meter. The difference is how the meter readings are collected. AMR readings are collected when a vehicle passes each property which provides the Utility with a single meter reading used for billing. An AMI system collects these meter readings constantly and passes this data back to the utility at least once per day.

To accomplish this an AMI system comprises a Data Collection Network, Collection Software (also known as headend software), Meter Data Management (MDM) software, and often a Customer Portal application. The Customer Portal is not technically part of AMI technology, but one of the reasons water utilities implement AMI is to provide their customers with consumption data and alerts. A Customer Portal represents this customer facing functionality.

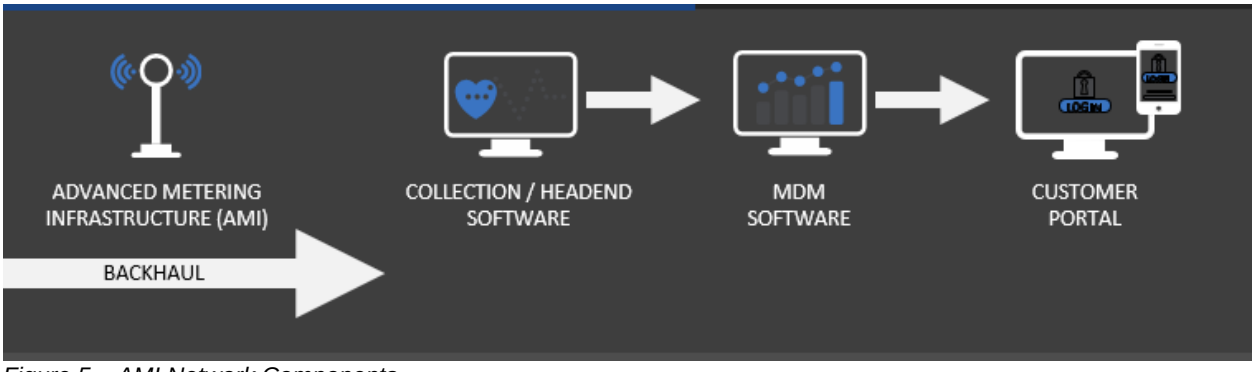

Figure 5 – AMI Network Components

These four components have some unique considerations that should be understood when selecting an AMI solution best suited to a water utility. An AMI system can be deployed where the software applications are presented as a single application. This relatively simple configuration is less complex allowing the system to be setup quickly. However, it may lack some of the functional elements required by certain utilities. Larger water utilities may find the best-in-class functionality is

desired and will maximize the features available to the customer. This more complex configuration may lead to the water utility selecting an AMI Network and Headend software separate from the MDM and Customer Portal. Often the Customer Portal is procured separately to ensure a best-in-class application has all the functionality the utility wants to provide to their customers.

Understanding the key considerations related to each component (Data Collection Network, Collection software, MDM Software, Customer Portal Software) is detailed in the sections below.

4.4.3. Data Collection Network

An AMI data collection network requires all water meter radio transmitters across the utility's service territory to be heard by at least one data collector. There are several approaches to obtaining this network coverage and considerations include whether the City or the vendor is responsible for the initial purchase and deployment of data collectors and who is responsible for the monitoring, maintenance, and support of the AMI network.

Utility Owned AMI Network

Traditionally, water-based Utility Owned AMI Networks were based on proprietary (licensed or non-licensed) RF networks which only collect meter reading from a single vendor's radio transmitters. Although new approaches are being introduced to the market that allow utilities to utilize a shared and/or third-party network, a utility owned AMI network continues to be the most popular. Understanding the considerations of this type of network is important. The other approaches discussed later in this report may shift responsibility of the elements discussed in this section.

Establishing the data collection network of a fixed base system can be one of the more challenging parts of a deployment effort. This is not because data collector installations are difficult but finding and getting the appropriate approval for locations that meet all the right conditions to allow the AMI network to collect readings for the metered population, is often much more difficult than utilities anticipate.

Propagation and Redundancy - Planning the right amount and location of equipment is determined through a propagation study performed by the manufacturer of a proposed solution. This "prop" study provides a theoretical performance of the system based on many factors including: the topography of the geographic area being covered, the strength and frequency of transmissions, location of the radio transmitter (inside or outside) and the number and location of data collectors. Once a radio transmitter is installed, there are many factors that can block or redirect transmissions and prevent a data collector from hearing the signal. An AMI system requires redundancy to ensure that if one data collector misses a radio transmission, another is in a position where it can receive it. This is achieved by having overlapping coverage areas where every single radio transmitter can be heard by at least two different data collectors where possible or practical. Having said that, most AMI systems do allow mobile meter reading should a meter not be communicating into the network as a redundancy measure.

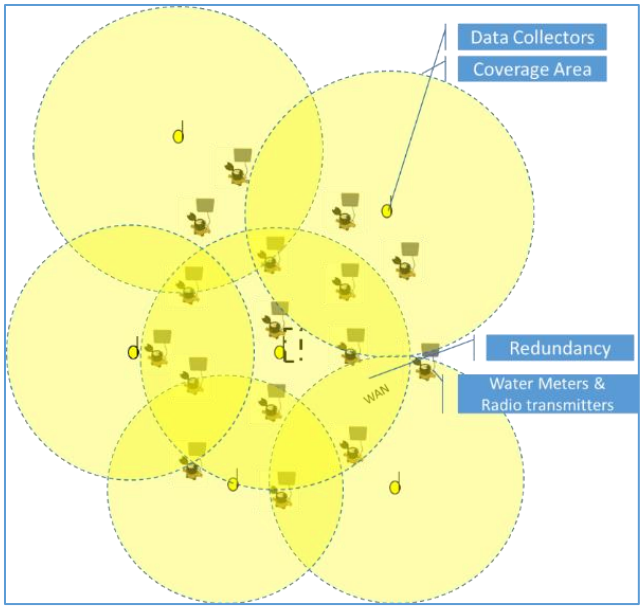

Figure 6 - Overlapping Data Collection Coverage Areas

A. Data Collector Location and Approval - Most utilities prefer to mount the system's data collectors on buildings, pump houses and water towers that the utility or City owns. Installing data collectors on the roof of these locations (buildings, pump houses, water towers, schools, fire and police halls, etc.) often avoids rental fees when installing the devices.

   Alternating current (AC) power is also required at these locations and relatively easy to wire to the device. Another advantage to these locations is that the utility's intranet may be available for backhaul eliminating additional data costs. To achieve the level of redundancy required, it is very likely that these locations will not allow for the propagation study to cover the entire area and more locations will need to be considered.

   After considering its own buildings, most utilities review the installation of data collectors on existing power or light poles that the utility or City owns and controls. Depending on where the poles are located, this infrastructure may be the next cheapest way of installing a collector. Installation on these types of poles may require additional costs for connection (including electric meter) to the electric grid. Some systems allow for optional solar panels to power the collector to avoid the need for a direct link to AC power.

   After all building and pole locations have been exhausted the next option would be for the utility to install new 30' to 90' poles (usually the higher the better) in the areas that have no available locations to install a data collector. This option may be frowned upon because it is usually not popular with the public or politicians to install new poles. Irrelevant of how unappealing this option is, a certain portion of the network will likely require newly installed poles to get full redundant coverage. The utility should position this option as a reality when selling the concept of a fixed based system.

B. Engineering Drawings and Approvals - Understanding the complete approval process that must be taken to install data collection equipment is important. Often very specific

engineering drawings are required for approval and some municipalities may not have a defined process for approving network locations and installations. Some approval processes require extensive review or public notices and input.

Ensuring the process for approval is clear and well documented, regardless of the type of data collector, is vital for a smooth deployment.

C. Wide Area Network/Backhaul - When planning for a fixed area network, backhaul consideration is required to allow the collectors to pass data back to the collection software. Usually, the most cost-efficient WAN process would be to connect the data collection unit (DCU) to the utility's intranet. This option would eliminate additional data charges; however, it could also introduce some network security risks. A utility may also have an existing fiber optic network that can allow access to their intranet. If this is the case, then the access points would need to be identified, so preferred locations could be planned around them. Cellular is often the most popular way to backhaul a data collector, especially if the data collector is installed on poles or privately-owned properties.

Shared and/or Third-Party AMI Network

A water utility's willingness to take-on the risk and responsibility associated with AMI networks leads utilities to consider both a shared and/or third-party AMI network. Often shared or third-party networks are owned and operated by someone other than the water utility, but the water utility would leverage the network for its AMI deployment. The typical shared and/or third-party AMI network options include:

- *Cellular AMI network (Shared & Third Party):* where the cellular radio transmitter communicates directly to the cellular provider that has adequate coverage across the service territory.

18(1)(c)(i) [redacted]

- *Vendor AMI Proprietary network (Dedicated & Third Party):* where the AMI vendor proposes to stand up and own the AMI network long-term charging the utility a subscription fee.

- *Smart City AMI Network*: (Shared & either City owned or Third Party) where RF data collection network does more than just collect water meter readings (typical example LoRaWAN). A LoRaWAN technology can also be deployed that is dedicated to a water utility use, which will act very much like a proprietary AMI network.

18(1)(c)(i) [redacted]

18(1)(c)(i) [redacted]

Some detailed considerations for each type of approach are discussed below.

- Cellular AMI Network:

Not all AMI/AMR vendors have a cellular AMI system available for the water market. Most vendors are working on having cellular radio transmitters to augment coverage (i.e., gap fill) for their dedicated fixed network. There are some benefits to using a cellular network including not having to worry about maintaining a separate fixed network and no additional backhaul costs.

Some AMI vendors do market cellular radio transmitters using a newly released CAT-M chip, but some limit the product warranty and may not support a 20-year product life. Where the cellular product is supported by a 20-year warranty (10 full replacement value + 10 prorated replacement value) and the price of the radio transmitter is market competitive, this technology may compete with other proprietary RF systems. The cost of a cellular system needs to be evaluated over the full 20- year life, due to the fact the annual cost to operate this system can be higher than that of a standalone RF system. In recent procurements the cost of both the cellular product and the on-going operational costs have continued to decline making the cellular choice more competitive with proprietary RF systems. Usually, cellular AMI systems are more cost effective for small water utilities (less than 25,000 services).

Another option for deploying cellular radio transmitters can be to install them only in parts of the distribution system where the meters are dispersed or there is no cost-effective data collector location. This approach can benefit the overall system cost by eliminating the need for data collectors for only a few endpoints.

A consideration of cellular radio transmitters is on-going compatibility with cellular networks. That is, cellular networks continue to evolve with the purpose of providing more data at greater speeds but ensuring the utility's investment in cellular AMI technology over the expected 20 years is something vendors need to contend with. The last limitation that should be highlighted is regarding latency. A cellular radio transmitter is not always awake, so the latency of a command (remote shut off) could be delayed between 4 and 24 hours depending on the vendor.

- Over Lapping Utility AMI Network

18(1)(c)(i) [redacted]

18(1)(c)(i) [redacted]

- Vendor(s) with an Existing AMI Network

AMI vendors will usually provide the option to own and operate the AMI network on behalf of the City. Although this option typically comes at a higher cost, it could be incorporated in procurement documents and compared against Utility owned AMI networks.

- Smart City AMI Network (LoRaWAN)

The technology touted to be the most "open" enabling a variety of Smart City solutions to run across a single network, including smart water metering, is LoRaWAN. LoRaWAN™ is a Low Power Wide Area Network (LPWAN) specification intended for wireless battery-operated things to communicate within a regional, national, or global network

A LoRaWAN network has the same components (radio transmitter, data collectors and data collection software) as an AMI network discussed above. Whereas proprietary/traditional AMI networks handle network management within their own head-end data collection application, LoRaWAN solutions add network management software as a consideration.

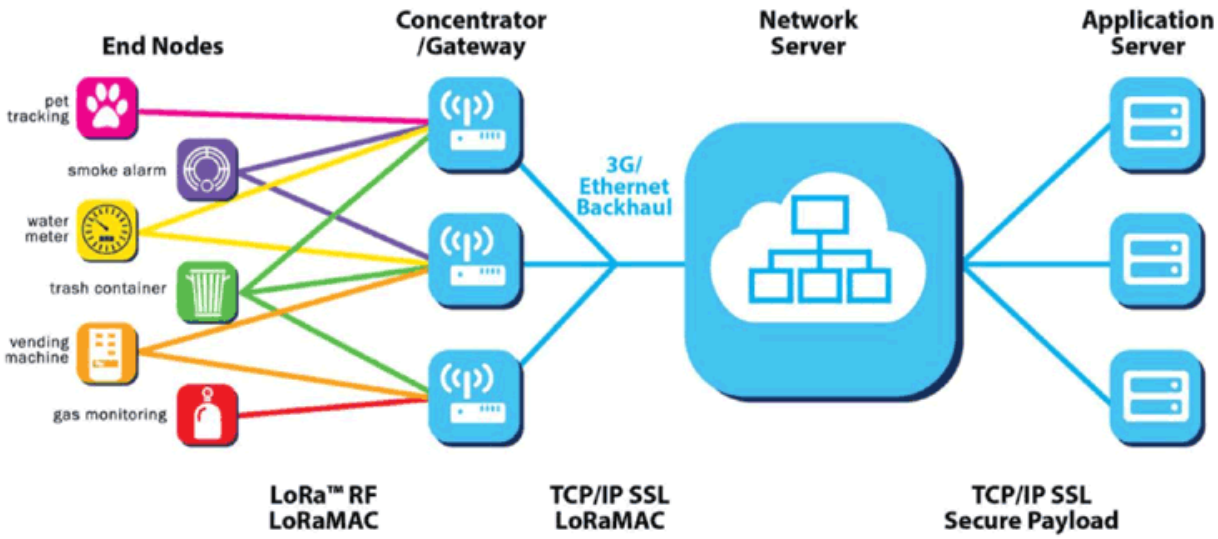

Figure 7 – LoRaWAN Network Components

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Smart City vendors generally belong to an organization called the LoRa Alliance. The LoRa Alliance is an open, non-profit association that is looking to create a global standard for Low Power Wide Area Networks. These networks are being deployed around the world to allow internet of things, machine to machine communication and smart cities models to be widely

adopted. The alliance which is made up of industry leaders and organizations of all types have adopted the LoRa protocol, LoRaWAN.

The LoRa alliance *has a primary goal* "to standardize LPWAN and through standardization enable large scale volume IoT deployments. The LoRaWAN® ecosystem will enable product availability, the LoRaWAN® Certification Program will ensure interoperability and both are due to our members collaborating on the LoRaWAN® standard."'

This is not to say that all LoRa devices will automatically communicate across all LoRaWAN networks. While the LoRaWAN protocol (from endpoint to Gateway) is standard, LoRaWAN networks will deploy different network software (NMS). Examples of NMS include OrbiWise, Senet and The Things Network. These network management systems perform tasks such as device authentication, network monitoring, maintenance and security, and firmware upgrades as a few examples and each end node device must work with the network management software provider to have their devices certified and ensure it can effectively operate across the network deployment. It should be noted that currently each AMI vendor providing LoRaWAN radio transmitters works with a different NMS to maintain the "stickiness" of proprietary AMI network choices.

The features and benefits should be the same as detailed in Proprietary RF AMI system section although some variance may exist based on the LoRaWAN AMI vendor.

4.4.4. Collection Software

A fixed base network requires collection or headend software that receives all the reading information from the collection network. This software monitors the network devices (collectors and radio transmitters) and can display and report on the different components in the field and their status. It is also passing the daily billable and hourly interval readings required to the MDM application, usually daily. The headend is also typically used to perform network management (in proprietary networks) such as time synchronization messages to the various components of the network.

Some AMI software vendors limit the number of years hourly consumption data can be stored in this system due to its impact on performance as the database gets larger overtime.

As discussed within the Smart City AMI Network section, where a LoRaWAN technology is chosen the collection software is replaced with the Network Management Application, and the AMI vendor application server.

4.4.5. Meter Data Management (MDM) Software – Core Functionality

Meter Data Management software is required in a fixed base AMI system due to the large amount of readings and consumption data that needs to be stored, accessed, and reported on. This software can be procured from the AMI vendor as part of the AMI system, as part of a CIS

application or can be procured separately as a standalone application. The MDM has several functions:

1. Data Repository – The software is optimized to store years' worth of data that an AMI system produces. For an AMI system that provides hourly readings, the MDM will need to store 8,760 readings and any alerts produced by the radio each year for every customer. Analyzing consumption patterns over a period of months or years necessitates the management of a large amount of data that needs to be accessed and reported on quickly. Most utilities store between three and five years of consumption data upon which time the data is generally aggregated and then deleted.
2. Validations, Editing and Estimation (VEE) – Depending on what the data is being used for, a utility may want the software to identify gaps in data or problem data and display estimates for that period of missing or suspect data. An MDM with VEE functionality can often define the types of data validations that can be performed, whereby a utility is able to create routines on how to handle the different situations. For example, if only 50% of the readings were received for a certain period, the validation will identify what is missing and then create estimates for the missing data. This will ensure when a customer graphs the data, it does not appear like there were large periods of no consumption. This functionality is often employed for electric smart meters. The need for this with a water utility may only be beneficial when displaying data through a customer web portal.
3. Reporting – Another function of an MDM is the ability to produce different types of reports in an efficient manner in comparison to custom SQL queries. Given the amount of data that is accessible, report generation can be problematic and can take up significant IT resources. MDMs provide a standard set of reports, in addition to a custom report builder which allows users to add fields of data or additional criteria and groupings.

   The more advanced MDM have built dashboards within their applications to display the data for the user, minimizing or eliminating reports being generated. More and more water-based MDMs are better understanding how to make the data usable and actionable without giving the utility data overload. Water based MDMs continue to see significant development in functionality, which is why most manufacturers are leaning toward Software as a Service (SaaS), to allow for an agile approach to software development.
4. Utility Management – MDMs used for water utilities usually have modules that perform water utility functions such as: district metering, leak detection, misapplied meters, and water consumption program monitoring. Ideally, the MDM will have a Reports and User Interface application that will allow the user to easily use and modify this functionality.

MDM and collection software can also be interfaced with other utility systems such as geographic information system (GIS), supervisory control and data acquisition (SCADA), 311/CIS and works management software. These interfaced connections to other systems need to be well planned to ensure the costs and effort to develop the interface is matched or exceeded by the benefits provided. For example, it may be very critical to be able to open a work order for field personnel to investigate a high-water consumption event that the MDM has

identified. In this case an interface from the work management software to the MDM may avoid manual entries and multiple staff engagement steps to resolve the problem in the field.

Meter Data Management (MDM) Software – Enhanced Functionality

Larger utilities often have options beyond an AMI vendor supplied MDM. For example, many Customer Information Systems (CIS) have an integrated MDM to make data management and implementation easier.

Larger utilities have also decided to procure a best-in-class MDM, which required them to have a separate procurement for MDM. This allows the utility to choose the MDM that best meets the desired functionality.

The enhanced MDM functionality can include the following elements:

1. Meter and Radio transmitter asset management – the MDM can store all water meter and radio transmitter assets. This link to the account and premise numbers associated with the CIS used for water billing. Some asset management applications can store maintenance history, RMA, warranty, and testing information.
2. Service orders based on the asset – once an asset has been identified as having a potential issue, the MDM would allow the utility to issue a service order to investigate and repair the asset. Depending on the MDM, this functionality may only issue the work order and may rely on a separate existing utility work order system in the field. It varies vendor by vendor.
3. Customer Relationship management: the MDM would hold key customer information that is associated with the account and premise. This would allow communication to be sent to specific or subset group of customers (boil water alert, water outage, water conservation messages)
4. Water Billing and collection: where the MDM is an integrated application with the CIS, some water utilities implement MDM prior to CIS, then build on the functionality later.

4.4.6. Customer Portal Application – Core Functionality

Most water utilities currently allow their customers to log in to view or download their water bill. Customers continue to expect more functionality through their internet and smart phone devices. Public utility operators (electric, gas, water) have been starting to address this expectation through more advanced customer portals.

With AMI, portals give customers access to their data to allow them to better understand their consumption. Portals allow them to set alarms and alerts to avoid unexpected large bills. This on-line experience differs depending on the type of customer facing application(s) selected. If the utility wants a seamless experience without the need for the customer to be redirected to different applications for consumption information, billing and payments, then a third-party application is likely the best approach.

Generally, billing systems effectively display billing information (dollars and cents) but often are short on functionality related to hourly consumption. Conversely, AMI vendors' customer

portals typically provide detailed consumption functionality but often do not do a good job of displaying dollars and cents. Interfacing two customer facing applications together is possible, but it is likely the navigation of the two system will be different and will be very noticeable to the customer.

A best in class third party customer portal will typically have the following functional:

A. Customer facing functionality: account and registration, billing display, consumption display, payment, alerts and alarms, two-way communication with the utility, reporting
B. Utility Facing Functionality: administration oversight, activity logs, marketing information, customer service, water consumption program management, service requests

4.4.7. Features and Benefits

There are many manufacturers of fixed base AMI/AMR systems with some providing a unique set of features and functionalities. RFP specifications may reduce the number of systems that could compete during the procurement process. A list of necessary or preferred features would need to be discussed prior to procurement when specification documents are being developed.

Radio Transmitter Alerts and Flags

Like walk-by and mobile AMR systems, fixed base radio transmitters may have algorithms within the radio transmitters that allow for various flags. Some fixed base systems have not added this feature to their radio transmitters as the same functionality can be achieved at the collection/headend or MDM software by analyzing the hourly consumption data. The benefit of performing these functions through the software (collection or MDM) is that the utility can more easily change leak detection thresholds. As an example, if identifying continuous consumption of a litre per hour creates too many events, the utility could easily alter how leaks are determined – i.e., more consumption per hour over a longer time frame. The second advantage of performing customer side leak detection with an AMI system is you do not need to wait for the water bill to identify a leak has occurred, the MDM can be configured to trigger an alarm over a much short time frame (say 3 days), so the alert being sent to the customer can better avoid high water bills.

Data Logging

With a fixed network AMI/AMR system, hourly read information is delivered to the collection software, so there is limited value to having the radio transmitter store reading information. Some systems have designed their radio transmitters to store readings, which can act as another means of data redundancy within the overall system. These radio transmitters will transmit past readings as well as new ones, so if a transmission was not heard by a data collector, the headend software can backfill these readings during a future transmission.

Software as a Service (SaaS) versus On-Premise Software

Data Collection, MDM and Customer portal software are all capable of being installed in-house on utility provided server hardware or in a professionally managed / hosted environment referred to as Software as a Service (SaaS). The decision to host or not to host certain pieces of software depend on several factors that include the following considerations:

- Reliability and Security
- System Support and utility expertise
- System maintenance
- Help desk
- Total life cycle
- Scalability
- Customization

These considerations and their level of importance to the utility should be reviewed because hosting can increase the operational cost of the system. This will ensure that the utility gets all the information they require from the vendors to make the correct decision.

Time Synchronized Readings and Two-way Communication

All currently marketed AMI systems are considered two-way communication system. The functionality of two-way AMI systems is:

Time Synchronized Top of the Hour Readings – "clocks" in radio transmitters tend to drift and become inaccurate. Synchronization ensures that the time-stamping of consumption is accurate but it requires a two-way radio transmitter to receive the time stamp from the network. Meter readings can be time synchronized to allow all readings in the utility's network to be read at the same time. An AMI system schedules these readings at the top of the hour (12:00, 1:00, 2:00, etc.) which allows hourly consumption periods to be easily compared.

On-demand Read – Some AMI systems allow a utility to request an on-demand reading. The reading may come from the data collector (in which case the reading may be a "few" hours old) or some systems may allow interrogation of the endpoint directly - understanding latency may be a factor in receiving the meter read quickly. That is, due to battery management, AMI radio transmitters are generally not always "listening" because of battery drain. However, when they "wake-up" to transmit data, they can remain "on" for a period to accept commands from the head-end software via the data collector. This might include meter reading for example. Most utilities are looking to obtain readings for final bills and a daily read pulled from the data collector would suffice. Final Bill reading can be accomplished by all AMI vendors in one way or another.

Remote Shut off Valves

A two-way AMI system can allow a utility to install remote shut off valves for certain customers who have a history of non-payment or other bylaw violations. These valves would be able to reduce flow to a site or turn off completely without the need for someone to attend the property.

Installation of these devices may be more challenging, as they will likely require changes to the meter setting or installing a specific manufacturer water meter that includes a remote shut off device

within the meter itself. Also, once a utility moves to device management it is usually necessary to add a higher level of encryption to the system's radio transmissions, which adds complexity and cost to the solution. It is unlikely a water utility would want to install these devices on 100% of the population due to the costs involved.

Some water meters are coming out with remote shut off capability within the standard water meter lay length, which would address some of the increased cost of installing this feature.

Some good applications for these products would include:

- Tenant properties with high tenant turn over. Some university or college areas may have many new water customers every year and it could be challenging and costly to utilize collection agencies and moving charges to Tax Roll.
- Master and child meters, some utilities have properties with a single curb stop but multiple customers, so if a single customer does not pay their bill there is no means for the utility to shut them off.
- Seasonal services – where the water is shut off and turned on twice or more each year, having a remote shut off meter may help reduce truck rolls.

Acoustic Leak Detection

An optional addition to a fixed base AMI/AMR system is the installation of acoustic leak detection (ALD) devices across part or all the utility's water system. These devices could be permanent or temporary installations where the devices are picked up and relocated on a regular basis. These devices measure the noise of the water flowing in the system and sends these acoustic readings through several radio transmitters in the network. It will then make its way back to a leak detection software that will place each device on a GIS map. Leaks in the system are detected by the pitch and change in acoustic readings from each reporting device. Typically, depending on the density of the devices and the type of material used for the water mains, an ALD device would be installed for every 10 water meters in the system.

Temperature and Pressure Gauge

Water utilities have expressed interest in receiving temperature and pressure readings from more locations within their service area and pressure zones. This additional information can help better manage their system in several different ways.

Temperature: A water utility whose temperature can drop below freezing may benefit from having temperature readings from meters situated in meter pits by way of alerts of potential freezing events. Temperature may also help a water utility in hotter climate better understand their chemical levels in various parts of the system.

Pressure: Water utilities with numerous pressure zones or limited SCADA points find it expensive to collect pressure readings. Pressure reading collected in more locations of a water system provide several benefits:

- Better response to customer's low-pressure complaints.
- Drop in pressure as an indicator of main or water service breaks.
- Pressure readings within the water utilities hydraulic model to better understand the distribution system.
- Reduce pressure within a specific pressure zone to reduce the leakage within the system while still maintaining minimum fire pressure levels.

Although this is still in the development phase with some vendors, this functionality will be more widely available by 2023. Pressure and temperature readings can be achieved through a separate device that would need to be installed on the water systems but communicates through the AMI network. Some devices lay length would allow them to be installed with a shortened 5/8" or ¾" water meter. This allows these devices to be installed in the existing lay length.

Other manufacturers are developing their non-mechanical water meter (C715-18 Cold-Water Meters – Electromagnetic and Ultrasonic Type, for Revenue Applications) to include a temperature and pressure sensor within the product itself.

It should be noted that some manufacturers have limited the meter's ability to pass this data to competitive AMI radio transmitters, so if this functionality is part of the business drivers it should be included in the quantities required within the AMI procurement.

4.4.8. City of Winnipeg Implications

4.4.8.1. Meter Reading Technology Implications for City of Winnipeg

When evaluating AMR and AMI technology it is clear AMI provides more functionality in terms of business drivers, AMI technology to fully achieve the 15 of 39 drivers ranked as important or critical. This technology option also aligns much better with the City of Winnipeg's water department long term goals and objectives. 18(1)(c)(i) [redacted]

18(1)(c)(i) [redacted]

4.4.8.2. 18(1)(c)(i) [redacted]

18(1)(c)(i) [redacted]

18(1)(c)(i)

4.4.8.3. Smart City Technology Implications for City of Winnipeg

There is no known existing LoRa network that covers the Winnipeg's service territory. AMI vendors proposing a LoRa technology would be proposing either a Vendor owned, or City owned LoRaWAN network. A City owned LoRa network would be similar to a Proprietary RF network; if they proposed an AMI Vendor owned LoRa network, it would be like the third-party network.

As one might expect after reviewing the various components of LoRaWAN networks as shown in Figure 7, all LoRa devices will not automatically communicate across all LoRaWAN networks. Different deployments of LoRaWAN networks will deploy different network servers and by extension different network management software (NMS). And each vendor of LoRaWAN AMI devices will provide a preferred NMS with whom they have completed integration efforts. In addition, each vendor will have their own proprietary application software that is required to receive data from the AMI radio transmitter via the Gateway and Network Management software.

As such, LoRaWAN networks should not be considered completely open or non-proprietary at this point since "Vendor B's" AMI radio transmitter will not operate seamlessly across "Vendor A's" LoRaWAN network deployment. Despite efforts by both water and electric utilities, AMI networks continue to be proprietary even though electric AMI networks have been widely deployed in North America for approximately 20 years.

A LoRa network could provide the future option to add additional smart City devices the network could collect data from.

4.4.8.4. Independent MDM Application Implications for City of Winnipeg

The City of Winnipeg currently uses Oracle CCB for water billing functions. Oracle's latest software offering is called Customer to Meter (C2M) which combines the CIS functionality available in CCB (but updated) and the MDM into a single application with no integration. Given the City currently uses Oracle, they may consider implementing MDM associated with the CIS instead of a AMI vendor's MDM.

Although there are options for connecting CCB with the Oracle MDM, Oracle would likely recommend a full upgrade to C2M. An upgrade to C2M would be a considerable upgrade.

During the system assessment, considerations for the benefits and drawback of this approach should be explored.

4.4.8.5. Third-Party Customer Portal Implications for City of Winnipeg

The City currently has some customer portal functionality available, the business drivers associated with a customer portal did not give a definitive direction on if the City should implement a third-party customer portal. The City has expressed some priority to ensure their customer facing systems are "seamless" but the full extent of the City's desired functionality remains unclear.

As the customer portal is not included in the initial scope and the City's preference seems to be toward building out its existing portal further, no further action on the customer portal is required at this time.

4.5. Water Meter Technology

Introduction

Metrology within the water industry has been around for more than 100 years, and some of the original types of measurement technology continue to be used today. This section will explain how each type of measurement works, the history of measurement products, product availability, and key advantages and disadvantages associated with each type of measurement. Lastly, key specifications related to each type of technology will be compared.

AWWA Specifications

AWWA is an industry organization that provides many manufacturers and utilities guidelines for the water meters used today. Unlike electric and gas meters, water meters are not governed by Measurement Canada and are instead left to the discretion of each utility to determine testing requirements, required meter accuracy and meter change-out requirements.

Some newer technologies have just recently been approved by the AWWA. These specifications provide water utilities with a common set of key characteristics (lay length, types of threads, type of material, etc.) and performance standards (accuracy at certain flow rates) that can be applied for comparison purposes during competitive procurement.

It is important to note that AWWA does not make recommendations nor state preferences with respect to the type of meter technology, nor does AWWA validate that meter manufacturers adequately comply with the AWWA specifications. The water meter technology selection and validation functions, therefore, remain the responsibility of the water utility.

There are two categories with respect to the types of water meter technology: 1) mechanical measurement, and 2) non-mechanical measurement. The AWWA specifications for each category are described below.

- AWWA Standards for Mechanical Measurement
    - C700-20 Cold-Water Meters – Displacement Type, Metal Alloy Main Case
    - C708-19 Cold-Water Meters – Multi-jet Type
    - C710-20 Cold-Water Meters – Displacement Type, Plastic Main Case
    - C712-19 Cold-Water Meters – Single-jet Type
- AWWA Standards for Non-mechanical Measurement
    - C713-19 Cold-Water Meters – Fluidic Oscillator Type
    - C715-18 Cold-Water Meters – Electromagnetic and Ultrasonic Type, for Revenue Applications

Water utilities usually opt to use these standards during water meter procurement. Although these standards represent different type of measurement technology, many have similar applications. Some water utilities consider meters from different AWWA standards as comparable, thus different types of technologies (and AWWA standards) would be price comparable. Other water utilities restrict their procurement to a single AWWA standard for a single type of application. Because there are many manufacturers that produce meters that comply with each standard, this has a limited impact on the competitiveness of the procurement.

Although multiple standards may be allowed, the meter performance and pricing may vary depending on the meter standard being used. Notably, the most common standard used in North America is the C700-20 positive displacement meter. Often water utilities restrict their residential water meter procurement to only allow meters that meet this standard. It is up to the water utility to decide which water meter standards will be allowed based on their experience and the manufacturer's stated product benefits.

4.5.1. C700-20 Cold Water Meters – Displacement Type, Metal Alloy Main Case

4.5.1.1. Description of Measurement

Positive displacement type water meters measure the actual volume of water that flows through the measuring chamber. There are two types common in the North American industry: nutating disc and oscillating piston. Both the nutating disc and the oscillating piston measure volumes of water; the method in which they do so, however, differ slightly. Figures 8 and 9 below display how each type works.

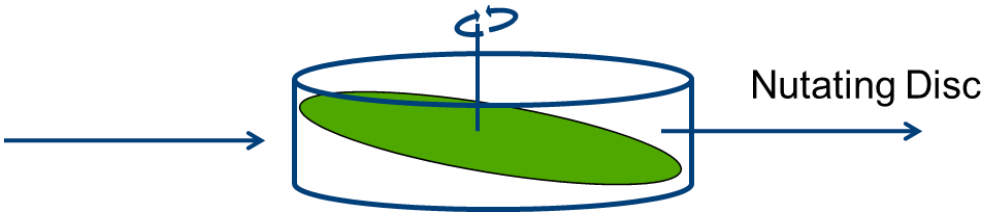


Figure 8 - Nutating Disc Position

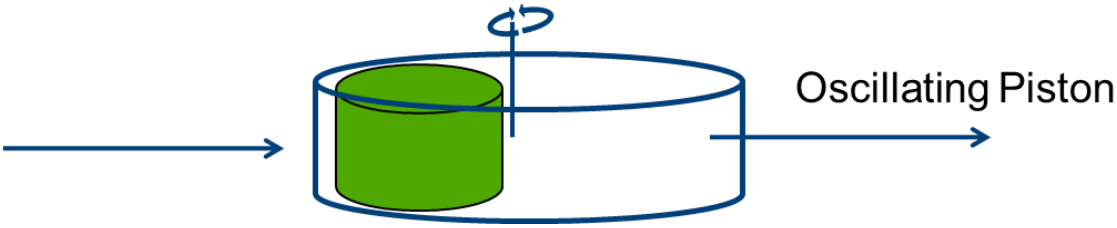


Figure 9 - Oscillating Piston Position

As the disc or piston rotates around the axis, it turns a magnet. This movement is detected by a corresponding magnet located in the register head. For each manufacturer, a known number of rotations equal a unit of measure.

These meters are typically installed in a horizontal orientation, although manufacturers of piston type meters often also market a warranty for vertical installations. Nutating disc meters have been known to extend their warranty for vertical installation in special situations where this is a mandatory requirement.

4.5.1.2. History

Positive displacement type of measurement is the oldest (over 100 years in use) and most popular type of water meter used in North America. The patent for the nutating disc meter was filed by James A. Tilden in 1887 and 1888. The oscillating piston meter by Lewis N. Nash in 1884 – this was adapting from older designs. It has proven to be a resilient and long-lasting water meter, with an expected life of between 15 and 25 years depending on the quality of the water it is measuring.

4.5.1.3. Market

There are five major domestic manufacturers of the positive displacement type water meters. These manufacturers include Badger Metering, Master Meter, Mueller, Neptune Technology Group, and Sensus Water Meters.

4.5.1.4. Advantages

Positive displacement type water meters are the most popular type of water meter in North America; most large water utilities rely on these meters for many of their residential applications.

These meters have good accuracy at low flows, with AWWA standards requiring these meters to achieve between 95% to 101.5% accuracy when measuring normal operational flow ranges (0.5 to

25 gpm). Many water meters manufacturers exceed this standard, either by exceeding the accuracy thresholds, or meeting the accuracy standard over a larger flow range. Different manufacturers publish slightly different performance specifications; however, at minimum, all major meter manufacturers meet the published AWWA specification requirements.

The positive displacement water meters do not require a power source to measure flow. The registers for some positive displacement water meters are powered by batteries; however, the measurement of flow is not dependent on this battery power source.

It is very rare for a positive displacement meter to over-register consumption. This provides some confidence to the utility that if a meter is inaccurate, it is to the benefit of the customer. If over registration occurs, it is usually due to an incorrect water meter register being installed on a small sized water meter.

4.5.1.5. Disadvantages

Positive displacement water meter chambers and discs/pistons wear over time. As these meters wear, they become less accurate. Depending on the quality of the water it measures, the life of a meter is usually between 15 and 25 years. At this point, replacing older meters with new ones is likely to have a reasonable payback of around five years.

Because mechanical water meters have moving parts, they can sometimes make noise as water moves through the meter. Residents may complain of a ticking sound that can vibrate throughout the plumbing of the property.

The tolerance between the disc/piston and the measuring chamber is quite tight. And while most positive displacement meters have a built-in screen on the inlet side to reduce large particles of debris from entering the measuring chamber, debris in the water can jam the meter, stop the disc/piston from turning and the restrict the available flow. When this occurs, the meter stops registering consumption and requires a repair/replacement.

4.5.1.6. City of Winnipeg Implications

The City currently uses positive displacement water meters for residential and small commercial applications (5/8” to 2”). The City’s excellent water quality allows meter accuracy to be maintained for a long period of time. These products continue to be very reliable and cost competitive technology and the City should continue their use in residential and small commercial applications unless value-added features of non-mechanical meters are required.

4.5.2. C710-15 Cold Water Meters – Displacement Type, Plastic Main Case

4.5.1.7. Description of Measurement

Refer to Section 4.5.5.1 for the description of cold-water meter measurement. Plastic Main Case meters use the same measuring elements (and registers) as their bronze counterparts and only the meter body material is different.

4.5.1.8. History

The market was influenced by factors including NSF/ANSI 61 Annex G and Annex F certification, and the Safe Drinking Water Act (NSF 372) that became effective January 4, 2014. Meter manufacturers needed to comply with providing lead free alloy. As the price of metals continued to rise, some meter manufacturers tried to lower meter cost by replacing a brass body with plastic or composite material.

4.5.1.9. Market

There are three major domestic manufacturers of positive displacement type meters constructed with plastic or composite material bodies. These manufacturers include Badger Metering, Mueller, and Sensus Water Meters.

4.5.1.10. Advantages

Replacing the brass body meter (C700-15) with a plastic/polymer/composite body can reduce the cost of the water meter between 5% and 10%.

All other advantages are the same as outlined in Section 4.5.1.4.

Some manufacturers' composite/polymer meters have a burst pressure rating that is higher than the rating for a similar brass meter. Main case strength may have limited benefit to the utility because both meters' burst pressure far exceeds normal utility operating pressure.

4.5.1.11. Disadvantages

One of the main issues related to plastic main cases is cross threading. Installation issues are encountered when the plastic meter is threaded with brass meter tailpieces. If the meter is not aligned perfectly, the threads can be cross threaded, which make the meter unusable until either the threads are repaired, or the meter is replaced. Cross-threading is not typically covered by warranty.

A second disadvantage reported by utilities is the inability for plastic/composite/polymer meters to withstand over torquing. Often a brass meter can withstand some torque due to the somewhat malleable nature of brass, whereas plastic/composite/polymer meters may break when subjected to the same conditions. In some cases, installers may tend to under torque the meter to avoid damage which can lead to repeat visits to the meter if it begins leak at the connection point following shifting or temperature changes.

These meters also have the same disadvantages as described in Section 4.5.1.5

4.5.1.12. City of Winnipeg Implications

City of Winnipeg existing water meter are almost entire metallic (bronze or epoxy coated cast iron on large sized meters). If the City were to allow non-metallic water meters for residential and small commercial applications permanent ground clamps and grounding wire should be installed to ensure ground continuity across the water meter setting.

Unless there is a significant cost savings (including grounding clamps and wire) there is no compelling reason to make non-metallic water meters the City's standard.

4.5.1.13. C715-18 Cold-Water Meters – Electromagnetic and Ultrasonic Type, for Revenue Applications

4.5.1.14. Description of Measurement

The AWWA standard applies to both Ultrasonic and Electromagnetic meters.

Electromagnetic water meters measure the voltage induced due to movement of water through a magnetic field. The amount of voltage induced is proportional to the velocity of the water. Since the velocity of the water is known, as is the cross-sectional area of the pipe, an algorithm then determines consumption for the flow-rate. As a result, the frequency of (velocity) sampling rates is important to the accuracy of an electromagnetic meter (i.e., more frequent sampling generally means higher accuracy rates).

Additional features can be incorporated into electromagnetic meters such as temperature, pressure, alarm conditions and remote shut-off within the existing meter lay length. Power is required to generate the magnetic field and for the sensors and comes from either battery or from AC depending on the manufacturer and the size of the meter.

Among Small Meters, the power is provided by a battery. The battery generally has a 20-year warranty, typically represented by a "10/10 warranty," which covers 100% of the replacement value for the first 10 years, and a prorated replacement value for years 11 through 20. This battery is typically "potted" and not replaceable in Small Meters. Intermediate and Large "mag" meters are AC or DC powered and may have replaceable batteries depending on the manufacturer.

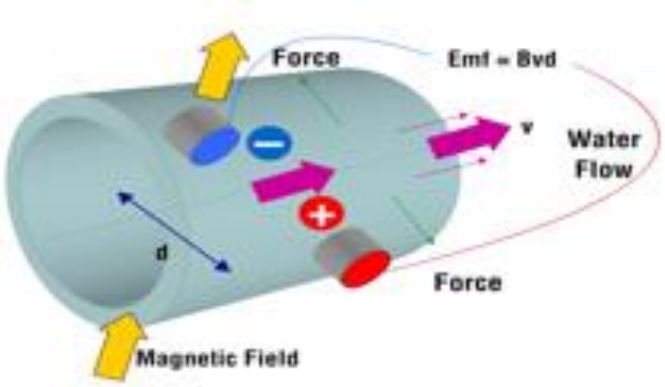


Figure 10 - C715-18 Cold-Water Meters Electromagnetic and Ultrasonic Type, For Revenue Applications (Courtesy of Sensus)

Ultrasonic meters measure the time it takes for a sonic pulse to travel between two transducers. Pulses reflect off particulates in the water.

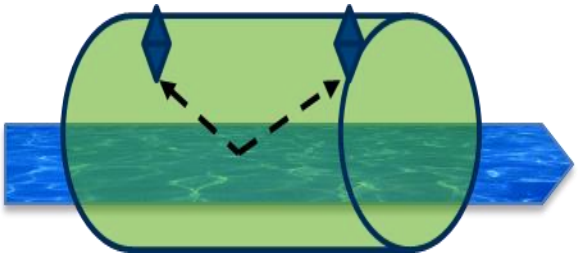


Figure 11 - Ultrasonic Meter

4.5.1.15. History

Electromagnetic consumption meters have been available in the market for about twenty years. Ultrasonic consumption meters have been readily available in the US market for approximately five years, in sizes up to 2-inch. In recent years, manufacturer have started introducing this technology in larger meters.

AWWA standards have just been approved, and C715 was approved at the AWWA Annual Conference and Exhibition in 2018.

4.5.1.16. Market

Electromagnetic meters: The only major manufacturer of residential electronic magnetic meter is Sensus Water Meters.

Ultrasonic meters: The major manufacturers of ultrasonic meters include Badger Metering, Diehl, Honeywell/Elster, Itron, Kamstrup, Master Meter, and Neptune Technology Group.

4.5.1.17. Advantages

One of the key features of non-mechanical meters over positive displacement meters are improved accuracy at very low flows, and very limited deterioration of accuracy over time.

They also offer some additional features and functionality, depending on make and model, including:

- Temperature reading
- Alarm conditions such as: Empty pipe, reverse flow, tamper, low battery, leak detection, etc.
- Pressure reading

Although these may not apply to all manufacturer products, the additional functionality described above of these meters has expanded beyond just meter readings.

Non-mechanical meters are essentially an open pipe and unaffected by debris that can impact mechanical meter performance. Large non-mechanical meters are typically installed without strainers which is a requirement of their mechanical counterpart. The accuracy of the meter over time will not show any degradation. In theory, the meter should be as accurate at year 19 as it was on the day of shipment. So, there are no lost revenues over time, and expected replacement date is defined which aids in capital planning.

Although there is a large discrepancy in pricing of non-mechanical meters among manufacturers, Large (non-mechanical) Meters are generally priced similar to mechanical meters of the same size. But, as mentioned above, Large non-mechanical meters, do not require strainers which is a cost savings.

4.5.1.18. Disadvantages

A key consideration is that this technology requires battery power to measure water flow. Typically, manufacturers offer a 20-year warranty. It is important to understand that these meters will have a known and firm product end date. This changes the water utility practice of performing meter accuracy sampling to determine the optimal replacement age. Meters in this class must be replaced prior to the end of their pre-determined (based on battery) meter age. Non-mechanical meters may provide a battery flag to the radio transmitter based on either voltage or meter age warning the utility the meter needs be changed.

Although this meter type is not new to the water industry, this is a new application of this meter type, and hence there is less history of performance and problems. It is not known/field proven if these meters will prove reliable long term.

The market has shown that Small and Intermediate electromagnetic and ultrasonic meters are typically more expensive due to lower manufacturing volumes as well as selling to water utilities based on some of the enhanced functionality. It is expected that these meters will eventually be competitively priced with positive displacement meters, but without a larger purchase volume, presently it is difficult to get the product cost to levels of a positive displacement meter.

Among Large Meters, it should be noted that the cost-savings provided by eliminating the strainer may be offset by the requirement of spool pieces because of the different lay lengths of non-mechanical meters. However, most meter manufacturers have mirrored the lay lengths of mechanical meter counterparts. As an example, some 3” ultrasonic meters come in both 12” and 17” lay lengths to address both turbine and compound meter replacements.

4.5.1.19. City of Winnipeg Implications

The City of Winnipeg has started to move to non-mechanical water meters for all locations 3" and greater. Diameter recommends continuing with this strategy and replace mechanical water meters 3" and greater with non-mechanical meters (ultra-sonic or electro-magnetic). At these sizes, the price of mechanical and non-mechanical meters is generally in line with one another. That coupled with the fact non-mechanical meters are touted to be more accurate across the entire flow range and do not degrade in accuracy over the life of the meter are the reasons Diameter is recommending non-mechanical for Large Meters.

4.5.1.20. Water Meter Specification Comparison

The table below shows a comparison of key performance specifications and characteristics of each type of meter technology.

Consideration	Positive Displacement	Electromagnetic	Ultrasonic
Age in market (yrs.)	>100	~20	~ 2 - 5
Estimated meter life	20 to 30 soft EOL	20 Hard EOL	20 Hard EOL
Flow Range	.5 to 25 GPM (at +/- 1.5%)	.11 to 25 GPM (at +/- 1.5%)	.1 to 25 GPM (at +/- 1.5%)
Extended low flow	.125 GPM (at +/- 5%)	.03 GPM (at +/- 5%)	.05 GPM (at +/- 3%)
Installation flexibility	Horizontal*	Any	Horiz. or Vertical
Power Source	None	Battery	Battery
Number of Suppliers	6	1	1

Table 28 – Comparisons of each type of meter technology

4.6. Meter Register Technology

Introduction

The foundation of an AMI system is the water meter and register technology. The register head tracks and displays the total volume of water that has passed through the water meter. Many registers allow remote meter reading. Advances in register technology have enabled the introduction of many other features and benefits since the inception of AMI. Different meter manufacturers present different options. Diameter reviewed the key features of the different technologies and discusses the benefits

4.6.1.1. Direct Read Registers

A direct-read register head is not capable of accommodating the technology necessary to allow the water meter to be read remotely. Direct read registers are an older technology that requires a person physically view and record the odometer reading. Meter manufacturers and water utilities are moving away from direct read registers due to their associated (and high) meter reading labor costs and lack of flexibility. Most of the industry has transitioned towards newer technologies that allow a utility to capture reading information with greater consistency and at a reduced reading cost.

4.6.1.2. City of Winnipeg Implications

The City's meter population is primarily composed of direct reading water meters. These types of registers are not compatible with either AMR or AMI technology.

4.6.1.3. Pulse Registers

A pulse type register is a much older type of register that allow pulses to be generated at the register head as a certain amount of water passed through the meter. Pulse registers are typically programmed to pulse based on the size of the meter and the amount of water passing through the meter. That is, while a 5/8" meter might be programmed to pulse per litre, a large 8" meter might be programmed to pulse once every cubic meter or every 10 m3. These pulses would be sent to a remote odometer or an AMR radio transmitter. The biggest issue with this type of technology is if the remote or radio transmitter was removed the pulse would be lost and not be billed.

This would result in the reading on the meter not matching with the remote or radio transmitter. Often when a meter was replaced there would be a catch-up bill to bill for any different between the two. This technology is no longer supported by most AMI vendors.

4.6.1.4. City of Winnipeg Implications

The City of Winnipeg has relatively few meters with pulse capabilities. However, in some cases industrial customers have connected their energy management systems to the pulse output which may provide some benefit to their conservation initiatives. However, pulse output water meters are not recommended as the primary output to AMR or AMI technologies but can be valuable as a value-added feature (in addition to encoder output) for situations as previously outlined.

4.6.1.5. Encoder Registers

Encoder technology is the most common water meter register used as the foundation of an AMI system. The AWWA standard that governs encoder registers is C707-10(R16). This technology allows the meter to be read directly from an AMI radio transmitter opposed to a pulse-type AMI-compatible register, an encoder register ensures that consumption is being recorded and read from a single source – the register.

Encoder registers do come with proprietary restrictions. There are predominantly two main encoder protocols which most water meter manufacturers adhere to: Sensus protocol (all meters except Neptune) and Neptune protocol. Fortunately, the technology has been around long enough that

agreements among most manufacturers have been worked out to allow reading devices (i.e., AMI radio transmitters) to read both protocols. When procuring any encoder technology, water utilities must fully understand the limitations of what and who is able to read a meter register.

4.6.1.6. City of Winnipeg Implications

It is recommended the City begin purchasing high resolution encoder water meters starting in 2022 because any residential direct read water meter will be replaced during the project. The cost of the register is about 75% the cost of the entire water meter with encoder registers, and because only the water meter manufacturer make compatible encoder registers it complicates procurement.

4.6.1.7. Other Register Features and Functionality

Some encoder registers provide water utilities with advanced features that provide a utility with additional functionality. They are also easier to read and provide the utility with more data in addition to the reading.

4.6.1.8. Digital Display

Some encoder registers are available with a digital display instead of a mechanical odometer display. These new registers may also allow for a toggle of the display, so the property owner or service personnel can see the flow rate, in various units, of water passing through the meter while it is being inspected together with any active alarm flags. This is a helpful feature that is often used during meter testing or when property owners want to understand a leak that may be at their building/residence.

One drawback of some digital displays is that they can be difficult to manually read or require a light source (flashlight) to view the display; this problem can be more pronounced in low light areas (meter pits, crawl spaces, etc.) or where dirt and water can impair visibility of the register (meter pits).

4.6.1.9. Powered Registers

With the advent of digital display registers, the issue of powering the display has been addressed in a number of ways. Some registers use a non-replaceable “potted” battery that comes with a 20-year warranty that matches the expected life of the water meter and the warranty for the transmitter. This trend of batteries being required for various metering products has reinforced the development of coordinating full meter and radio transmitter replacement every 20 years. In other words, the industry has shifted customer expectations to accept a fairly firm end date for its products’ life cycle, regardless of Positive-Displacement or Ultrasonic meter type, driven largely by the battery life that supports the register.

This risk should be evaluated at the time of procurement by establishing an evaluation criterion that allows the Utility to apply a technical weight to those products that effectively addresses these concerns. One important feature may be the register’s ability to transmit a low battery flag to the radio transmitter.

4.6.1.10. Detection Flags

Some advanced encoder meter registers and most AMI radio transmitters have detection flags (i.e., alarms conditions) embedded in the product. They have algorithms that detect certain simply defined conditions; once those conditions are met, a “Yes” flag is transmitted to the radio transmitter and data collector.

Common flags include a continuous consumption flag, a backflow detection flag, and a zero-consumption flag. The majority of meter and AMI manufacturers have designed the radio transmitter to perform the algorithms necessary to produce these flags, however a couple manufacturers perform these functions in the meter register. When flags are produced using the register head, often only that manufacturer’s AMI radio transmitter can access them. As a result, if an encoder register is responsible for performing these algorithms, then the utility may tie itself to a specific radio transmitter and water meter manufacturer if it chooses this kind of solution. On the other hand, when the radio transmitter performs these functions, the utility can continue to competitively procure a wider variety of water meters in the future.

Diameter recommends that the utility seek a solution that allows these flags to be generated and provided by the MDM or the radio transmitter and not prefer flags provided by the encoder register.

4.6.1.11. High Resolution Registers

A high-resolution water meter register head allows for higher precision increments to be recorded; smaller units of measure (i.e., litres) can be communicated to the AMI radio transmitter. Although having high resolution registers is not a mandatory requirement, it is highly recommended to ensure resolution does not negatively impact the Utility’s ability to perform many of the business drivers the Utility identified as essential (i.e., small meter leak detection). It is also important for water meters of the same size and application to have the same resolution, therefore even for new water meters Diameter recommends replacing the low-resolution registers (6 digits) with high resolution ones (8 digits). All water meter manufacturers produce a high-resolution meter; meaning this specification will not limit procurement to a single manufacturer.

Table 24 above shows the resolution expected at various sized meters to provide effective AMI data.

As an example, to demonstrate the difference between high and low-resolution registers, a residential sized (i.e., 5/8” to 1”) low-resolution meter would pick up a “leak” of 1000 litres of water per hour, whereas a high-resolution meter would pick up a leak as little as 10 litres of water per hour.

4.6.1.12. Integrated Radio with Register

Some meter manufacturers who also have AMI products have produced an integrated encoder register with an AMI radio transmitter incorporated into the register itself (often referred to as “radio under the glass”). The single product comes shipped attached to a water meter and requires no installation of the radio transmitter itself. Some manufacturers require the installer to activate the radio transmitters by sweeping a magnet across a location on the register, while others detect water moving through the meter which activates the radio transmitter.

The main benefit of this type of product is ease of installation. The installer does not have to run a wire, connect the wire to the meter encoder, and at times program the radio transmitter. An integrated encoder and AMI register does not require these additional installation steps and there is no future maintenance required for the wiring.

There are a couple disadvantages to an AMI solution that is built on an integrated radio transmitter and encoder register. First, this type of product eliminates competitive water meter purchases for the entire life of the system (15 to 20 years). An AMI system already has restrictive RF protocols that prevent a utility from using radio transmitters from a different supplier. Combining a radio transmitter with the integrated water meter register puts the same procurement restriction on the water meter purchase. In the future if issues develop relating to product quality or pricing the utility will have limited options for alternatives.

The second issue with an integrated radio transmitter for AMI technology is that the radio transmitter's location cannot be relocated to maximize propagation (i.e., raised to the floor Joists). Where meters are installed inside properties, which is the City's predominant installation type, the RF propagation (radio transmitter performance) is impacted. The implication for the City of indoor radio transmitters is additional network infrastructure (such as data collectors) increasing capital costs and operational costs. Diameter has seen examples where inside radio transmitters require 3 to 6 times more network infrastructure than if the radio transmitters were located outdoors.

Manufacturers who market an integrated radio transmitter with the register are:

- Neptune R900i product
- Sensus Ally electro-magnetic meter
- Kamstrup MULTICAL 21/flowIQ 21xx water meter
- Diehl
- Master Meter

For these reasons, Diameter recommends being cautious with a solution that requires an integrated radio transmitter with a water meter register. The short-term benefits (ease of installation) may expose a utility to long term risk. Some Ultra-sonic meters have an integrated radio transmitter with the meter register, allowing a single battery to perform the reading and transmission functions. These should be evaluated with the additional risk discussed above.

4.6.1.13. Registers that Adapt / Program to Different Meter Manufacturers

Encoder registers that can be installed on various manufacturer water meters, be programmed to a specific gearing (number of rotations / units of measure) ratio and record the water moving through the meter are available on the market.

These registers usually have different mounting rings for the different meter manufacturer register bayonet mounts. The programming depends on the installer selecting the correct meter manufacturer, meter model, and size. Any issues with this programming can lead to high or low registration. Some manufacturers also include the AMI radio transmitter integrated into this register.

The benefit of a single register is that it can be installed on any manufacturer's water meter, which is relevant to the Utility given the lack of upgrade pathway for its existing Elster meters by the manufacturer. This alternative may eliminate the need to replace meters less than 15 years old due to AMI incompatibility.

There are two main disadvantages for this type of product:

- Firstly: billing errors in installing these registers. Programming can be problematic, and any type of installation error could lead to significant billing issues. If the public loses confidence in the water meter used by the utility, it could force a 100% inspection to ensure that programming is correct on all meters.
- Secondly: void of warranty. Neither the meter manufacturer nor the retrofit register manufacturer will warranty the combined product as installed, meaning that any issue with meter accuracy or readings are owned by the Utility.

Manufacturers of these types of products include:

- Master Meter 3G Interpreter, Elinx Interpreter

Due to the high liability of installation programming errors, this product is not recommended for the large-scale AMI solution required by the Utility. For residential meters, it is more cost effective to replace the entire water meter.

4.6.1.14. City of Winnipeg Implications

The water meter encoder is a foundational device to any AMR or AMI system. Different water meter manufacturers have developed register products with some, or all the above considerations discussed. It is recommended high resolution register is the only mandatory specification that will ensure the City is able to get the benefits of AMR or AMI systems. This change in City specification should occur as soon as possible prior to the start of the project.

Encoder registers with batteries, especially on small meters where batteries are not replaceable, will continue to limit the product life to 20 years. This is in line with the AMR or AMI radio transmitter which will also need to be replaced at the end of its 20-year life. So, the City should not discriminate against products that rely on batteries instead plan to replace all water meters (including the register) with the radio transmitter every 18 to 20 years.

The City of Winnipeg has approximately 6,000 integrally mounted Itron ERT's. If the City chooses to move ahead with a AMR mobile solution these could be used if the City chose Itron as its technology provider.

If AMI technology is selected, most non-mechanical meters can be retained and fitted with AMI radios as it is understood they are currently fitted with inline connectors and remote mounted radios. However mechanical meters will either need complete meter replacements or register replacements replaced if they are under 10 years old. Please see Section 3.9 for a breakdown of meter implications.

4.7. Other Field Sensor Technology

In addition to traditional consumption meter reading functionality, some AMI systems are starting to support the other types of field devices. The most common devices that AMI systems are starting to support include pressure and temperature monitoring devices, remote shut-off valves, acoustic detection sensors, and water quality (WQ) sensors.

4.7.1.1. Pressure Transmitters

Availability alternatives: Most AMI vendors do have radio transmitters that can be connected to pressure monitoring devices. Although separate devices are available, it is expected the pressure monitoring devices will be included in the non-mechanical water meters (i.e., ultra-sonic meters). Including pressure monitoring within the meter itself avoids additional devices and radio transmitters having to be installed and maintained.

Viability: Yes, most AMI and meter manufacturers have developed or are developing both radio transmitters that can communicate to pressure monitoring devices or meters that include pressure readings with the normal volumetric meter reading.

Vendors: Sensus, Neptune, Kamstrup, Itron

Advantages:

- Provides ultimate flexibility for setting pressure transmitters within the Utility's service area with minimal infrastructure compared with traditional SCADA installations.

Disadvantages:

- Hourly pressure data may not provide enough granularity for real-time Operational decisions.

4.7.1.2. City of Winnipeg Implications

Based on the City's business drivers, pressure information would not be considered necessary as part of an AMI project. For this reason, it is not recommended to implement residential water meters with pressure sensors.

4.7.1.3. Remote Shut-off Valves

Availability alternatives: Most AMI systems have developed remote shut off devices for residential applications. Like pressure monitoring devices, the remote shut off valve is either a separate device or has been incorporated into the water meter, often with the same AWWA C700 lay lengths. The remote shut off valve often has three settings, open, closed and partially closed. This allows a utility to either partially or fully shut off the water to a residential property without the need to send a person to the property. This device requires two-way communication between the radio transmitter and Head End system.

Viability: Most AMI systems have proven the technology works on a small scale. There are still no known large-scale North American deployments.

Vendors with separate devices: Neptune

Vendors with devices included in the water meter: Sensus, Mueller, Kamstrup, Badger

Advantages:

- Claimed maintenance free operation for the life of the valve. Most products include a regular (typically monthly) valve actuation during periods of zero consumption.
- Battery operated, requiring no utility power infrastructure, for the life of the valve.
- Potential to be cost effective for locations with specific sets of conditions (i.e., accounts with high delinquent payment history, etc.).

Disadvantages:

- High cost.
- Bulky construction may not be compatible with all residential existing meter box sizes.

4.7.1.4. City of Winnipeg Implications

Based on the business drivers and discussions with the City of Winnipeg, remote shut off water meters would be of primary value to landlords.

Ultimately, unpaid tenant water bills are the responsibility of the landlord and may be added to the landlord's tax bill if they remain unpaid. The City will disconnect a tenant's water for non-payment, as resources permit, if the account is in the tenant's name and the shut off valve does not impact another property. However, if the tenant vacates the premise without payment, the shut off valve services more than one property or the City does not have resources to disconnect, the outstanding charges are transferred to the landlord's property tax bill making them ultimately responsible.

Since the benefit would go to the landlord for limiting their exposure to tenant's unpaid water bills, there are two options as it relates to remote shut-offs at rental properties:

1) The City could make the remote shut-off option available to the Landlord for a fee and activate per City policy or,
2) The City could install remote shut-offs on landlord accounts and charge the water turn-on fee for each activation

Diameter has estimated $350 for a non-mechanical water meter with remote shut-off capability. However, it should be noted that this is purely an estimate given the recent availability of this functionality and the fact it has not been bid yet in our procurements. Regardless, placing shut-offs at all landlord accounts would be a substantial investment for the City with uncertain pay-back and not recommended by Diameter. Instead, Diameter recommends option 1 and that remote shut-offs are made available to landlords who would like to purchase them for a fee. In this scenario, a meter with standard functionality is included in the financial model since additional fees for remote shut-offs would be paid by the landlord.

5. SYSTEM ASSESSMENT

5.1. Existing Systems

Through workshop activities, Diameter performed a system review with the City of Winnipeg's project team. The purpose of this assessment was to identify the systems currently used in the meter to cash process and those systems that may be impacted with the implementation of meter reading technology whether AMR or AMI. In addition, risks and challenges were identified as well as opportunities to improve processes or the customer experience.

The system diagrams below identify the level of integration between existing systems, what the transition would look like with the implementation of new systems during the installation portion of the project and the anticipated future state of City systems. Diagrams are not intended to be the final solution as different vendors may propose different types of system architecture. It is intended to give the City a good idea of the scale of the impact this project may have on their systems. This section intends to provide an understanding of the systems impacted, new systems that are required and the level of integrations Winnipeg should anticipate supporting with this organizational change.

The diagram below shows the existing systems, the automated interfaces and manual processes or interfaces that existed at the time of assessment, although the City has been working on improving many of the interfaces below. It is recommended to update this at the beginning of the procurement phase of the project.

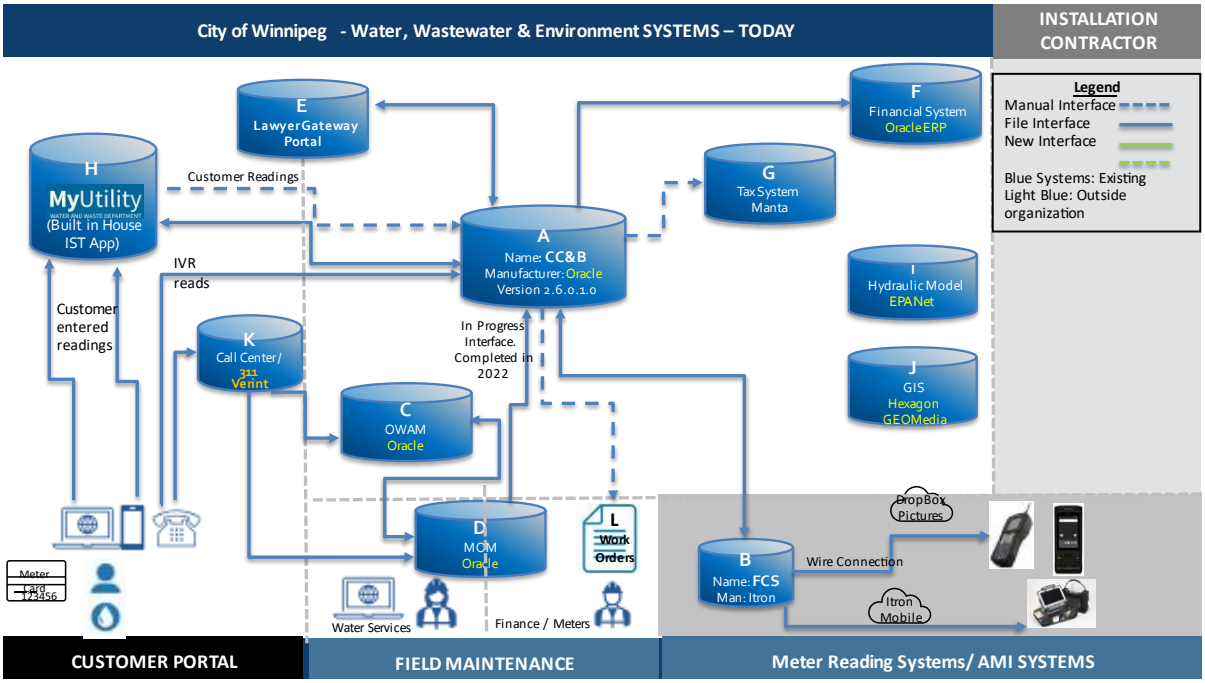


Figure 12 – Existing Systems Assessment Diagram

5.1.1. System A: CCB CIS

The City of Winnipeg bills water customers and maintains meter asset information using Oracle's Customer Care and Billing or CCB outlined as system A in the diagram above. To bill customers, CCB accepts meter readings in several ways including:

a) Meter reads are input by customers using the City's IVR system where the customer keys in the meter read using their touchtone phone. IVR reads are directly input into CCB.
b) Meter Technicians manually input meter reads they have collected in the field as part of an Inspection Appointment.
c) Customers can speak to a billing representative and provide their meter reading which are manually entered.
d) Dial-a Read occurs when a customer leaves a recording of their meter reading which require a manual review by Customer Accounts, Billing to notate the readings and manually enter them into CCB.
e) Customers can either email their meter reading using the online form or they can email their meter reading directly to the UBC if the customer knows the email address. Readings received either way are manually entered by the UBC
f) Meter readings can be submitted through the MyUtility Portal as registered or unregistered customers and are automatically uploaded to CCB.
g) For meters with Itron ERT radio transmitters and for the annual summer meter readings, meter reads are provided through an interface with Itron's FCS.
h) Where there is a change of property ownership, Final Reads can be obtained through the Lawyer Gateway Portal.
i) Meter readings can be submitted by customers who mail in a new customer application. These are manually entered into CCB by Customer Accounts, Billing.
j) Meter readings can be submitted as part of a customer's Water Leak Credit or H2O application and are manually entered into CCB by Customer Accounts, Billing
k) Meter readings can be submitted by Water Services via an electronic field slip. These readings are manually entered in CCB by Customer Accounts Billing.
l) Meter readings can be submitted by Meters Office staff who carry out a meter inspection.

All customer information is housed in CCB along with logs of customer service interactions. Meter information (meter size, age, manufacturer, # of dials, etc.) as well Itron ERT radio transmitter information (model, age, serial number) associated with each customer is also held in CCB where applicable. Meter and Itron ERT inventory are treated as separate assets in CCB. An ERT is considered an "Item object" and the meter is considered a "meter object" in CCB. The ERT is linked to a meter and the meter is linked to a Service Point in CCB. Currently, there is no direct link between the ERT and the Service Point. If the meter is moved to a new service point, the ERT is by default moved with it.

Work Orders in CCB are called Field Activities and are created for anything that requires work. Field Orders outline work that needs to be done by the Meters Office and are provided via hardcopy. For example, if work is required of the Meters Office, a PDF Field Activity is sent via email and a Field Order is printed and manually completed. Results of the Field Order are manually updated in CCB. However, if Water Services is to perform the work, the UBC operator creates a Service

Request in OWAM and then copies and pastes the work order number into Field Activity in CCB since the is no interface between CCB and OWAM to support this business process. Note that all Field Activities related to Water Services should have an OWAM Service Request but not all OWAM Service Requests have an associated Field Activity in CCB. For example, an unplanned meter exchange will not have a related Field Activity in CCB.

Systems Interfaced with CCB (System A) include:

- Flat file interface with Itron's FCS (System B) to download meter-reading routes from CCB and provide CCB the latest meter readings from either the meters with Itron ERTs installed or the manual meter readings collected (commercial with no ERT's or summer reading program).
- Flat file interface with MyUtility (System H) to provide utility bills through the customer portal and a manual interface to input meter readings submitted through MyUtility. This can be done as either a registered (email verified) or non-registered user.
- IVR interface to accept meter readings input using a phone. Touchtone produces a text file of customer responses and WAV audio files for those who do not have touchtone phones.
- Manual Interface with the Manta tax system (System G) for overdue bill amounts that are put on the tax bill.
- Lawyer Gateway (System E) interfaced to CCB allow lawyers to obtain current balance information about the premise, including amounts from previous owners, and the ability to input start or stop meter reads when there is a change of property ownership.

The current version of CCB deployed at the City of Winnipeg is 2.6 but the intent is to upgrade to version 2.9 starting in 2023 with most of the upgrade work being done by Q3 of 2024 and being completed prior to the Startup phase of the AMI project.

5.1.2. System B: Meter Reading Software (FCS)

The meter reading application currently used to facilitate the collection of meter readings is Itron's FCS.

FCS has 3 components:

1) The handheld software application
2) A cloud-based service called Itron Mobile
3) the "bolt-on component" to the FCS server for the communication to the Itron Mobile Service.

FCS is licensed by the number of endpoints based on Itron's endpoint segmentation. The City pays for up to 300,000 licenses even though they only have ~ 217,000 meters due to this licensing segmentation.

FCS currently uses a flat file interface to receive and provide information to CCB. Reading routes created in CCB are uploaded into FCS and ultimately to the meter reading equipment for meter read capture (RF capture or manual read). Once captured in the reading equipment, the meter reading data is uploaded to FCS either through the Itron Mobile cloud service or through a direct connection with FCS depending on the age/capability of the meter reading equipment used for that route. That is, where Itron FC300s are used, they are directly connected to FCS to transfer meter readings whereas the Honeywell CN80s or the Panasonic FZ-G1 Tablets have the capability to communicate with FCS through the cloud.

Aside from FC300s, there are no direct connected handheld devices to the meter reading software anymore as Itron is moving utilities to operate through the cloud to download/upload data. The City does have plans to de-commission the 24 remaining FC300 handhelds and replace them with Honeywell CN80s at a rate of between 2 and 5 per year.

In addition to the ability to communicate with Itron Mobile through the cloud, Honeywell CN80 handhelds and Panasonic FZ-G1 tablets offer additional capabilities over FC300s such as the ability to capture pictures. For example, if a meter reader is using a Honeywell CN80 or a Panasonic tablet and needs to take a picture of the meter (i.e., tampering situation) the picture is captured and then utilizes the Itron Mobile Cloud service to place the picture in FCS. However, since FC300 handhelds cannot operate through the cloud and do not have the capability to captures pictures, the City of Winnipeg has introduced a Dropbox cloud service to store pictures taken in the field. In these situations, the meter reader would use his/her phone to capture the picture and upload to Dropbox. Currently the City is leaving the pictures in FCS as well in the Dropbox but may consider centralizing all pictures within Dropbox.

23(1)(a) [redacted]

[redacted]

23(1)(a) [redacted]

[redacted].

5.1.3. System C – Oracle Work and Asset Management (OWAM), System D – Mobile Operations Management (MOM) and System K – Verint (311 Call Centre)

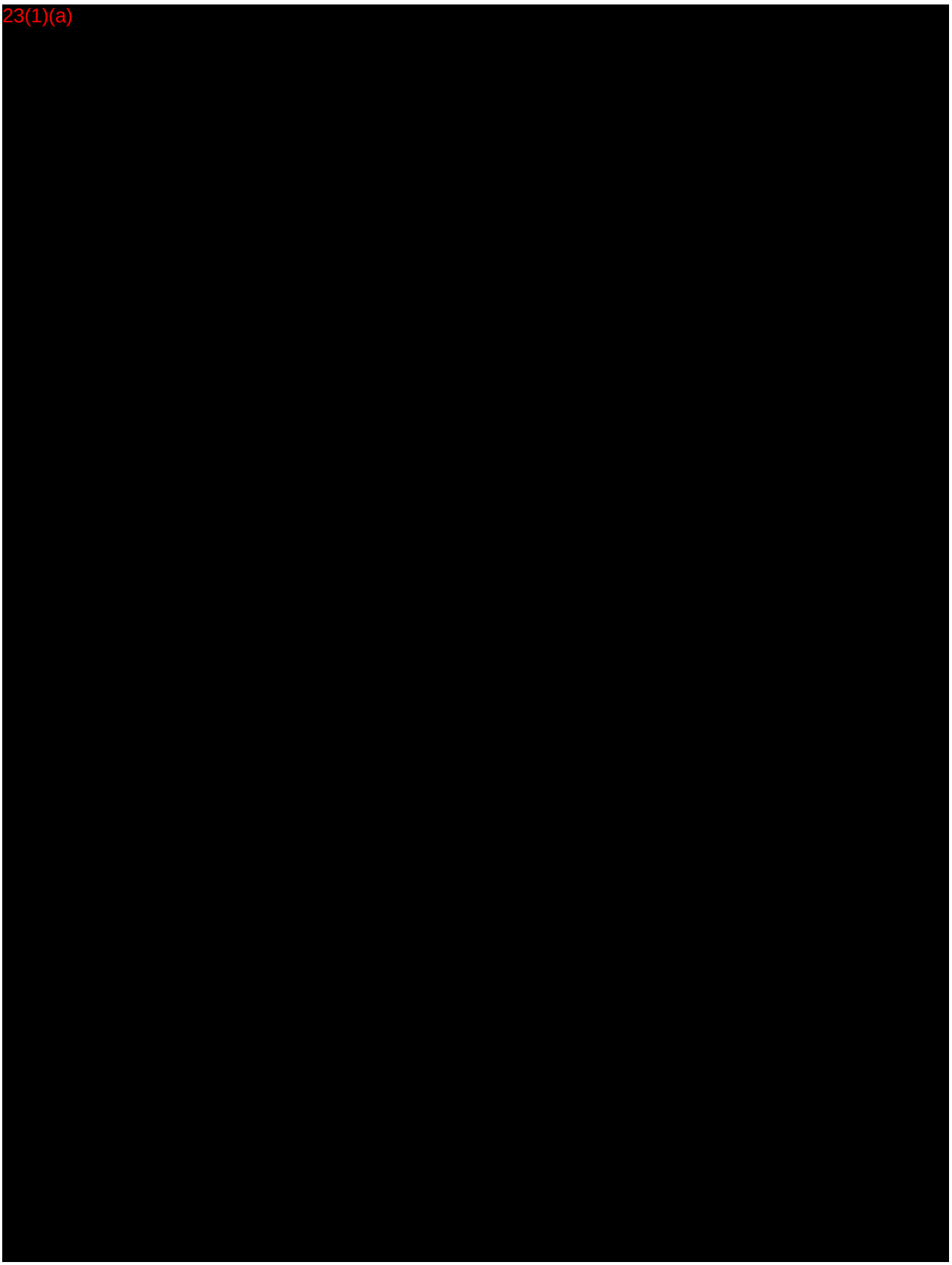
Emergency Service Request calls from water customers – such as requesting a turn-off, for repairs due to a leaking meter - originate in 311. In these instances, the 311 operator books the Service Request in their CRM software called Verint which is interfaced to the OWAM (Oracle Work and Asset Management).

All customer and billing related inquiries/requests, such as a Service Request for a stopped meter, are coordinated through the Utility Billing Centre (UBC) department. Service Requests originating out of the UBC are input into CCB and are called a Field Activity. The UBC also creates a Service Requests in OWAM when the work is intended for Water Services and then copies and pastes the Service Request number into the Field Activity in CCB since the is no interface between CCB and OWAM. Both the UBC and Customer Accounts, Billing can access OWAM to create and view the result of a Service Request. However, the UBC does not have general access to MOM (Mobile Operations Management) which houses the electronic field slips whereas Customer Accounts Billing does have regular access to the electronic field slips with the capability to update and mark field slips as complete.

Work Orders going to the Meters Office are not for meter exchanges but instead to do an Inspection, a “check read” or to look for leaks (as examples) and are provided via an emailed PDF of CCB Field Activity. Meter exchanges are typically performed by Water Services; however, the Meters Office personnel can decide to change a meter even though that was not their primary reason for visiting the site. In this case, the meter technician can access MOM and create a digital field slip to record all the appropriate information regarding the meter exchange. Note that all Field Activity’s related to Water Services should have an OWAM Service Request but not all OWAM Service Requests will have a Field Activity. For example, an unplanned meter exchange will not have a related Field Activity in CCB or a Service Request coming from 311 will also not have an associated Field Activity.

MOM was created as a front-end gap solution that enables workers in the field convenient access to OWAM. The department’s current version of OWAM is accessed via workstation/laptop and VPN and isn’t setup for convenient mobile access in the field outside of the City’s WAN. Nevertheless, field work is still dependent on OWAM functionality, but is accessed through MOM.

Presently, because there is no interface between MOM and CCB, the electronic field slips sit in MOM and wait until Customer Accounts, Billing manually process the change-out in CCB. The City is developing an interface currently between MOM and CCB around field activities/field orders to enable read/write activity associated with field work.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5.1.4. System E Lawyer Gateway Portal

The Law Society of Manitoba established Legal Data Resources Corporation or LDRC. As part of registration with the LDRC, lawyers can access the Lawyer Gateway Portal provided by the City of Winnipeg.

Lawyers access Lawyer Gateway to obtain current balance information about a premise which may include outstanding balances from previous account holders. In this portal, users can request final account information, provide a vendor's forwarding mailing address and both purchaser and vendor lawyers can submit meter readings for their respective clients either moving in or moving out. Both lawyers in the transaction are recommended to submit readings and take photo proof to protect their clients from being charged for water consumption that belongs to the other party.

Through a file interface with CCB, the Lawyer Gateway includes utility account balances as reflected in CCB. A vendor lawyer who uses Lawyer Gateway to request final account information will receive a copy of the vendor's final bill or email notification to search again only if the lawyer uses this feature. Not all vendor lawyers make a request. If they do not and there is an adjustment on the account, they will not be notified.

With AMI, the Lawyer Gateway will become more efficient. Meter readings will no longer rely on submissions from lawyers or property owners and instead, the Lawyer Gateway would rely on CCB to provide the meter readings. Optionally, the Lawyer Gateway could be interfaced to the MDM so latest meter reading information provided by the AMI system are in the Gateway.

5.1.5. System G: Tax System (Manta)

The Manta tax system is only involved from the standpoint that past due amounts are sent to the tax system on an ad hoc basis and via flat file. The AMI implementation is not seen as impacting this process.

5.1.6. System H: MyUtility

The MyUtility customer portal focuses on the City of Winnipeg's water, wastewater, recycling and garbage services. As it relates to water services, the portal provides customers extensive information on virtually all aspects of the utility including water consumption, the variety of ways to

pay their bill, instructions to stop, start or transfer their utility billing service, water rates, water meters, how to read the meter, etc. Importantly, MyUtility also enables customers to input their meter reading and enables customers to view their utility bills using the portal.

There is currently a flat file interface between MyUtility and CCB so utility bills can be presented through the customer portal and a flat file interface to input meter readings submitted through MyUtility into CCB.

5.1.7. L – Field Orders initiated out of CCB

Service requests for the Meters Office would generally be booked by the Utility Billing Centre in CCB and a Field Order is initiated to commence the work. Although the Field Order would be related to doing an Inspection, checking for leaks, performing a check read, etc., and not related to performing a meter exchange, the Meters Office personnel may exchange a meter while they are at a site if required in an effort to increase customer service and minimize costs for the City.

In performing meter exchanges, Meters Office staff has access to MOM to create a digital field slip to record the meter information from the meter being removed as well as the meter being installed. Meter exchange information provided in the digital field slip is then manually updated in CCB by Customer Accounts, Billing.

5.2. System Assessment – Transition

The diagram below provides an overview of the systems and interfaces that will be impacted by movement to an advanced metering system. The diagram has assumed AMI is the meter reading system selected.

The systems and interfaces in blue are existing systems. New systems that will be implemented during the project are in green and in orange are systems that are impacted as part of the project. The intent of this diagram is to provide an understanding of the impact this project will have on the City of Winnipeg's system architecture.

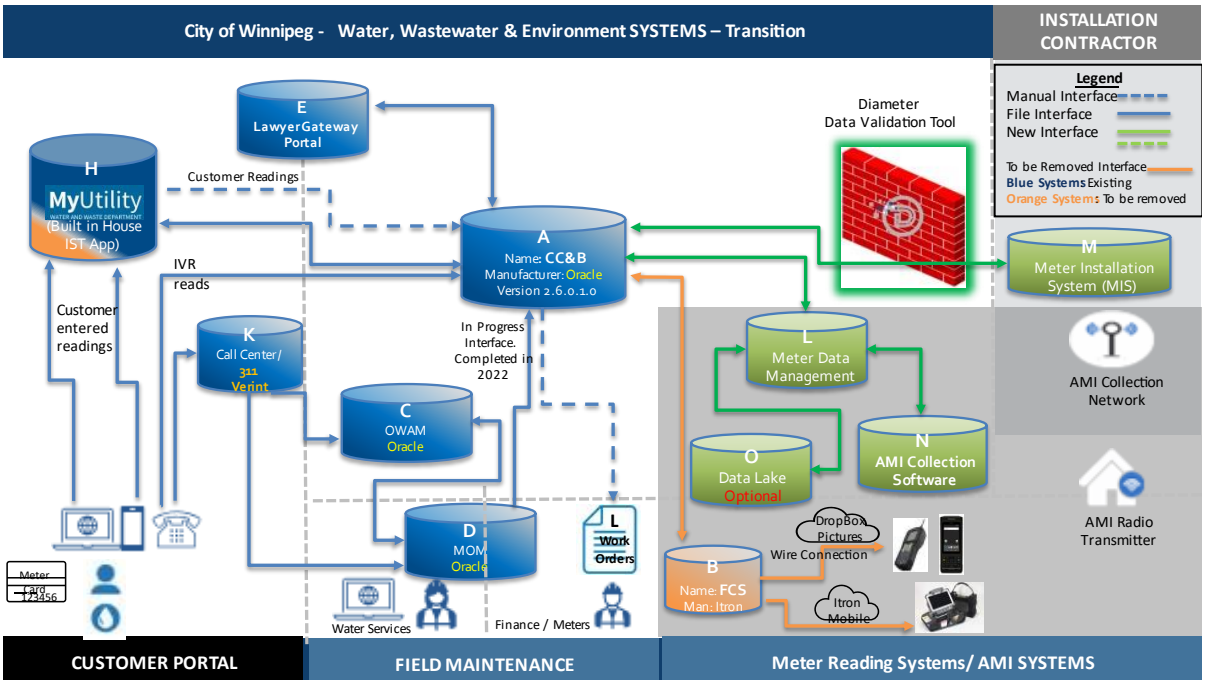


Figure 13 – Systems Transition

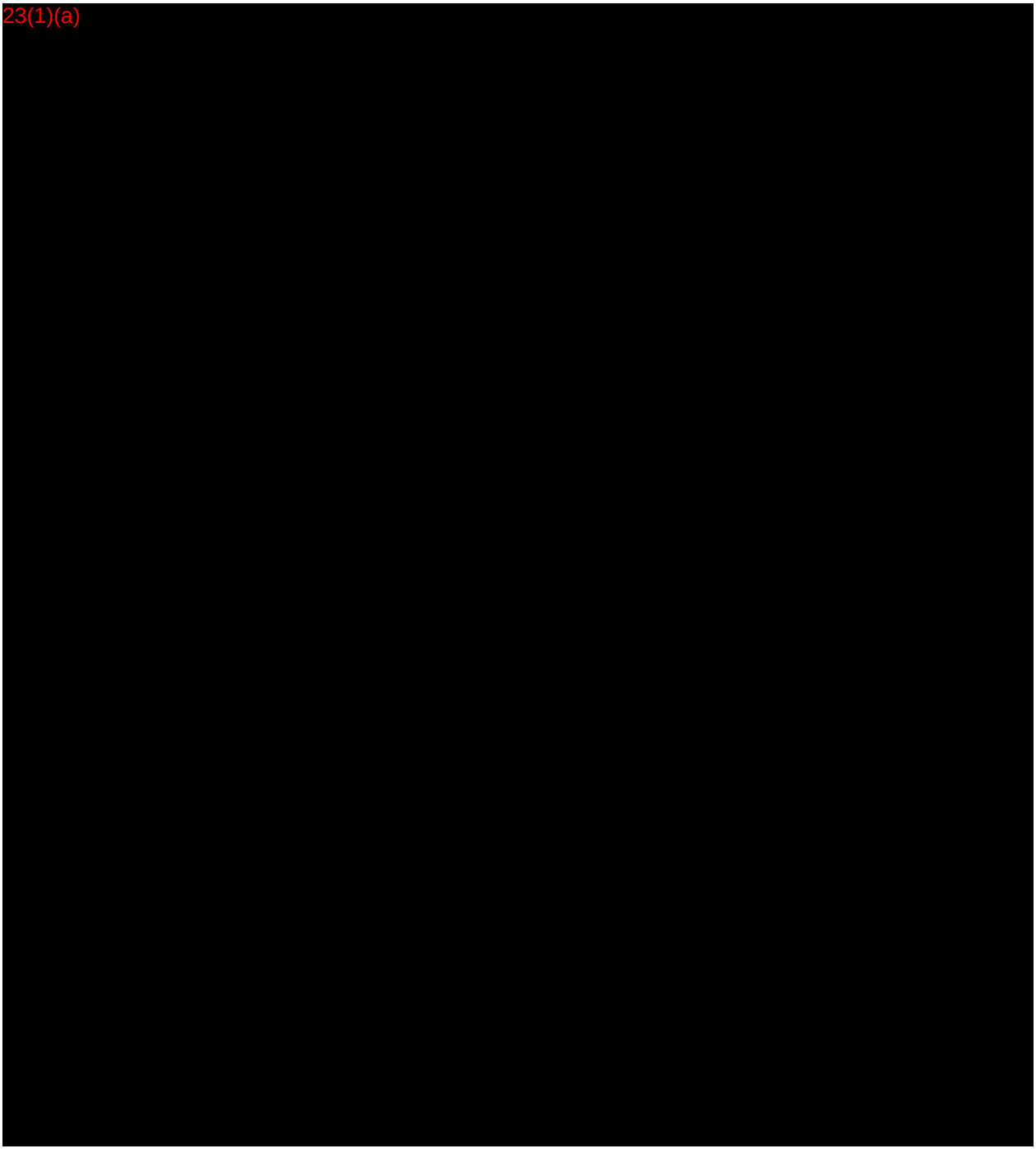
The new systems required as part of the AMI project include:

5.2.1. System N – AMI Collection Software and System L - MDM

The AMI system upgrade will add equipment to the field (water meter radio transmitters, fixed data collectors) and AMI software applications. Although systems N (AMI collection software) and system L (Meter Data Management software) are shown as two applications they may be one or two applications depending on the AMI vendor. Regardless of whether the MDM is a stand-alone solution or combined with the AMI data collection software, ultimately the MDM will be the source of data that would accept meter reading requests from CCB and provide meter reading responses to CCB so customer billing can be completed. In addition, the MDM is generally integrated with the customer portal to provide (hourly) consumption information, alarms, consumption comparisons (i.e., same time last year) and might incorporate weather data as a few examples.

MDMs provided by AMI vendors have varying levels of functionality and most AMI vendors' MDMs fall well short of a Tier 1 stand-alone MDM in terms of flexibility and functionality. An independent MDM application would cost more to purchase, implement (~$2-4M), and maintain ($500K annually) but has the benefits of additional functionality. This functionality might include Validation, Estimation and Editing (VEE) to ensure data integrity and flag non-conforming data, serve as the central integration point to consolidate meter data from different sources/vendors (if applicable), provide asset management, perform exception handling for situations outside of the VEE rules and can perform data analysis as a few examples.

23(1)(a)



5.2.2. System O - Data Lake

AMI vendors generally provide data to integrated applications through flat files and do not (yet) satisfy the requirements for real-time API integrations. While a data lake would duplicate meter reading and interval data in a separate system, the purpose of the data lake would be to provide this level of timeliness to data updates where required.

23(1)(a)

[redacted]

5.2.3. System M - Meter Installation System

System M involves the introduction of the Meter Installation System (MIS) provided by the installation contractor vendor. The MIS is only provided temporarily during the Startup and Deployment of the Project and is removed once the Project is complete.

The MIS requires a two-way integration with CCB to receive installation and customer data so appointments can be generated. It controls the workflow on the handhelds enabling tracking of meter assets removed from the distribution system along with the meter reading and records the new assets that have been added, upgraded or retrofit with a radio transmitter. Once the work in the field is completed, a Service Order Completion file is provided from the MIS to CCB that contains all information associated with the assets removed and links new meter, with radio transmitter along with the address where those assets were installed.

5.2.4. Data Validation Tool (Diameter Value-Added Service)

Diameter's extensive experience as Program Manager for the installation portion of AMR/AMI projects has indicated a need for more robust data validation between CCB and the MIS to reduce workload on CCB support staff and ensure data integrity. To that end, Diameter has developed a data validation tool that performs data checks not normally provided by CCB systems or the MIS to ensure projects are implemented as smoothly as possible.

Diameter's Data Validation Tool ensures the data being sent to the MIS has not been previously received and prevents duplication of work and data confusion. It also ensures work orders that are sent are completed and not missed ensuring the highest possible completion rate for the installation contractor. The Data Validation Tool also ensures the data coming back to CCB is correct in areas not normally validated. Examples include the validation of meter sizing for that account and that the radio transmitter is configured properly for that meter size and account to avoid billing issues. As it relates to contractor billing, the Data Validation Tool checks validates work types being billed and billable items that have been charged to ensure fair contractor billing. From an AMI system perspective, it helps ensure Read Success Rate (RSR) of the system being implemented so it can

be “accepted” and that the register read data and interval data is being provided per the contractual obligations.

23(1)(a) [redacted]

5.2.5. Existing System Implications: System B - FCS and System H – MyUtility

Itron FCS may be impacted when fully implementing AMR or during the move to AMI depending on the system/vendor chosen. Assuming a move to an AMI system other than Itron, FCS will ultimately be de-commissioned following the removal of Itron’s ERTs from service and replaced with the new vendor’s radio transmitter installation software if applicable. Generally, this software can run on Android, Windows or iOS operating systems enabling the City to likely take advantage of its investment in the Honeywell CN80 handhelds. Although not required by all vendors, this software will enable the City to program its radio transmitters as required (interval lengths, number of encoded digits, time between broadcasts, leak parameters, etc.), create the marriage file creating the relationship between the radio transmitter, the meter and the address, and subsequently update the CCB.

Although MyUtility is considered outside the scope of this AMR/AMI project, it is shown in Blue/Orange since there will be implications on the portal when the City decides to enhance the functionality and leverage the data from its meter reading system.

5.3. System Assessment – Future

The diagram below provides an overview of the City of Winnipeg's future system architecture. This should act as a guide or reference point as the City moves forward with some of the recommendations made in this report.

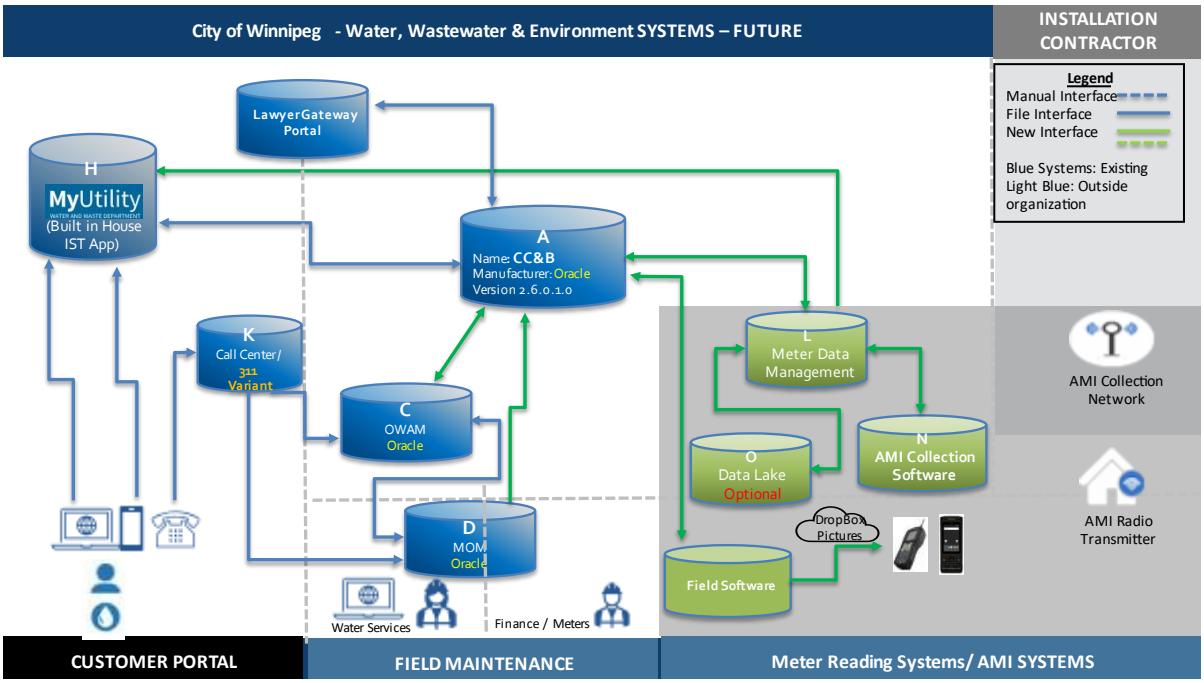


Figure 14 – Future Systems Diagram

As mentioned above, the MIS is a temporary application not required after full deployment and therefore is not shown above. The AMI collection software and the MDM are all required with the introduction of AMI and require the development of new interfaces as shown in green.

All meter readings for CCB and MyUtility now originate from the MDM removing any customer input meter readings into MyUtility, manual input of meter reading from voice recording, IVR meter readings etc. In addition, this diagram introduces a Field Software used in the programming of radio transmitters, installation of meters and would require interfacing with CCB. The Field Software is assumed to leverage the Honeywell CN80 handhelds since most will utilize any of Android, iOS or Windows operating systems.

6. PROCUREMENT STRATEGY

6.1. Scope and Groupings

The framework for the procurement strategy is established by decisions related to what to include in the procurement scope and how to group the different procurement elements. This process begins by defining the products and services required for procurement and determining who should perform the work (City resources or outsourced resources). In the case of the City, the following elements and support structures for the AMI system, water meters and installation were discussed in a procurement workshop with Diameter to provide a broader understanding of all of the procurement elements and how they pertain to the City.

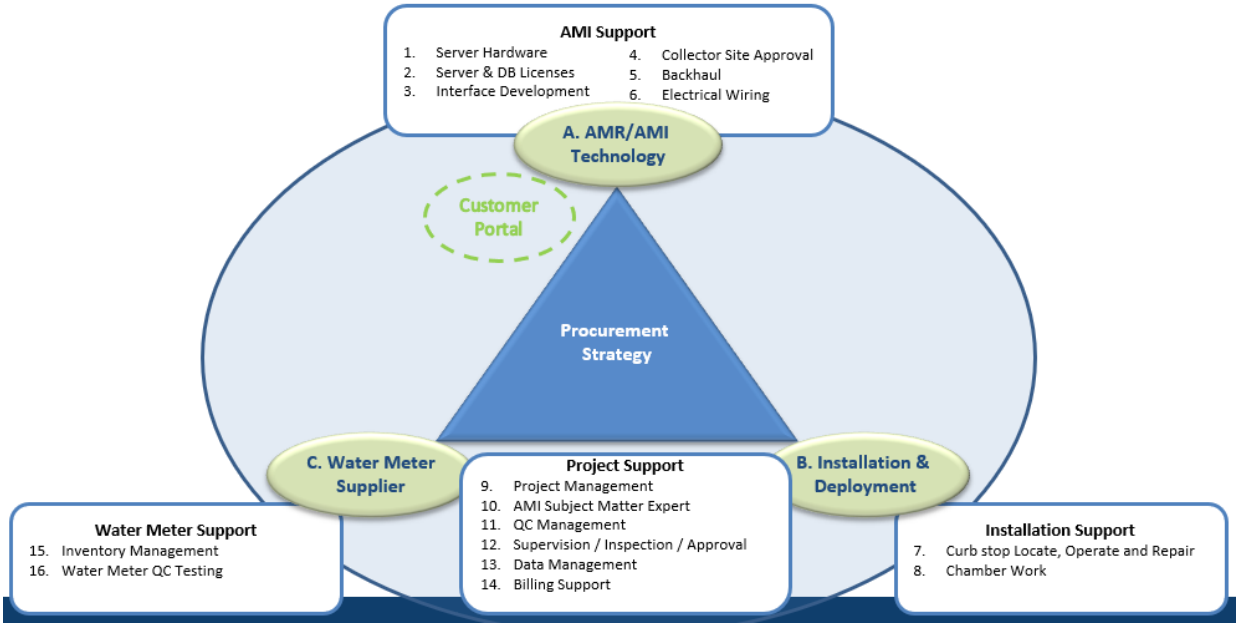


Figure 5 - Project Scope

With an understanding of what products and services are required as part of the procurement strategy, the City's decisions shifted to determine what elements should be grouped during procurement and in which order should the various components be procured.

The primary procurement groupings include:

A. AMI/AMR technology (which may include the MDM software), and
B. Installation and deployment, and
C. Water meter supply

The customer portal may also be procured as a component of the AMI technology if the AMI vendor's features and functionality meet the City's needs. Most AMI vendors are provide only limited functionality and are more and more recommending a third-party full functional customer portal to be

procured separately. The vendors who would respond to an independent (of AMI) customer portal RFP is completely different than who would be interested in an AMI RFP.

6.1.1.1. Procurement Strategies

Based on the primary procurement groupings depicted above, there are five procurement options for the City's consideration:

Options	Description
Option 1	One Procurement: 1. Turnkey Single Procurement (A+B+C).
Option 2	Two Procurements: 1. AMI + Installation (A+B) 2. Meter Supply Separate (C)
Option 3	Two Procurements: 1. AMI Separate (A) 2. Installation + Meter Supply (B+C)
Option 4	Two Procurements: 1. Install Separate (B) 2. AMI System + Meter Supply (A+C)
Option 5	Three Procurements: 1. Install Separate (B) 2. AMI System (A) 3. Meter Supply (C)

Table 29 – Procurement Options

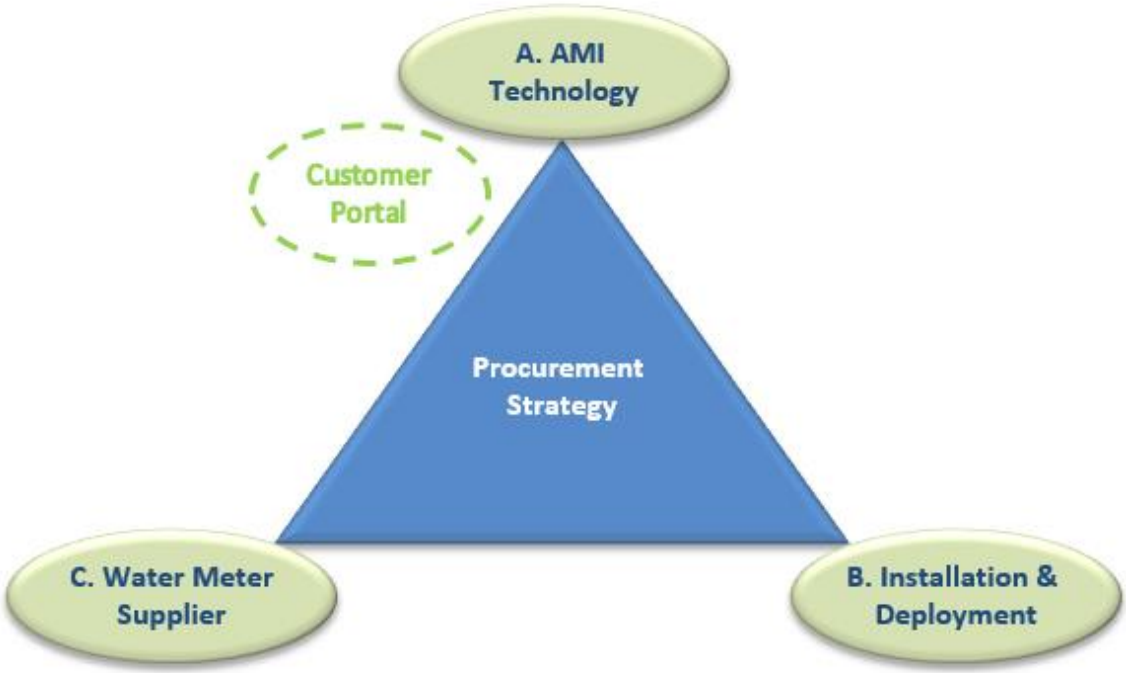
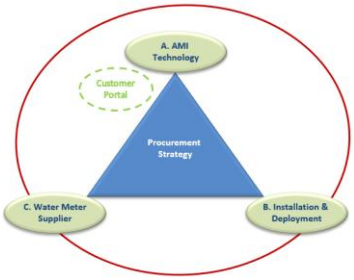
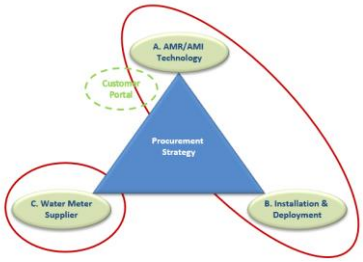
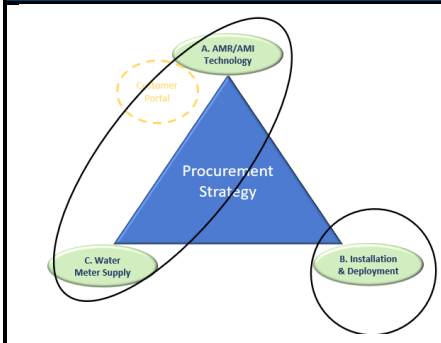
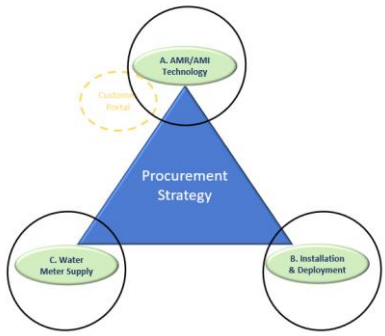


Figure 6 - Procurement Strategy Diagram

Option 1 Single Procurement Turnkey (A+B+C)	Option 2 Two Procurements AMI + Installation (A+B) Meter Supply Separate (C)	Option 3 Two Procurements AMI Separate (A) Installation + Meter Supply (B+C)
		
Advantages (Benefits) • Responsibility for all components in a single vendor. • Product warranty can include in/out costs for the first year. • Product payment is tied to installation. • Less City and consulting effort to develop procurement documents, perform evaluation and negotiations with a single vendor.	**Advantages (Benefits)** • Responsibility for AMI performance is in a single contract. • Installation remains with AMI vendor who then has complete responsibility for successful communication to collection equipment. Since Installation issues create the most risk of poor AMI performance coupling Installation with AMI is advantageous for the City. • Allows for multiple meter manufacturers and components, often appealing to larger water utilities.	**Advantages (Benefits)** • Medium cost scenario. • Provides best selection of AMI systems. • Can allow a slower role out
Disadvantages (Risks) • May be higher costs due to some vendors having to put margin on margin for products. • Prime contract performance bond requirements may limit vendors (smaller companies will not be able to bid).	**Disadvantages (Risks)** • Issues with faulty meters will be a City responsibility. • Bad wiring to encoder could be blamed on meter (City responsibility), a mitigation strategy to specify Nicor (or approved equivalent) connector, but these are best suited for meter pit applications.	**Disadvantages (Risks)** • City will bear liability supplying radio transmitters • Install and AMI system working together has the most liability and this option separates these two components • Non-mechanicals meters – when AMI and meter supply are not procured together some functionality related to alarms (low battery, temperature, pressure, continious leak, high consumption leak alarms) may be pass through the radio transmitter. This is

Option 1 Single Procurement Turnkey (A+B+C)	Option 2 Two Procurements AMI + Installation (A+B) Meter Supply Separate (C)	Option 3 Two Procurements AMI Separate (A) Installation + Meter Supply (B+C)
		applicable when meter and AMI radio transmitters are not the same manufacturer.

Table 30 – Procurement Advantages and Disadvantages

Option 4 Two Procurements 1. Install Separate (B) 2. AMI System + Meter Supply (A+C)	Option 5 Three Procurements 1. Install (A) 2. AMI system (B) 3. Water meter Supply (C)
	
Advantages (Benefits) • Medium cost scenario. • Ensures new meter functionality will be compatible to the AMR/AMI technology. • Can allow a slower role out when a utility may want to deploy meters and radio transmitters with their own forces.	**Advantages (Benefits)** • Likely lowest cost scenario. • Allows the city to select the best in class of all three components.
Disadvantages (Risks) • City will bear liability of forecasting and supplying products the installer. • Poor Installation or data quality or failure to adhere to manufacturer installation specifications by the installer may impact AMI performance. • Likely high third-party inspections rates would be required.	**Disadvantages (Risks)** • City will bear liability of forecasting and supplying products the installer. • Poor Installation or data quality or failure to adhere to manufacturer installation specifications by the installer may impact AMI performance. • Likely high third-party inspections rates would be required.

Option 4 Two Procurements 1. Install Separate (B) 2. AMI System + Meter Supply (A+C)	Option 5 Three Procurements 1. Install (A) 2. AMI system (B) 3. Water meter Supply (C)
• Faulty products under warranty will cost	• Faulty products under warranty will cost • The City will be required to coordinate between the multiple contracts and vendors

Table 30 – Procurement Advantages and Disadvantages Continued

Each procurement strategy option has advantages and disadvantages, and the applicability of each strategy is based on the number of services, existing water meter and AMR manufacturers, or the desired functionality as determined in the business drivers.

Option 1 Single Procurement – this strategy often applies to water utilities that are smaller in size but could be applicable to larger utility as well if there is a desire to for liability to be placed on a single vendor. This strategy may also be applicable if a large percentage of the water meters or existing radio transmitters need to be replaced.

Option 2 Two Procurements, water meter supply separate – This strategy often makes sense when a water utility has a preferred existing water meter supplier, and the utility does not want this preference to influence the selection of the AMI technology. This may also make sense when a water utility has several different water meter manufacturers, and it was decided to upgrade a large percentage of the existing water meters with new high-resolution encoders. Given this situation would provide advantage to a single manufacturer, procuring water meters separately could eliminate this advantage and make AMI technology and install more competitive.

Option 3 Two Procurements, AMI Technology procured separately – This strategy would be recommended if a water utility wants to continue with existing water meter and installation / maintenance contracts. Another example would be if the AMI technology was part of a Smart City strategy and there are other use cases for Smart City devices (streetlight controls, smart parking, etc.) on the network beyond water meter data. This scenario would require AMI to be procured separately to maximize the Smart City AMI vendors who can participate in the procurement process. Finally, some water utilities want the maximize the number of solution submissions or a preferred AMR/AMI technology does not have a water meter or installation partnership. If the utility opted for this option the AMI procurement should be conducted first, then followed by the installation and meters as a secondary procurement.

Option 4 Two Procurements, Installation procured separately – This strategy would be most applicable if the business drivers identified necessary features that require the water meter and AMI technology to be the same manufacturer (pressure, temperature, battery status data) and the water utility either has a preferred installation provided or they intend to install the meters and devices with their own forces.

Option 5 Three Procurements, Installation procured separately – This strategy should be considered if the water utility has a strong desire to select the best in class of each component. This may also be applicable if there are existing contracts for the different components and the utility does not want to terminate them.

6.1.1.2. Competitive Landscape

While there are advantages and disadvantages to each option, some options are more prevalent than others in the marketplace. It is important to know that the groupings can also influence the competitiveness of the marketplace and impact overall project costs and resource demands for the City. The competitive landscape is expected as follows:

PRIME	AMI	METER	INSTALLATION
KTI	Sensus	Sensus	KTI
Neptune	Neptune	Neptune	Neptune
Metercor	Itron	Kamstrup MasterMeter	Metercor
Eleven-X	Eleven-X	(?)	Metercor
Iconix	(?)	(?)	None
Aclara	Aclara	Badger(?) Other (?)	Badger(?) Other (?)
Wolseley	Itron Badger	Badger Mueller (?) Honeywell (?) Other (?)	Wolseley Metercor (?)
Mueller	Mueller	Mueller	(?)
MasterMeter	MasterMeter	MasterMeter	(?)
(?)	(?)	Zenner	(?)

Table 31 – Procurement Competitive Landscape

The (?) shows the market uncertainty, as distributors and partnership change in the market.
With a turnkey procurement strategy (option 1), it is expected that the City would receive at least 4 submissions including the major market players.

6.1.1.3. City of Winnipeg Implications

The City of Winnipeg is considered a large water utility in comparison to other North American utilities and because of this there are a couple additional considerations that need to be considered.

Oracle C2M Migration

The City currently uses Oracle's CCB application version 2.6 for water billing. Oracle's latest major software release provides utilities with a migration path from CCB to their latest offering called C2M. C2M incorporates the water billing and a meter data management (MDM) functionality into a single offering. MDM is a critical component of an AMI software solution and is generally included in AMI solution offerings.

The City's IT team is mapping out a plan that will eventually move the water billing to the C2M product. A C2M migration is a significant upgrade to CCB and the time it would take to plan implement and test this migration would delay any AMI deployment. It is not recommended to perform any significant CCB upgrade during the start up or proof of concept phases of the AMI project.

Incorporating the MDM provided by C2M may also make sense at some point. Advantages of Oracle's MDM is it envisions workflows that are linked to both water billing and water consumption behaviors so City users can identify and resolve these events all within the application itself. One of disadvantages of this application is the cost. The Oracle C2M carries a significantly higher cost to license and implement as compared to an AMI vendor provided MDM application. Also, some functionality in C2M is lacking, primarily C2M does not have mapping or graphing functionality yet. These are features are ones that most AMI vendor's MDM offer today and is often a feature utility users find most useful.

23(1)(a)

[redacted]

Customer Portal

Several business drivers (leak notification, high consumption alerts) will require customer engagement and the City letting the customer know of these types of events. One avenue to increase engagement with City customers is through a customer portal. Consumption information can add functionality to a customer portal, give the customer more control over alerts and be an efficiency way of emailing or texting customer these alerts.

The City has already developed a customer portal for City residents that supports more than just water functions which the City intends to continue to utilize going forward.

23(1)(a)

[redacted]

Procurement Strategy

The City of Winnipeg can reasonably consider any of Option 1, 2 or 3. Option 1 (single "turnkey" procurement) is preferred by many utilities who want to place the responsibility for all aspects of the project on a single vendor and prevent any "finger pointing" between vendors when issues arise. This is the least expensive approach to procurement since there is less City and consulting effort and it is the fastest approach to implementation since it avoids additional procurements which can prolong the procurement phase.

In most cases, Option 1 will see the City receive bids where the meter and AMI vendor are the same. Option 1 can limit AMI technology choices for the City because AMI vendors who do not provide a meter option or installation services may opt not to bid. Also, smaller vendors of AMI systems may not be able to meet performance bond requirements given the increased cost installation and meter supply will contribute to their bid. In addition, this option might result in higher prices in cases where the prime vendor needs to add their own margin in addition to that of their partner's margin (i.e., margin on margin). However, it bears repeating that receiving enhanced meter information (or flags) including pressure and temperature generally require the meter and AMI system to be provided by the same vendor which Option 1 promotes.

Option 2 and Option 3 couple with the installation portion of the project with either the AMI system (Option 2) or the meter supply (Option 3). In both cases, a question that needs consideration is 'which companies are not going to bid because of the installation requirement?' 23(1)(a) [redacted]

If Option 3 is chosen the City would have the opportunity to choose virtually any AMI system since all solutions accept the industry standard Sensus or Neptune meter encoder protocols. Diameter would expect approximately of six Tier 1 AMI submissions for AMI systems at the City of Winnipeg versus approximately four for option 1. If Option 3 is chosen, the City would bear the responsibility of supplying radio transmitters and given current supply chain issues it is something to consider.

Regardless of what option is chosen, the City may have to accept some sub-optimization in one area of the project. While Option 3 allows the City to choose its preferred AMI vendor as mentioned, the fact installation is tied to meter supply may force the City to choose between its preferred meter and its preferred installer. Similarly, a turnkey will force to City to decide what is most important in a bid and where they're prepared to "sacrifice".

In Canada, the biggest issue facing AMI and meter replacement projects currently is the lack of installation companies. Some Tier 1 meter vendors do provide their own installation services and others will require an installation partner. However, independent Canadian installation companies are very limited but as one of the larger meter replacement and AMI projects in the county,

6.2. Procurement Type

Diameter presented the City with several competitive procurement methods for consideration. It is important to mention that typically AMI projects do not fall neatly into normal procurement rules. Through workshop discussions, Diameter reviewed the advantages and disadvantages of pursuing an RFP versus a tender process; notably the tender process primarily focuses on price solicitation for specific goods and services (generally commodity items), is highly structured, and leaves little room for deviation from what has been requested.

RFP Process	Tender Process
Advantages • Allows for apples to oranges comparison • Allows for alternatives • Procurement includes strong specification BUT allows for variation in the offering • Software can be difficult to compare • Most common type of AMI/AMR procurement	**Advantages** • Likely lowest price • Save time on evaluation • Could work for just water meters
Disadvantages • The awarded solution may not be the lowest cost solution • Can be difficult to convince politicians as to why a higher cost solution is better	**Disadvantages** • No consideration for innovative solution • Easy to have bidders disqualified due to a small non-compliance • Price is not the only factor with these types of projects • Quality of team and proven products need to be evaluated

Table 32: RFP Versus Tender Advantages and Disadvantage

Diameter does not recommend a tender process for the AMI or the installation procurement as the market offers too much variability in experience and product functionality for a tender process. An RFP for the water meter supply also allows the City to score product support and customer service levels offered post project. It could also allow the City to place value on a Canadian presence. This approach also allows for the City to evaluate product options as some manufacturers have unique features related to AMI that should be given qualitative points should they align with the City's business drivers.

The City of Winnipeg's Project Team expressed preference for an RFP process and the evaluation would assure that the City would be moving forward with vendor(s) that were proven in the market.

7. IMPLEMENTATION SCHEDULES

7.1. Introduction

An AMI system implementation project is not your typical engineering project. The combination of products being supplied (often from different vendors), installation services, software applications and software integration to existing and new applications presents unique challenges. Complicating this further, the products and software application all need to be compatible with one another and provide the right data, in the right way, to the right systems, and at the right time in the business process. In fact, often AMI projects more closely mirror technology projects rather than installation projects. Finally, the work needs to be done while ensuring City's water customers are being informed and engaged in this very important project.

These challenges support a single, dedicated and focused implementation approach. A program of this nature requires a Program Master Schedule that will drive key tasks, dependencies, timelines, and resource assignments. This Program Master Schedule has been developed using a Microsoft Gant chart and has been submitted as Appendix B to this report. The schedule assumes the project will go to Council for approval in February 2023 and progresses through the various project phases detailed in the Project Support section. This will allow the City to plan for when key activities and workstreams will begin and provide realistic timelines for them and will be the pace the installation contractor will likely take in completing the project.

Appendix C of this report is a weekly Production Schedule which provides estimated weekly production installations from Proof of Concept to final installations. This production schedule has been developed based on our experience on similar size projects as the City of Winnipeg.

The final element of the Implementation Schedules is the Cashflows Forecast. This is based on the weekly Production Schedule using average costs and some flat line estimates for the support elements. This schedule will be finalized with the Financial Report.

All three of these elements, 1) Program Master Schedule (Appendix A), 2) Production Schedule (Appendix B, tab Production Plans, and 3) Cashflow Forecast (Appendix B, tab Cashflow) are all summarized in this section.

7.2. Program Master Schedule

The Program Master Schedule is grouped into the key project phases as discussed in the project support section of this report. A Phase 0 has been added as a preparation task to procure the services of a water focused AMI subject matter expert consultant team.

Detailed tasks, dependencies and responsibility associated with each task can be viewed in the Appendix.

A summary of the project phases duration is detailed in the table below.

Task Name	Duration	Months	Total Duration
Project Approval	**16 days**	**1 M**	**1M**
Contract Administration / Phase 0	**120 days**	**6 M**	**7M**
Procurement Stage / Phase 2	**266 days**	**13 M**	**20M**
Manage Stage / Phase 3, 4a, 4b, 5	**1876 days**	**86 M**	**106M**
Pre-Startup	**51 days**	**3 M**	
Phase 3 - Startup	**193 days**	**8 M**	
Phase 4 - Proof of Concept, Installation and Deployment	**971 days**		
Phase 4a - Proof of Concept (POC)	**85 days**	**4 M**	
Phase 4b - Installation and Deployment	**885 days**	**40 M**	
Phase 5 - Close Out	**155 days**	**6 M**	
		Total Months	**106 M**
		Total Years	**8.8 Years**

7.2.1. Project Approval and Phase 0

Task Name	Duration	Total Duration
Project Approval	**16 days**	**16 Days**
Submit Council Report	10 days	
Standing Policy Committee on Water and Waste, Riverbank Management and the Environment	20 days	
City Council Meeting	0 days	
Contract Administration / Phase 0	**120 days**	**136 Days**
Procurement for Consulting Services	**40 days**	
Prepare 1st draft RFP for Consulting Services	20 days	
Prepare 2nd and Final RFP for Consulting Services	20 days	
Release RFP	0 days	
Procurement Period	20 days	
Receive Proposal Responses to RFP	0 days	
Evaluation of Responses	20 days	
Prepare Council Report	20 days	
Standing Policy Committee on Water and Waste, Riverbank Management and the Environment	20 days	
City Council Meeting	0 days	
Prepare PO and Commence Work Notification	10 days	
	Total Days	**146 Days**
	Total Months	**8.5 M**

7.2.2. Phase 1 – Design

Phase 1 of the project is the design or Profession Consulting Services for an Advanced Water Meter Business Case (RFP No 801-2020) which produced this report.

7.2.3. Phase 2 – Procurement

Task Name	Duration	Total Duration
Procurement Stage / Phase 2	**266 days**	**266 Days**
Procurement Stage - Kickoff Meeting	**2 days**	
Project Management	**240 days**	
Risk Management Monitoring	**240 days**	
Oracle Integration SOW - Negotiation	**246 days**	
Specification Development	**91 days**	
AMI and Installation Specification & RFP Development	**75 days**	
Water Meter Specification Development	**75 days**	
Procurement	**95 days**	
Procurement #1 - AMI, Installation and Water Meters	**95 days**	
Contract Negotiations	**35 days**	
	Total Days	**266 Days**
	Total Months	**12 M**

The lower level work streams all have different start dates which is why the totals can

7.2.4. Phase 3 - Start up

This phase of the project will include the City, the CCB integrator, the consultant team and the AMI and Installation vendors. The purpose of this phase is to pre-plan the project, develop the customer outreach program, develop and test interfaces, configure the new and existing software applications.

Task Name	Duration	Total Duration
Phase 3 - Startup	**193 days**	**193 Days**
Project Kickoff Meeting (Vendor, City, Diameter)	2 days	
Project Start-up Meetings	5 days	
Progress Meetings	173 days	
Steering Committee Meetings	**173 days**	
AMI and Installation Software Integrations	**160 days**	
AMI Network Deployment and Installation	**186 days**	
Public Education Development	**96 days**	
Software Installation and Training	**178 days**	
Solution Walkthrough	**47 days**	
Installation Preparation	**121 days**	
Communications to Customers	**11 days**	
Initial User Acceptance Test (I-UAT)	**15 days**	
Pre-Construction Meeting	1 day	
Readiness Items		
By-law Amendments	180 days	
Rates Review and Changes	180 days	
Standard Construction Drawing review / changes	180 days	

Task Name	Duration	Total Duration
Non-compliance process	180 days	
	Total Days	**193 Days**
	Total Months	**16 Months**

7.2.5. Phase 4a Proof of Concept

This phase of the project will include the City, the CCB integrator, the consultant team and the AMI and Installation vendors. Having passed in the Initial User Acceptance Test, the AMI and Installation Contractor will proceed to install approximately 5,000 water meters. The purpose of this phase is twofold: first, it validates the installation Contractors people, processes and systems ability to handle the production volumes that will be necessary in the next phase; secondly, it will provide real consumption data using water meters installed in a production environment, this data will be used in the Final User Acceptance testing (FUAT). It is a critical pre-plan the project, develop the customer outreach program, develop and test interfaces, configure the new and existing software applications.

Task Name	Duration	Total Duration
Phase 4 - Proof of Concept, Installation and Deployment	**971 days**	
Phase 4a - Proof of Concept (POC)	**85 days**	**85 Days**
First Installation	0 days	
Installations (POC)	17 wks	
Network Deployment Coordination	30 days	
Progress Meetings / Dashboarding	80 days	
Quality Assurance Program	80 days	
Pre-Installation Approvals	80 days	
Installation Data Management Review	80 days	
Post Installation Approvals	80 days	
Progress Claim Approvals	80 days	
Incomplete (Task) Management Approvals	80 days	
Liaison for the City	80 days	
Business Process Redesign	80 days	
General Services	80 days	
Final User Acceptance Test (F-UAT)	**15 days**	
	Total Days	**85 Days**
	Total Months	**4 Months**

7.2.6. Phase 4b Installation Phase

Task Name	Duration	
Phase 4b - Installation and Deployment	**885 days**	**885 Days**
Installations	175 wks	
Public Education / Communication / Open houses	175 wks	
Progress Meetings (Weekly)	175 wks	

Task Name	Duration	
Steering Committee Meeting (Quarterly)	**875 days**	
Contract Management (Program Management)	**875 days**	
Communications and Project Coordination	175 wks	
Scope Management	175 wks	
Budget Management	175 wks	
Schedule Management	175 wks	
Risk Management	175 wks	
Document Control	175 wks	
Project Performance Dashboard	175 wks	
Approvals and Oversight	**875 days**	
Pre-Installation Approvals	175 wks	
Progress Claim Approvals	175 wks	
Task Management	175 wks	
Compliance Management	175 wks	
Material Handling	175 wks	
Quality Management	**875 days**	
Installation Data Management Review	175 wks	
Post Installation Review	175 wks	
Field Inspections	175 wks	
Contractor Project Performance Review	175 wks	
	Total Days	**875 days**
	Total Months	**41 Months**
	Total Years	**3.5 years**

7.2.7. Phase 5 Close Out

Task Name	Duration	Total Duration
Phase 5 - Close Out	**155 days**	**155 Days**
Clean up Installations	24 wks	
System Acceptance	10 days	
Project Close Out and Reporting	10 days	
Lessons Learned	5 days	
Transition Program to Operations	10 days	
	Total Days	**155 Days**
	Total Months	**7.4 Months**

7.3. Production Schedule

The production schedule of a project of this size requires a strategic ramp up. Structuring the project in key phases require the installation and AMI contractor to prove their system and business processes are producing the desired performance prior to ramping up production. The Proof-of-Concept phase (Phase 4a) has two purposes, 1) to ensure the AMI technology works and is able to

support the water billing process; 2) to ensure the installation contractor meter installation system (MIS) is able to handle the production volumes this project requires.

Given the Program Master Schedule it is expected the ramp up with have the following number of installs completed in each year.

Year	Installs
2023	-
2024	-
2025	8,580
2026	52,320
2027	91,860
2028	58,140
2029	6,420
Grand Total	**217,320**

This shows a peak production in 2027 with installation being completed in 2029, if this peak production is to large (due to project support or financing limitation) the project's production schedule could be flatten which would push more installations being completed in 2029, but this would delay the project.

8. PROJECT SUPPORT

An AMI/AMR technology and water meter replacement project requires input and support from both internal and external stakeholders with various skills sets. A metering project that affects 100% of the City's water customers is critical to engage the various stakeholders within the Water and Waste Department's many service areas such as Finance, Customer Accounts Billing, Customer Accounts, Meters, Utility Billing Centre, Water Services and Communications.

The amount of effort from individuals in these service areas, and the subsequent internal project support costs will vary based on the stage of the project and the role of the individual. This section will explain the project phases and the expected tasks to be performed by phase. In addition, it will provide estimates of total hours each task will require, and the skill set, or expertise required to perform them. These estimates will help the City plan for the project support roles that will be required to make this project a success. Lastly, this information has been used to calculate the internal project support cost that will be required to make the project a success.

8.1. Project Phases

A project of this nature is implemented in major project phases, each phase being treated as a key decision point, where the City can reflect on the progress made in terms of project scope, cost and schedule. The major phases are shown in the diagram below.

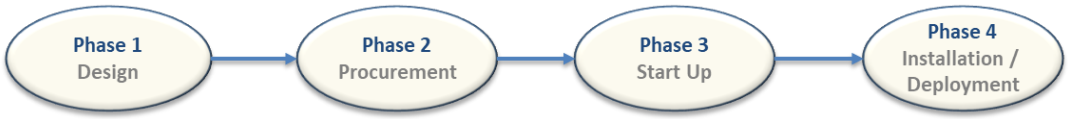


Figure 17 – Key Tasks in an Advanced Water Metering Solution Deployment

Each phase requires a combination of skill sets and roles which will be discussed below. It should be emphasized the many benefits with having a consistent team for some of the key roles throughout all phases of the project. Each major phase has several steps and specialties that may allow some roles to only focus on specific parts of the project. The general purpose of each project phase and the expected specialties are detailed below

8.1.1. Phase 1 Design

The City is currently completing Phase 1 Design. The goal of this phase is to allow the City to understand the benefits, costs, and organizational implication of implementing certain types of meter reading technology. The purpose of this project phase will be for the City to decide "if" and "how" the project should go forward and will provide a project framework for defining scope, schedule, and Class 3 Project Cost estimate.

This phase of the project includes the following workshop and analysis:

- Project management (progress meetings, minutes, schedule updates, progress reports)
- Review of historical information (information request, stakeholder engagement, database assessment)
- Technology evaluation
- Review of metering implementation strategies
- Development of AMI Business case (business process review, project goals definition, AMI business drivers, risk management, project scope and phasing, procurement strategy, readiness assessment for systems finance and customer, cost estimate and public communication planning)

This project phase is to last approximately six (6) months and will require representatives from the key Water and Waste department service areas responsible for the meter to cash business processes.

8.1.2. Phase 2 Procurement

Following the Design phase, the City will move into Phase 2 Procurement. For the Procurement Phase to be successful it should start with a number of pre-procurement activities. These activities will prepare the City's resources, setting expectations on the level of involvement that will be required to support the complex procurement process. There are also some activities with a historically long lead time and engaging them early will ensure the right resources are available at the right time.

Pre-AMI Procurement activities include:

- Consultant Request for Proposal development, procurement for the consultant who will fill the subject matter expert role. This RFP should include technology, product and installation procurement development and program management activities that will support Phase 2 to Phase 4 of the project. They will act as the utility representative, managing the Contractor and providing recommendation and advice throughout the project.
- Internal Project Team assignment: assigning people to fill the various roles in the project organization chart will ensure they are properly engaged. It is essential to select a Project Manager who will lead the entire project on a full-time basis. Other roles may be filled with key personnel from various departments with partial responsibilities to the project during the procurement phase.
- Evaluation Team established: During the procurement phase, 4 to 6 key stakeholders of the Internal Project Team should be selected who will be part of the evaluation team. They will be responsible for reviewing submissions and making recommendation of the selected Vendor(s) to the Steering Committee.
- Establishing a project Steering Committee: project governance is an important part of the project to ensure the project's priority throughout the entire organization. Regular executive leadership meetings will be key to ensure the right resources are available at the right time and a forum is established to allow for (large) decisions to be made quickly and efficiently. The City has already established a Steering Committee during Phase 1 Design. Diameter recommends continuing to meet on a quarterly basis.
- Vet the list of City locations where data collection equipment could be installed. There may be limited information about the City facilities and require gathering additional information. It

is recommended to review this list early in the process as it often requires some time to put this information together. This vetted list of City sites will be used in the future RFP allowing multiple types of AMI systems to plan their network infrastructure deployment.

- Vendor Engagement (Optional activities): some water utilities see benefit in engaging with the vendor community for the Project Team to get a better understanding of the key benefits of the various manufacturers system. It is recommended to do this in a controlled manner, with the consultant facilitating discussions so all vendors continue to get the same information about this large opportunity. This has a secondary benefit of informing the vendor community of the pending project and allows them to prepare the proposal team well prior to the RFP being released. We find this increases competition, puts pressure on price and provides the greatest opportunity for more proposals to be submitted.
- Integration Statement of Work Development: AMR and especially AMI systems require interface development and testing to occur to allow data to pass from the various systems to the City's Oracle Customer Care & Billing (CCB)). Often, CCB integration to the MIS or AMI applications requires long lead times to define, cost and resource. If this activity starts when the technology is selected (at the end of the procurement phase) securing these resources leads to significant delays in Phase 3 Start up. Diameter's approach is to take a three-step process that provides additional details to the Integrator that allows them to cost and resource this project much further in advance. Step 1 requires an initial system assessment be performed and technology type to be selected. Step 2 provides requires the AMI manufacturer to be selected and an initial Scope of Work to be developed, this step will revisit both scope and effort and confirm the timing that resources will be assigned to the project. Step 3 will deliver have the Integrator working with the AMI/AMR vendor and the project team to detail the exact business requirements. This will include all use cases that will support the desire functionality of the systems. Step 1 would be started during the beginning of the procurement process.

The above activities should be started during the first 4 weeks of the procurement phase.

Once these pre-procurement activities have been started and the project Consultant has been selected the project procurement documents can be developed. The number of RFP procurements that need to be developed and how the major components will be grouped together is an outcome to Phase 1 Design Procurement Strategy. The number of expected procurements will impact effort for both internal and consulting resources and the duration of Phase 2. The activities below are required for each RFP developed.

The Procurement activities include:

- Progress and Steering Committee meetings: typically progress meeting will occur every second week and the steering committee will need to meet three or four time during the procurement phase.
- Review procurement policy and incorporate the various parts of the specifications, submission requirements and evaluation criteria into the City standard procurement documents. Identify areas that may require adjustments to the standard documents or terms and conditions.
- Specification development for the various parts of the project including AMI/AMR technology, meter data management software (as required), water meter and meter component supply, installation services. As an optional specification a best-in-class customer portal may also be included as an option to the AMI / AMR technology or independent.

- Proposal Submission Requirements that allow the vendors to know the structure of their proposal response and the questions requiring a response. This should be structured to support the Evaluation Criteria
- Develop the Evaluation Criteria: provides the structure for how the proposed solutions will be evaluated and awarded.
- Procurement support: this activity will include review and responding to questions from the Vendor community, development of addendum(s), and optionally a pre-bid meeting that the consultant would facilitate.
- Submitted Proposal review: entails reviewing all proposal responses.
- Consensus Evaluation: the Evaluation Team and the City of Winnipeg's Materials Management department will meet to evaluate each proposal and fill out the evaluation sheet that will support the recommendation.
- Recommendation Report: developing the report that approves the start of negotiations with the preferred Vendor.
- Negotiation process: which will include several meetings and contract document development or City agreed adjustments to the RFP specifications.
- Project Award and notice to proceed.

Assuming a single RFP is being developed, the procurement process will take between 8 and 10 months.

8.1.3. Start Up

The Startup phase of the project involves the City's internal project team, the City's external integration team (if outsourced), the consulting team and the AMI technology and Installation team that start to engage on a continuous basis. This critical step is often very labour intensive as the AMI and Installation Contractor works through their internal setup activities and engage the City in system configuration, integration and user acceptance testing.

The detailed activities the City should expect to monitor include:

- The Contractor will setup the local project office and warehouse to support project Installation Phase.
- The contractor's development and internal testing of the Meter Installation System (MIS) to manage the installation work orders.
- Development of installer training policies, procedures, and training.
- Setup and training of the contractor's call center personnel in project specific requirements
- Material planning, approval and forecasting of all water meter, encoder register, radio transmitter and other required installation materials.

The detailed activities where the City should expect to be an active participant include:

- Development and approval of the public outreach program and materials.
- Integration business requirements, development and testing between the AMI System and Oracle CCB, the Contractor's Meter Installation System (MIS) and CCB, and any other system identified in the system assessment.
- Configuration and training on all proposed software applications.

- Inspection, planning, deployment, and configuration (as required) of the AMI collector network. Work typically starts by focusing on the Proof-of-Concept area but would expand to installing the network across the remining service territory, completing the network deployment in Phase 4.
- Perform Initial User Acceptance Testing (IUAT) to ensure all systems are ready for installation and continued water billing. Approval of the Final User Acceptance Test (FUAT) is the milestone to ensure the new systems support the billing process and will allow the Contractor to move into Phase 4a – Proof of Concept.

Phase 3 Startup phase typically takes between six (6) and eight (8) months.

8.1.4. Phase 4 Installation / Deployment

Phase 4 Installation / Deployment starts with the approval of the Initial User Acceptance Test (IUAT). This IUAT represents confirmation that:

- water meter work orders can be sent to the Contractor,
- the Contractor can complete the various work types in their MIS and can pass completed installation data back to the City
- the work can be processed in CCB and water billing can proceed successfully using the AMI or AMR system.

Once the IUAT is passed, it is recommended to start the installations in a limited and controlled manner. This is referred to as a Proof of Concept (POC) and would include an area of approximately 5,000 water meter and AMI / AMR radio transmitter installations. The purpose of this POC is two-fold; first it validates the Contractor is ready to ramp up production. Second, it allows the City to perform a Final User Acceptance Test (FUAT) to occur which confirms the identified business drivers will be achieved with the proposed solution. Many of the business driver use cases included in a FUAT will require real customers and real consumption behaviours to be reflected in the data and AMI software.

The City should expect the internal and external Project team to be involved with the following activities:

- Progress meeting, installation review meetings, data exception meetings, AMI network collector coordinating meetings, curb stop coordination meetings. Most of these meetings will occur on a weekly or biweekly basis.
- Steering committee update meetings which will likely occur at key milestones or on a quarterly basis.
- Monitor and communicate key performance indicators related to key project elements.
- Complete the deployment of the AMI Data collector network across the entire service territory.
- Processing of installation data into CCB.
- Perform quality assurance on the work being performed (data assurance, field inspections, data collector inspections).
- Review and resolve the incomplete tasks that Contractor identifies that prevents an installation from occurring.

- Approval of compliance process
- Approval and implementation of the public outreach program
- Review and approve contract changes, project invoices and escalate deficiency issues.
- Planning and implementation of the FUAT to ensure all identified AMI business drivers as well as Contractor committed functionality are achieved. Approval of the FUAT is the milestone that allows the Contractor to move out of the POC and into production.
- Support curb stop locate and operates requests by the Contractor.
- Investigation and repair of inoperable curb stops by the City or an outsourced Contractor.
- Perform customer communication via phone and at times field visits to resolve complications that the Contractor identifies.

The consultant will support the above activities through the following tasks:

- Project Management – Team leading to ensure the project's goals and delivered on time and on budget.
- Contract Management – Ensuring the terms of the contract are met, the vendor is cooperative and responsive, and disputes are avoided to the extent possible or rectified when they do occur.
- Progress Meetings – Facilitate the review of progress on the project against established timelines, outstanding tasks and deliverables to ensure the project stays on track or is brought back into good standing.
- Dashboard Reporting – developing and updating the KPI for the project.
- Pre-Installation Approval – the task of approving additional work for the Installation Company to proceed with non-standard or difficult installations (i.e., construction work, plumbing modifications)
- Large meter survey to collect key water meter and site information to approve the work required to replace large meters.
- Installation Review and Approval: ensuring the work being performed is required and in line with the contract.
- Progress Claim Approval – the task of approving payment for completed installations per the contract
- Incomplete Resolution – the City to follow up with customers who were unresponsive to appointment requests (soft refusal) or left incomplete due to extenuating circumstances (inaccessible, poor plumbing).
- Quality Assurance Program – the task of inspecting installations per the contract and documenting quality / acceptability.
- Data Management – monitoring and identifying data exceptions prior to them being passed to CCB.
- Public Outreach – Communications and collateral development aimed at achieving the public's cooperation and acceptance of the project. This is a critical factor in helping to ensure overall project success.

Phase 4 Installation / Deployment phase for a project of the City's size will typically take between 36 and 40 months. The proof of concept would occur during the first 3 months of this project phase.

8.2. Project Roles

It should be noted that the roles described below may need to be filled by one or more individuals, and the time estimate may vary based on the level of dedication to the task.

Some of the roles described should be considered dedicated solely to the project, whereas other roles may be filled while the individual is performing other duties and responsibilities on a part time basis. The costs will be updated once the financial model is developed and presented.

8.2.1. All Phases - Executive Leadership

A project of this nature is one of the bigger projects a water utility will undertake in terms of project cost and its impact to the utility customer base. Rarely, do water utilities engage in a project that requires participation of 100% of the customers. For these reasons it is important to have regular executive leadership meetings in the form of a Steering Committee.

These meetings should be held during key milestones (finalize Contractor selection, final negotiated agreement, IUAT and FUAT) and then quarterly thereafter. The Steering Committee should be made up of managers and directors from Finance and Administration, Information Systems, Water Services and the dedicated Project Manager. Often these meetings can be facilitated by the Consultant's Principal In Charge.

The resource estimate is also submitted in excel as Appendix D.

Role	Organization	Specialty	Task	Frequency	Starting Phase	Ending Phase	Hours / Month	Duration in Months	Total Project Hours
Steering Committee	City	Manager/Director Finance and Administration, Manager/Director Water and Waste, Manager/Director Information Systems, Manager/Director Water Services, Project Manager	Attend Steering Committee meetings to guide the vision of the project.	1 - hours per month for 106 months, starting Phase 2 Procurement endingPhase 5 Close Out	Phase 2 Procurement	Phase 5 Close Out	1	106	**106**

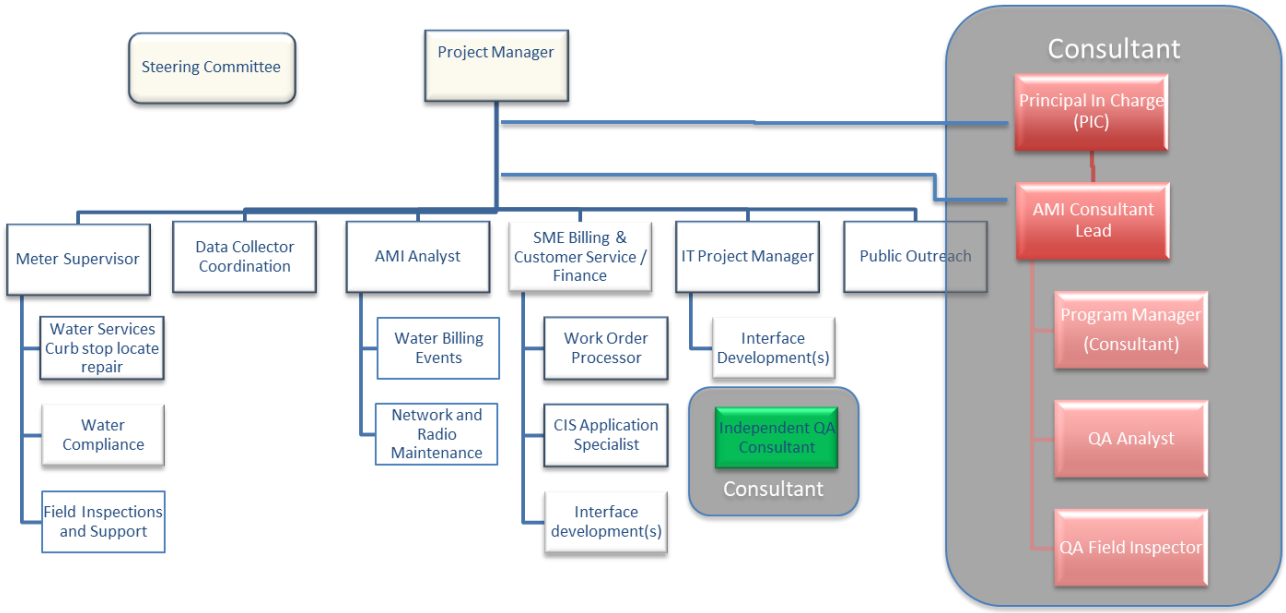
8.2.2. Phase 2 Procurement – Procurement Evaluation Team

During Phase 2 the City will need to identify the Evaluation Team as well as engage supporting personnel. Although most of the procurement document development will be performed by the Consultant, the City will need to support this development through document review and feedback.

Role	Organization	Speciality	Task	Frequency	Starting Phase	Ending Phase	Hours / Month	Duration in Months	Total Project Hours
Procurement Evaluation T	City	Representatives from the Meter shop, Finance, Water billing, information technology, the Project Manager.	Key personnell that contributes to the design and procure phases.	32 - hours per month for 13 months, starting Phase 2 Procurement endingPhase 5 Close Out	Phase 2 Procurement	Phase 5 Close Out	32	13	**416**
Procurement Support Subject Matter Expert	City	Representatives from Procurement agent, legal, finance, IT (Security, Applications), Facilities,	Key personnell that contributes to the design and procure phases.	40 - hours per month for 13 months, starting Phase 2 Procurement endingPhase 2 Procurement	Phase 2 Procurement	Phase 2 Procurement	40	13	**520**

8.2.3. Phase 3 and 4 Startup & Installation/ Deployment – Project Core Team

An outline of the various project roles required by both the City and the Consultant as the City's representative are shown in the diagram below.



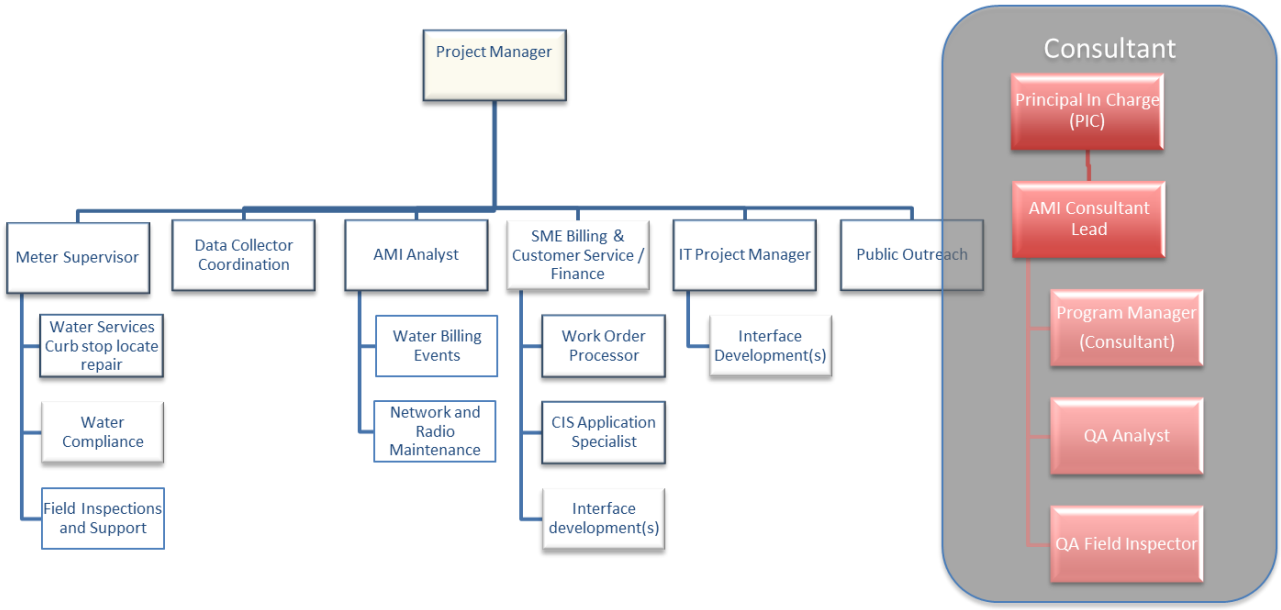


Figure 18 – Project Core Team

8.2.4. Project Manager

Project Manager – The Project Manager is the main point of contact for all project related matters whether from internal stakeholders, the consultant, the AMI Contractor or the media. They are responsible for ensuring the full scope of the project is completed on time and within budget. The Project Manager does not need to be a subject matter expect in AMR/AMI; generally, Contract Compliance will support the Project Manager. They will sign off on all invoices and additional resource requests, report to the Steering Committee. It should be noted that a poor installation contractor will require more Project Manager time than one who is well versed in running an installation project smoothly.

Role	Organization	Speciality	Task	Frequency	Starting Phase	Ending Phase	Hours / Month	Duration in Months	Total Project Hours
A. Project Manager	City	Project Management	Progress meetings, contract management, overall project coordination, steering committee.	160 - hours per month for 72 months, starting Phase 1 Design endingPhase 5 Close Out	Phase 1 Design	Phase 5 Close Out	160	72	**11520**

8.2.5. Meter Supervisor and Inspector

The Meter Supervisor plays a role during the RFP Specification development and review and as an evaluator following vendor submissions. During Start-up and Installation, the Meter Supervisor will support the Installation Contractor in the field and resolve non-compliance situations so that installations can be completed. They will be responsible for the field inspectors and the curb stop report.

The field inspector could be performed by internal City employees or could be included in the Consultant scope of work as part of the Quality Assurance program.

Role	Organization	Speciality	Task	Frequency	Starting Phase	Ending Phase	Hours / Month	Duration in Months	Total Project Hours
E. Field Supervisor	City	Field Supervision	Task Resolution, field support (5% of all accounts) / Progress meetings	160 - hours per month for 78 months, starting Phase 4a POC endingPhase 4b Installation	Phase 4a POC	Phase 4b Installation	160	78	**12480**
F. Field Inspector	City	Field Inspector	Quality inspections, support supervisor on task Resolution	160 - hours per month for 78 months, starting Phase 4a POC endingPhase 4b Installation	Phase 4a POC	Phase 4b Installation	160	78	**12480**

8.2.6. Curb Stop support and Repair

The curb stop support required to locate and shut off curb stops will require dedicated resources. If the City allows the AMI Installation Contractor to locate and operate curb stops when a building control valve is inoperable, or it is a large meter, then it will significantly reduce the City's support requirements. This would allow the city to only focus on difficult to locate and damaged curb stop valves or box and rods.

The City of Winnipeg has expressed concerns with regards to outsourcing curb stop operations to an AMR/AMI installation contractor based on by-law requirements for operation of curb stops, plus potential collective agreement concerns with contracting out duties. It is expected, the City of Winnipeg will operate, and repair of curb stops internally as part of this AMR/AMI project. The City has indicated curb stop repair would be performed by the existing distribution department. The volumes and response time will need to be properly understood to ensure reasonable resolution times can be achieved.

The estimated frequency of work that would be required during the project is calculated in the below table.

Events **(5/8 to 1")**	Low	High	Low	High
Number of Water Meter **(5/8 to 1")**	208000		Volume Per Day	
% of Curb Stop Locate and Operate	2.50%	4%		
Qty of Curb Stop Locate and Operate	5200	8320	7.22	10.40
% of Curb Stop Locate - difficult	25.00%	35%		
Qty of Curb Stop Locate and Operate	1300	2912	1.81	3.64
% of Curb Stop Box & Rod Repair/Replace	15.00%	25%		
Qty of Curb Stop Box & Rod Repair/Replace	780	2080	1.08	2.60
% of Curb Stop Valve Replacement	4.00%	6%		
Qty of Curb Stop Valve Replacement	208	499.2	0.29	0.62
Total Small Meter Curb Stop Support (per day) - Operate Only	**5200**	**8320**	**7.22**	**10.40**
Total Small Meter Curb Stop Support (per day) - Investigate/Repair	**2288**	**5491**	**3.18**	**6.86**

Table 33 – Frequency of curb stop tasks (Small Meters)

Note if the City allows the Contractor to locate and operate the curb stops the number of sites requiring City involvement and support reduces dramatically. This is a common practice on project of this scale, City personnel would only focus on the difficult to locate or operate.

Events **(1.5" to 2")**	Low	High	Low	High
Number of Water Meter **(1.5" to 2")**	3,000		Volume Per Day	
% of Curb Stop Locate and Operate	5.00%	10%		
Qty of Curb Stop Locate and Operate	150	300	0.21	0.38
% of Curb Stop Locate - difficult	50.00%	65%		
Qty of Curb Stop Locate and Operate	75	195	0.10	0.24
% of Curb Stop Box & Rod Repair/Replace	25.00%	35%		
Qty of Curb Stop Box & Rod Repair/Replace	37.5	105	0.05	0.13
% of Curb Stop Valve Replacement	5.00%	10%		
Qty of Curb Stop Valve Replacement	7.5	30	0.01	0.04
Total Small Meter Curb Stop Support (per day)			**0.38**	**0.79**

Table 34 – Frequency of curb stop tasks (Intermediate Meters)

It is recommended the City support curb stop operation of all meters 1.5” and greater.

Events **(3" and greater)**	Low	High	Low	High
Number of Water Meter **(3" and greater)**		300	Volume Per Day	
% of Curb Stop Locate and Operate	100.00%	100%		
Qty of Curb Stop Locate and Operate	300	300	0.42	0.38
% of Curb Stop Locate - difficult	0.00%	0%		
Qty of Curb Stop Locate and Operate	0	0	-	-
% of Curb Stop Box & Rod Repair/Replace	5.00%	10%		
Qty of Curb Stop Box & Rod Repair/Replace	15	30	0.02	0.04
% of Curb Stop Valve Replacement	5.00%	10%		
Qty of Curb Stop Valve Replacement	15	30	0.02	0.04
Total Small Meter Curb Stop Support (per day)			**0.46**	**0.45**

Table 35 – Frequency of curb stop tasks (Large Meters)

8.2.7. Data Collector Coordination

This role is only required during Phase 3 and stretches into the first part of Phase 4 depending on the system selected and the number of data collector sites. This role will review, approve and coordinate work to be performed at each data collector installation site (in conjunction with the AMI installation contractor). Since AMI systems function differently and require different amounts of infrastructure, the amount of effort associated with this role will vary depending on the vendor/technology chosen.

This role is often filled by a facilities position who are responsible for the City's and utilities buildings and properties.

Role	Organization	Speciality	Task	Frequency	Starting Phase	Ending Phase	Hours / Month	Duration in Months	Total Project Hours
D. Data Collector Coordina	City or External	Project Management	Gain access, coordination surveys and installations with the Contractor	40 - hours per month for 12 months, starting Phase 3 Start Up endingPhase 4a POC	Phase 3 Start Up	Phase 4a POC	40	12	**480**

8.2.8. SME – Billing and Customer Service

During Project Start up and Installation, the Billing and Customer Service SME will assist in the design of CCB interfaces. They will lead CCB testing (work order processing, interfaces) and validate that they function properly through the IUAT.

During Phase 4 this role will process all installation information into CCB and identify and resolve all data exceptions.

Role	Organization	Speciality	Task	Frequency	Starting Phase	Ending Phase	Hours / Month	Duration in Months	Total Project Hours
J. Billing and Customer Se	City	Billing	Business Requirements Meetings, documentation, IUAT and FUAT.	240 - hours per month for 12 months, starting Phase 3 Start Up endingPhase 4a POC	Phase 3 Start Up	Phase 4a POC	240	12	**2880**
J. Billing and Customer Se	City	Billing	Data and Progress Meetings	32 - hours per month for 86 months, starting Phase 4a POC endingPhase 4b Installation	Phase 4a POC	Phase 4b Installation	32	86	**2752**
J. Billing and Customer Se	City	Billing	Process work orders and exceptions	160 - hours per month for 86 months, starting Phase 4a POC endingPhase 4b Installation	Phase 4a POC	Phase 4b Installation	160	86	**13760**

8.2.9. Information Technology Resource

During Start Up, I.T. Resources are required less from a hardware standpoint since vendors have largely moved to a SaaS, and more for interface / integration and testing associated with newly introduced systems (MIS interface, AMI Software interfaces, Single Single-On, etc.). The City IT personnel will be required to manage the security and interface contractor. The City may decide to outsource the actual interface and CCB system develop to an external resource. We understand the City typically uses Oracle Services, which would need to be engaged quickly into the procurement process to ensure they have the technical resources when they are required (Startup). The table below shows interface development being an internal resource, but consideration should be given to outsourcing this element.

Role	Organization	Speciality	Task	Frequency	Starting Phase	Ending Phase	Hours / Month	Duration in Months	Total Project Hours
H. IT SME	City	System/Application Architect	Review Security Configuration	40 - hours per month for 8 months, starting Phase 3 Start Up endingPhase 3 Start Up	Phase 3 Start Up	Phase 3 Start Up	40	8	**320**
H. IT SME	City	System/Application Architect	Business Requirements Meeting & documentation	160 - hours per month for 8 months, starting Phase 3 Start Up endingPhase 3 Start Up	Phase 3 Start Up	Phase 3 Start Up	160	8	**1280**
H. IT SME	City	System/Application Architect	User Acceptance Testing	40 - hours per month for 8 months, starting Phase 3 Start Up endingPhase 3 Start Up	Phase 3 Start Up	Phase 3 Start Up	40	8	**320**
H. IT SME	City	Interface Developer	Business Requirements Meeting & documentation	160 - hours per month for 12 months, starting Phase 3 Start Up endingPhase 4a POC	Phase 3 Start Up	Phase 4a POC	160	12	**1920**
H. IT SME	City	Interface Developer	Interface Development	320 - hours per month for 12 months, starting Phase 3 Start Up endingPhase 4a POC	Phase 3 Start Up	Phase 4a POC	320	12	**3840**
H. IT SME	City	Interface Developer	User Acceptance Testing	160 - hours per month for 8 months, starting Phase 3 Start Up endingPhase 3 Start Up	Phase 3 Start Up	Phase 3 Start Up	160	8	**1280**

8.2.10. Public Outreach / Change Management

A project of this nature will require significant public outreach and change management planning and coordination. These plans depend on the stakeholders being targeted. Internal City stakeholders require identification of the impact the project will have on the different departments and positions within the organization. Implementing a vision of how the organization needs to change and defining these required changes through the update of organization charts and job descriptions. Developing a communication program that keeps people informed and allows those whose positions may be impacted to plan an alternative position within or outside the organization.

External stakeholders, namely water customers, require an extensive public outreach program be developed. The focus on this program would be to inform customers of the project, emphasize the need for their participation (to book appointment when required) and to promote some of the new tools that may be available.

To do this planning and coordination, the City will require their Communication team to be engaged in the project during the Startup phase of the project. There may also be a need to develop certain materials, messages and collaterals that can be used to engage with the public. These often include letters, door knockers, websites, booklets, public information nights, bill inserts and training of customer service representatives.

Role	Organization	Specialty	Task	Frequency	Starting Phase	Ending Phase	Hours / Month	Duration in Months	Total Project Hours
H. IT SME	City	System/Application Architect	Review Security Configuration	40 - hours per month for 8 months, starting Phase 3 Start Up endingPhase 3 Start Up	Phase 3 Start Up	Phase 3 Start Up	40	8	**320**
H. IT SME	City	System/Application Architect	Business Requirements Meeting & documentation	160 - hours per month for 8 months, starting Phase 3 Start Up endingPhase 3 Start Up	Phase 3 Start Up	Phase 3 Start Up	160	8	**1280**
I. Public Outreach SME	City	Communications	Review specifications	16 - hours per month for 8 months, starting Phase 3 Start Up endingPhase 3 Start Up	Phase 3 Start Up	Phase 3 Start Up	16	8	**128**
I. Public Outreach SME	City	Communications	Outreach materials - Development/review/approval	40 - hours per month for 8 months, starting Phase 3 Start Up endingPhase 3 Start Up	Phase 3 Start Up	Phase 3 Start Up	40	8	**320**
I. Public Outreach SME	City	Communications	Graphic's Development	40 - hours per month for 8 months, starting Phase 3 Start Up endingPhase 3 Start Up	Phase 3 Start Up	Phase 3 Start Up	40	8	**320**
I. Public Outreach SME	City	Communications	Public outreach meetings	8 - hours per month for 86 months, starting Phase 4a POC endingPhase 4b Installation	Phase 4a POC	Phase 4b Installation	8	86	**688**

8.2.11. AMI Data Analyst

The role of the AMI Data Analyst would be required during Project Start Up and then during Installation / Deployment. This person will receive training on the head-end software (and MDM as

applicable) for the chosen AMI system (data collection, review, exception management, trouble shooting). They may also be involved in AMI User Acceptance Testing.

Role	Organization	Specialty	Task	Frequency	Starting Phase	Ending Phase	Hours / Month	Duration in Months	Total Project Hours
G. AMI Analyst	City	Business Analysis	Review and defining business requirements, performing the system testing, being main point for training (to become the trainer), run reports, monitor system.	80 - hours per month for 86 months, starting Phase 3 Start Up endingPhase 5 Close Out	Phase 3 Start Up	Phase 5 Close Out	80	86	**6880**

1.5.1. 28(1)(b) [redacted]

The internal project support costs over the duration of the project are summarized in the table below.

Description	Scenario 1 AMR – Drive-by	Scenario 2 AMI (CoW	Scenario 3 AMI - Cellular
28(1)(b) [redacted]			

Description	Scenario 1 AMR – Drive-by	Scenario 2 AMI (CoW Owned)	Scenario 3 AMI - Cellular
28(1)(b) [redacted]			

Table 36 - Internal Project Support Financial Impact

Some of the above roles may be budgeted already within existing positions. If this is the case this additional cost may not be required within the financial plan.

1.5.2. 18(1)(c)(i) [redacted]

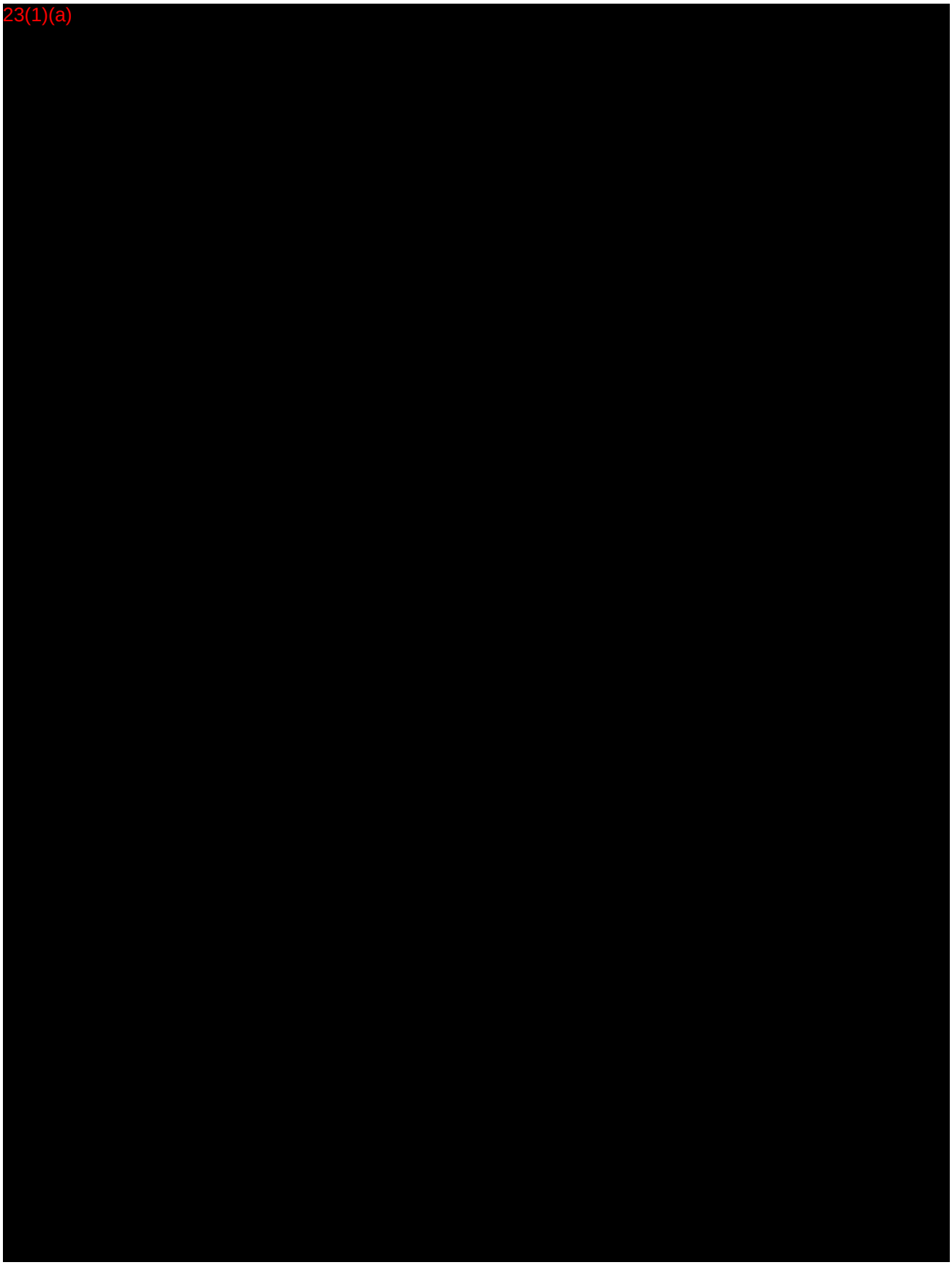
18(1)(c)(i) [redacted]

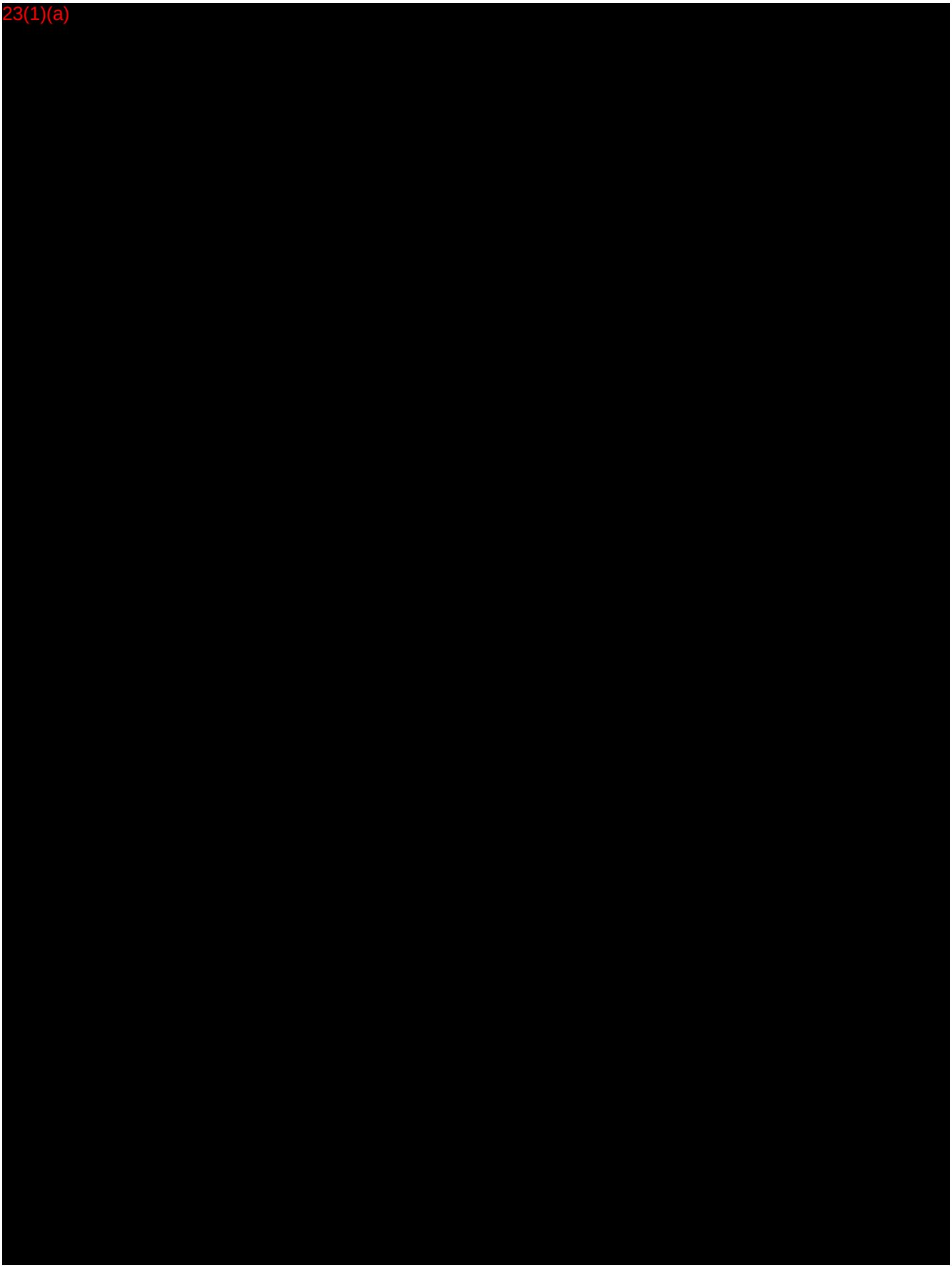
The procurement includes the development of a single procurement document and process. Where the procurement is broken into more than one procurement additional cost may apply.

Program management assumes a full-service project lead that includes contract management, interfacing support, installation Contractor management, public outreach, meeting management, key performance indicator monitoring and quality assurance. Field inspections are an optional service that could be incorporated into the QA services but has been assumed to be an internal resource.

9. 23(1)(a) [redacted]

23(1)(a) [redacted]


23(1)(a)


23(1)(a)

23(1)(a)

[redacted]

APPENDIX A: EXPANDED BUSINESS DRIVER ASSESSMENT

Table 29: Detailed Non-Financial Business Driver Assessment

Ref	Importance	Business Drivers & Description		Utility	Technology Assessment
Revenue Protection (RP)					
RP1	**(3) Critical**	**Zero Consumption** **Stopped Meter/Tamper Detection**	Stopped Meter - Positive displacement meter is jammed and requires replacement. Applicable to residential or small side of compound meters which have a tendency to "burn out" and stop registering. Tamper Detection - Residential customers: removal of register head or meter (zero consumption for full days in the middle of a billing period). Tamper Detection - Commercial customers: turning on bypasses (zero or reduced consumption compared to other similar industries). AMI technology allows a utility to detect potential tampering in a number of ways: • Abnormal consumption: by way of detecting consumption (or a reduction in consumption) in accounts where Winnipeg would be expecting the opposite behavior. Examples include: - A commercial property (for example a laundromat) that requires water to operate suddenly has zero consumption during peak times. - A property is vacant and should be zero consumption, but suddenly shows consumption. - At a commercial property, the bypass is opened thereby reducing consumption through the meter.	**Discussion Points:** • Would there be any financial benefits or efficiencies with consumption-based algorithms? • Alerts to property owner (high) or low consumption alert to utility? **Discussion Outcomes:** • Big focus at Winnipeg to identify tamper or stopped meter situations • Need enforcement on this aspect and to reduce the number of individuals tampering ○ Includes customers opening by-passes, removing registers, removing meters, using magnets, etc. • Many situations are not identified and it is reasonable that there are double the number of occurrences the City is aware of. • Average greater than 1,600 per year in known tampers • Can take months to identify stopped meter issues. Potential financial benefit from catching stopped meters sooner.	**AMR (**PART) - There are zero consumption flags and they can be collected on a monthly basis but cannot analyze unusual consumption behavior. • Zero consumption are a Yes / No flag • Limitation due to resolution • Cannot determine patterns **AMI** (FULL) – The utility can analyze consumption behavior (through hourly readings for example). When trends are detected special stopped meter or tamper reports can be created to initiate action. • Can build algorithms to find certain types of consumption patterns (or zero consumption notification through the MDM for example). • Can establish "watch" list customer that creates alerts.

			- If applicable, detector check meters show consumption (where none was expected). • Meter removed tamper (manufacturer specific) – whereby a customer removes the register or the meter, and the register detects the physical movement. This would have to be reset by the utility. • Empty pipe alarm (specific to Ultrasonic and Mag meters) – there is no water in the meter and an alarm is sent.		
RP2	**(3) Critical**	**Zero Consumption** **Turned off for non-payment**	• Monitor those customers that were turned off for non-payment • Ability to put them into a "virtual" shut off groups and receive notification if there was unsuspected consumption	**Discussion Points:** • What effort is associated with monitoring turned off customers? • Do customers turn the water back on? • 2,195 turned off for non-payment in 2019; In 2020 there were only 424 cases where customers were turned off for non-payment (likely related to COVID) **Discussion Outcomes:** • It can/does happen where customers will turn the water back on • City will roll a truck to make sure they are turned off – i.e., roll a truck based on special requests from finance (requires repeated visits to some locations). • 10% of all shut offs need to be checked • Virtual shut-off ability would be valuable • Cost savings of not having to do a return visit • Faster visibility	**AMR** (PART) – Meters can be monitored but reaction would be every 90 days (depending on read frequency) after the bill is produced. **AMI** (FULL) **–** Hourly consumption tracked and meters report daily or multiple times per day. MDMs can provide notification of unsuspected consumption. Customers using fire service for domestic purposes could be identified prior to bills are produced.

RP3	**(1) Nice to Have**
	
	**if using non mechanical meters*
		Zero Consumption
		
		Empty Pipe Alert
			• Detect meters removed from service.
			• Additional considerations:
			  • Would require non-mechanical meters to be in place with the capability.
			  • AMI Radio Transmitter and Meter Manufactures would need to be the same.
				Discussion Points:
				• Do meters get pulled or stolen and replaced with spacers?
				
				Discussion Outcomes:
				• Applies to non-mechanical meters.
				• Today, people could call in a reasonable estimate; current tampers are likely very difficult to monitor
				• Vast majority is the register removed (broken seal)
				• Does happen that the meter is removed
				• Swap meters between locations to confuse the billing system
				• Quantities of Tampers as follows:
				  ○ 2020: 216 (influenced by Covid)
				  ○ 2019: 1597
				  ○ 2018: 1549
				  ○ 2017: 1746
					AMR (ZERO) – It is unlikely an AMR radio would read this flag from the meter.
					
					AMI (PART) – Depending on the manufacturer of the product this feature may or may not be available.
					• Requires AMI transmitter ability to recognize the flag and non-mechanical Meter's ability to produce a flag
					• Likely requires Meter and AMI vendor to be the same.

RP4	**(0) Not Important**	**Detect Misapplied Meters**	• Determine if turbine meters are installed where a compound should be. Determine if a compound is oversized or significant flow is going through at the cross over point. • **Type 1:** Compound meters, uneven wear results in either the high or low side of the meter to wear out and record much less accurately. Rule of thumb 70% high side, 30% low side (smaller the consumption buckets the better; hourly vs every 30 days). • **Type 2:** Compound meters, cross over: identify those meters where a significant amount of a customer water demand flow rate around the cross-over flow rate with lower meter accuracy. Where a large % of flow is being measured at the cross over. Could lead to 5-10% accuracy loss. Hourly consumption analysis can detect this	**Discussion Points:** • Do you typically match service size with meter size? • If so, there may be some small benefits based on the number of large meters. • Calculate the % of misapplied meters, expect an annual improvement in revenues. • Capture situations where meters are running in the "cross-over" where compounds are less accurate. • Non-mechanical meters have no obstruction and generally speaking, non-mechanical meters can be down-sized while maintaining maximum flow rate. **Discussion Outcomes**: • When meters are due for exchange, the City does look at potential for downsizing	**AMR** (PART) – Can be performed manually. Field visit required. Most radio transmitters could download hourly data for an individual meter, so specific analysis can be conducted to properly size the meter. **AMI** (FULL) **–** No field visit required. **Type 1&2:** Hourly Consumption of both high and low dial on the compound meter can be analyzed to determine if the meter is running at the "crossover" as well as the maximum flow rate through the meter to determine if the meter is properly sized. **Type 3:** Hourly consumption can be calculated to determine average hourly flow rate per hour. Then the percentage of flow can

			• **Type 3:** Low flow on turbine meters: meters that have a significant amount of a customer's water demand flow rate is lower than the meter in place.	• Can install a datalogger to help assist with the process of confirming a downsize • Project scope discussion, need to determine if this is inside or outside of project scope • With a move to non-mechanical meters - even if the meter is oversized, it may not have as a big of an impact • Daily service charge could be impacted	be determined at low rates that are less accurate.
RP5	**(2) Important**	**Support for Leak Forgiveness Program**	• Where a major leak occurs (customer side leak) and there is a leak forgiveness program in place. • Pin-point major leak to a specific event or date. • May lead to fewer people qualifying.	**Discussion Points:** • Reduce the total pay-out dollars due to Alerts catching these issues sooner. • Customer Portal could provide a more efficient way of managing these types of programs. **Discussion Outcomes**: • 138 qualified in 2021 • 1 time qualification • City spends $110,000 on average/year for leak forgiveness • The amount credited is the difference between 2x the normal consumption amount and the leak amount; - The reading must be within a year; - Customer cannot be away for 7 days or longer • Could be easier for customers to qualify for leak forgiveness; may need to revamp the program • Benefit to the financial model: budgetary impact (more applications but for a lower amount) • A reduction on the need/dollars spent on the program could be anticipated • City questioned whether there is a liability of having data and "not notifying" the customer. (Internal city question to explore)	**AMR** (PART) – AMR would partially support this business driver. The opportunity for customers to be notified of leaks is limited to meter reading frequency and is simply a "yes/no" flag. Interval data can be captured by most AMR systems as requested on a limited number of meters which can help pinpoint start of the event. **AMI** (FULL) **–** Capturing hourly consumption information daily, would help the utility calculate how long and how much water leaked on a customer service.

Operational Efficiency (OE)					
OE1	**(3) Critical**	**Reduce Regular Meter Reading Cost**	• Reduces the need to collect meter readings in the field.	**Discussion Points:** • Costs associated with meter reading and what can be eliminated with the use of technology. – **Discussion Outcomes:** • While the driving force for the project initially wasn't to reduce regular metering costs – instead it was to improve billing accuracy and reduce inaccuracy due to meter age, etc. – the opportunity to do so is another critical component of the project. • Current meter Reading costs $927,000	**AMR (PART)** – AMR mobile allows meter readings to be collected by driving in close proximity to the property. Typically, meter readings are collected for billing purposes, although some manufacturer AMR mobile can allow daily and hourly readings to be collected at the cost of some system performance (driving speeds). Mobile data collection will also collect leak detection, tamper, and backflow flags. This provides a Yes / No response that can be incorporated into reports and CCB. **AMI (FULL)** – Allows for all meter readings to be collected from fixed network devices via the head-end software. Eliminates 95% of meter reading performed in the field.
OE2	**(2) Important**	**Same Day Final Reads**	• Collect off cycle meter readings to facilitate Move In / Move Outs • AMI technology allows for reading during off cycles eliminating the need to send out a meter reader. • AMI and MDM technology will allow for customers to be classified into groups; in this case a zero-consumption group which can alert the City when consumption occurs at the property prior to the new customer setting up a new water account.	**Discussion Points:** • How long does it take to perform a final reading? • Are there any segments of the population that this would be more applicable? (university, rentals) **Discussion Outcomes:** - Reads are phoned in for move in or move out or otherwise provided through normal channels - If a read is not received, the bill is estimated or prorated - Media situations and legal issues can happen due to discrepancies (b/w move-out read and the move-in read) - There are situations that the final read and the start read are different resulting in lost revenue for the City - Goal is to avoid inaccuracies	**AMR** (PART) – Still require a field visit. • Certain types of system may be able to produce a daily read through Mobile. • Would require some software to store it.) **AMI** (FULL) **–** No field visit required. On-demand readings will eliminate manually reading out of cycle meters to accommodate the account closing or move in dates. Virtual shut off groupings will alert the Utility to customers using water prior to setting up an account with the Utility.

OE3	**(3) Critical**	**Improve Meter Reading Safety**	• Reduce lost time Injuries related to meter reading. • AMI technology will significantly reduce liability associated with employees in the field. • It is important to highlight that improving meter reading safety may not drive functionality, but it is still a business driver that supports PWB's culture of safety initiatives.	**Discussion Points:** • LTI's relating to meter reading? Are there any costs associated with them? **Discussion Outcomes:** • Training junior employees • Safety takes priority • Driving is a safety offset of current situation with regards to safety	**AMR** (PART) – Will eliminate meter readers from the field and decreases some safety aspects of manual meter reading (slips and falls, dog bites) but increases vehicle safety risks to meter readers and citizens. **AMI** (FULL) – This virtually eliminates all readers in the field as it relates to meter reading.

OE4	**(3) Critical**	**Meter Reading Reliability (Incorrect Reads Provided)**	• Reduce the time and work associated with customers delivering inaccurate reads
			• AMI delivers meter reads daily. Suspected incorrect reads can be caught within the MDM or at CCB.
				Discussion Points:
				• Are there any customer complaints the City receives due to meters not being read ?
				
				Discussion Outcomes:
				• Creates billing issues, customer service burden
				• 10 staff who work on adjustments with some focus on other areas;
				  • 4-5 FTE dealing with high estimates etc. / adjustments.
				• Defined as when a read is provided incorrectly
				• Extra effort on the Utility Billing Centre to make calls for bills over a particular amount
				  • Calls can help identify incorrect billing / inconsistencies with previous reads
					AMR (FULL) – Encoder registers generally provide the AMR radio transmitter the correct read. It is possible for encoders to transmit an incorrect reading although this is a rare occurrence.
					
					AMI (FULL) – Encoder registers generally provide the AMR radio transmitter the correct read. It is possible for encoders to transmit an incorrect reading although this is a rare occurrence.

OE5	**(3) Critical**	**Water Bill Estimates**	• Reduce number of estimates needed to be calculated and associated staff time as a result of needing to estimate water bills.	**Discussion Points:** • How many estimates are sent out per year?	**AMR** (FULL) – Encoder Reads provided through radio transmitters are generally reliable

				• What is the cost of performing estimations? • Is there an opportunity, through the use of technology to reduce costs associated with billing estimates? • **Discussion Outcomes:** • ~270,000 total estimates provided per year • Estimates are both “System Estimates” that are automatically created and “Office Estimates” that are manually created • Per year, there are ~250,000 system generated estimates and prorations and ~20,000 are manually generated. • System Estimates are progressively higher to encourage customers to provide a reading. Ultimately, there is manual effort involved in a system estimate for the reconciliation.	For required Re-reads - a second truck roll to capture missed reads is necessary **AMI** (FULL) – Usually meter reading exceeds 99.5% Read Success Rate. Encoder Reads provided through radio transmitter are generally reliable. Reads are provided at least daily and there is the ability to perform re-reads where necessary OTA (over-the-air).

OE6	**(2) Important (in targeted accounts)**	**Remote Turn-off / Turn-on**	• A two-way AMI technology can allow a water utility to remotely shut off valves or valve enabled water meters. This would eliminate the need to send a technician out to shut off the water.
			• Remotely shut off the water options:
			  • 100% off
			  • Partially off (~75%)
			  • 100% on
				Discussion Points:
				• Who performs this work? How many people are dedicated to this? Are the shut offs that are occurring in a certain area or associated with certain customers? Would charging customers the cost of a meter technician to turn the water back on a reasonable policy?
				Discussion Outcomes:
				• Was not an initial driver but could be a potential benefit
				• Throttling the water would be more palatable than complete shut from the City’s perspective
				• 2,200 in 2019 for non-payment (shut offs not allowed in 2020 due to covid)
				• 2019 – 250 truck rolls to confirm water is off.
				• 8566 turn-offs for repairs in 2019 and 5244 in 2020. These are situations where the customer is putting in a new hot water heater or new appliances and the BCV does not work
					AMR (ZERO) – No benefits.
					
					AMI (FULL) – Possible with the following conditions:
					• Two-way with reasonable latency (sub-hour).
					• Most are incorporating valve into a non-mechanical meter.
					• Others use a secondary device that would require large meter set.
					• RF encryption should be employed to prevent unauthorized use.

				• City doesn't have resources to respond to all requests in a timely manner • Functionality would be a benefit to the Landlord community as landlords are responsible for unpaid bills.	
OE7	**(3) Critical**	**Better Data for (Reduced) Customer Inquiries**	• More accurate meter reading data is expected to reduce customer inquiries and help CSRs with the inquiries they do receive. • Better data will help CSRs respond to customer inquiries more effectively. AMI data helps CSRs respond more thoroughly and accurately because of the detail provided in the data.	**Discussion Points:** • Does the City see an opportunity to help reduce customer inquiries through more accurate meter reading data • Does the City expect CSRs will be better prepared to effectively handle customer inquiries? **Discussion Outcomes:** • City sees this opportunity as critical. Having more reliable information is proven to solve issues. The City is not seeing issues from radio read meters - issues are completely focused on areas without technology.	**AMR** (FULL) – Encoder Reads provided through radio transmitters are generally very reliable **AMI** (FULL) – Hourly, daily, monthly consumption information available to customer service reps and customers through Portal. Ability for enhanced flags may help reduce problems with customers before they occur (i.e., leak flags).
OE8	**(2) Important**	**Ability to Perform Monthly Billing**	• Meter Reads Provided in a timely fashion to enable more frequent billing – i.e., from quarterly to monthly	**Discussion Points:** • One-time cashflow increase of ~ $53M (i.e., reducing 2 months of A/R) • Moving from Quarterly to Monthly Billing has been shown to reduce bad debts. **Discussion Outcomes:** • Moving to monthly billing has been a discussion this year; some high-level estimate costs ($24M estimate) • Ability to make a payment monthly is an option	**AMR** (FULL) - Electronic Reads collected monthly. Estimate is for 3.5 FTE Meter Readers **AMI** (FULL) – Hourly, daily and monthly consumption information available to bill as required.

APPENDIX A: EXPANDED BUSINESS DRIVER ASSESSMENT

Table 29: Detailed Non-Financial Business Driver Assessment

Ref	Importance	Business Drivers & Description		Utility	Technology Assessment
Improved System Distribution (DS)					
DS1	**(0) Not Important**	**District Metered Areas**	• Identify and monitor real losses on the distribution system. • Perform non-revenue water calculation on a subset (or district) of customers within a given geographic area. • Requires all distribution mains to be metered to measure water in and out of a districted metered area (DMA). • An AMI system takes all the identified customers within the DMA and subtracts consumption from the master / district meters.	**Discussion Points:** • Does Winnipeg have DMAs? **Discussion Outcomes:** • There are no DMAs in Winnipeg. • One Pressure Zone –	**AMR** (ZERO) – Not able to perform with AMR data. Does not allow this type of program to be implemented. **AMI** (FULL) – Requires: • Master meters on distribution network. • Hourly readings from all meters. • MDM has the ability to group and calculate water loss. Meter consumption can be grouped and compared to master meters within most high-quality MDM software if the master meters are in place.
DS2	**(2) Important**	**Water Balance Calculation Frequency**	• Water utilities perform a water balance (AWWA Water Audit Software) to calculate non-revenue water across their system. • With hourly AMI consumption data for all customers, this type of water balance could be performed both more accurately and on a more frequent basis, allowing utilities to identify and react to significant changes in non-revenue water percentage. • Dynamic water balance could be implemented either on the entire system or just smaller more problematic parts of the system.	**Discussion Points:** • Granular Data allows for more regular water balance (monthly / weekly) • Can monitor changes more quickly and take action to reduce losses • Variable Production cost of water is $.12/m3 • % of non-revenue Water in 2019 is 17.4% • Water Losses 71.8M3; Real losses at $.12 / M3, apparent $4.67 / M3 **Discussion Outcomes:** • Water Audit done once a year.	**AMR** (PART) – Not able to perform this calculation. Would not allow this type of program to be implemented. Since all customers are not read on the exact same day there is still an estimation that happens. **AMI** (FULL) – Requires: • Meters on all water sources and to be setup as a revenue meter.

				• Lack of confidence in the numbers since the data isn't available. • Metered Consumption comes "after the fact" and significant portion of the consumption is estimated • Very old meters coming from the pumping stations ('60s vintage). Therefore, not confident in the amt of water being pumped. • Hard to tell if there's a big leak somewhere • City does monitor night-time pumping to provide indication of changes in the distribution system • Many areas are estimated including Real and Apparent Losses, Metered Consumption, Meter Inaccuracies, and unauthorized consumption.	• MDM has the ability to group and calculate water loss. Provides actual meter readings for all meters for the same day. Consumption information can be summed and monitored on a frequency of the utility's choosing (monthly, weekly, daily) and can be compared to SCADA. MDM may be able to interface with SCADA to perform water loss calculation in a report or user interface, but this functionality is still in development within the system available.
DS3	**(1) Nice to Have**	**Acoustics Leak Detection (ALD)** **Main Break Monitoring** **Drop and Place**	• Detect changes in noise that a leak will cause. • Typically expect 1 ALD for each 10 meters. • Very dependent on distribution system. • Materials - Drop and place does this temporarily.	**Discussion Points:** • Helps reduce all real loss categories. • Does the City have a drop and place acoustic program? • What is spent on this per year? **Discussion Outcomes:** • Winnipeg uses Drop and Place when they have a known leak to pinpoint where the leak is located • On older mains, Winnipeg used to do some leak detection but discontinued about 7 years ago. • 50% PVC and 30% Concrete and 20% Cast Iron –	**AMR** (ZERO) – Not applicable. Does not allow this type of program to be implemented. **AMI** (PART) **–** Can help facilitate these programs. Requires: • Acoustic ALD • Additional software to map it The utility could install radio transmitters and acoustic monitoring devices on the water systems which would be collected by the fixed network along with the readings.
DS4	**(0) Not Important**	**Acoustics Leak Detection (ALD)** **Main Break Monitoring** **Entire System**	• Acoustic leak detection installed across the entire system would allow a water Utility to respond to leaks quickly and in real time. Increasing response times to system wide leaks will reduce potential damage to infrastructure and property and reduce water loss. • Detect changes in noise that a leak will cause. • Typically expect 1 ALD for each 10 meters. • Very dependent on distribution system.	**Discussion Points:** • Are there specific parts of the water systems where this type of monitoring would be beneficial? • Type of pipe across the distribution system (plastic, Ductile). **Discussion Outcomes:** • Not important at this point	**AMR** (ZERO) – Not applicable. Does not allow this type of program to be implemented. **AMI** (PART) **–** Can help facilitate these programs. Requires: • Acoustic ALD • Additional software to map it

			• Materials - Monitoring on the entire system. • Pipe replacement planning: acoustic vendors promote the ability to prioritize distribution pipes for replacement. Over time the sound signature changes allowing a Utility to prioritize those parts of the system that require replacement.	• The City does need to evaluate the status of leaks which may increase the importance of this business driver –	The utility could install radio transmitters and acoustic monitoring devices on the water systems which would be collected by the fixed network along with the readings.
DS5	**(0) Not Important**	**Acoustic Leak Detection (ALD)** **Hydrant Monitoring**	• Detect changes in noise that a leak will cause. • Catch water haulers stealing water. • Hydrant Monitoring: installing acoustic monitoring devices on all or some hydrants would allow a water utility to be a real time alert/alarm to unauthorized hydrant use.	**Discussion Points:** • Reduce apparent water losses. • Capital cost = between $4.7M and $5.7M for this technology to be installed on all (23,107) hydrants. o May target certain hydrants – would reduce the cost significantly • Are there specific areas (remote) where this would be beneficial? **Discussion Outcomes:** • 3 hydrant monitors installed currently; mostly use these to collect pressure and temperature information • Used as a pressure monitoring device also monitors water and chlorine level	**AMR** (ZERO) – Not applicable. Does not allow this type of program to be implemented. **AMI** (PART) – Can help facilitate these programs. Requires: • Acoustic ALD • Additional software to map it The utility could install radio transmitters and acoustic monitoring devices on hydrants within the water systems which would be collected by the fixed network along with the readings.
DS6	**(2) Important** ***Specific for commercial meters***	**Detect Backflow Events**	23(1)(a) [redacted]		

			23(1)(a) [redacted]		

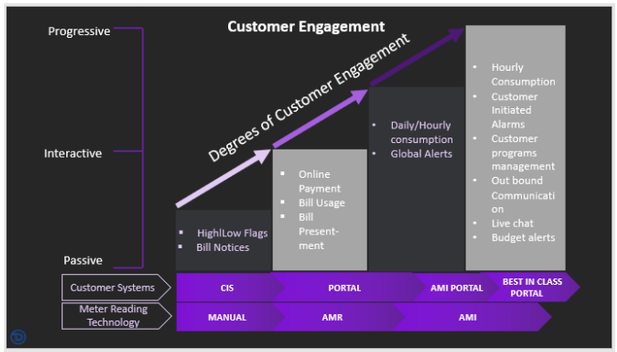
DS7	**(0) Not Important**	**Bylaw Enforcement**	• Support Bylaw compliance on water restrictions:
			  • Water bans
			  • Odd / even lawn watering provisions
			  • Support seasonal water pricing
				Discussion Points:
				• Does the City have regular water restrictions?
				  • Does the City enforce the bylaws?
				• Types of restrictions Winnipeg would consider.
					AMR (ZERO) – Not applicable. Does not allow this type of program to be implemented.

			• Often bylaw enforcement is dependent on customer complaints or utility personnel driving through neighborhoods to identify customers who are in violation of a water enforcement ban. • AMI technology can allow for monitor customer consumption and highlight those who may be violating the ban. Depending on the fines issued, this may increase utility revenues. Repeat offenders could also be flagged on a separate report to more closely monitor them.	**Discussion Outcomes:** • Never have water bans • Water capacity is very stable	**AMI** (FULL) **–** MDM requires reports / alerts that can identify and compare odd / even days and compare. The utility could set up reports that would monitor customers during water restriction events.

DS8	**(1) Nice to Have**	**Pressure Monitoring**	• Monitor Pressure across the distribution system. Changes in pressure may:
			  • Indicate potential leaks.
			  • Reduce pressure - lower real water loss
			  • Respond to customer complaints.
			• Pressure readings can be taken across a water system on a daily (or more frequent) basis. The pressure readings will either come from a pressure gauge or a non-mechanical water meter that is compatible with the selected AMI technology.
			• Pressure readings can be used for a few purposes:
			  • Better respond to customer pressure complaints.
			  • Monitor pressure for fire protection.
				Discussion Points:
				• Changes in pressure may:
				  • Indicate potential leaks.
				  • Reduce pressure to lower real water loss.
				  • Respond to customer complaints.
				• Does the City receive pressure complaints?
				• Would additional pressure information help distribution management?
				
				Discussion Outcomes:
				• There were no pressure issues recorded in the Work Order Database
				• Pressure complaints potentially go to 311 (rarely system problems)
				• Could be a tool to trace leaks - potentially have it on some targeted locations
					AMR (ZERO) – Not applicable. Does not allow this type of program to be implemented.
					
					AMI (PART) **–** Would require:
					• Water meter that transmits pressure or 3rd party pressure monitor that is compatible with the RF network
					• Meter and AMI manufacture to be the same
					AMI technology would need to either have a radio transmitter that can communicate and pull pressure readings from a pressure device or the AMI technology in combination with a water meter capable of monitoring pressure (manufacture specific).

DS9	**(3) Critical**	**Temperature Monitoring**	• Monitor temperature on shallow services. • Be able to better proactively respond to freezing temperatures. • Could indicate problems in the system (e.g. water main frozen, unknown valve closed) • Some areas are more known to have frozen services – implement in certain areas of the City	**Discussion Points:** • To what extent is freezing an issue? **Discussion Outcomes:** • In some years, thousands of frozen services and thousands of households running water • Customers run water and the City provides an allowance on their bill. Customer is billed their daily average – if the freeze is on the City side. If the freeze is on the customer side, the customer isn't granted any relief. – Problems differentiating what was on the customer side compared to City side. Everyone was getting free water. • City staff checks freezing issues and makes the determination as to whether it's a City issue or a customer issue • For City side freezes, City personnel would go on site to try to thaw from the property line to the meter (some need excavation, depends on connectivity of the water main). Running electric current through the pipe; hot water machines to try to thaw. • Temperature monitor is relatively new; typically, in a non-mechanical meter; have not seen data on how much temperature changes inside the home. • Lack of meter reading history makes it difficult to determine who has been running water • In 2014, there were 6884/9505 accounts frozen on City-side, 636/9505 accounts frozen on property-side and 35/9505 both city and property side. And 1950 unknown. • City has ranked Temperature Monitoring as Critical contingent on the data quality/applicability. Potential for specific areas of the City. Budget for 500 in the POC and for 10,000 installations as part of the project. –	**AMR** (ZERO) – Not applicable **AMI** (PART) **–** Would require: • Water meter that monitors and transmit temperature (C715) • Meter and AMI manufacture to be the same Alerts to be emailed within a reasonable timeframe

DS10	**(0) Not Important**	**Peak Demand Monitoring/Planning**	• Using more detailed consumption information (specific time of day or seasonal) to monitor capacity limits in pumping and distribution	**Discussion Points:** • How close is the City to its peak pumping capacity? **Discussion Outcomes:** • The City is "not even close" to a demand problem in terms of pumping, treatment and distribution • Good information to know when planning pump upgrades for example or optimize energy usage	**AMR** (PART) – Could get hourly data from select endpoints **AMI** (FULL) **–** 15 minute or hourly data from every endpoint provides opportunity to understand overall system demand and individual customer demand
DS11	**(1) Nice to Have**	**Hydraulic Modelling**	• Using more detailed consumption information (specific time of day or seasonal) to better model the system and understand peak demand volumes and timing for system growth/planning.	**Discussion Points:** • How often does Winnipeg update or use the Hydraulic Model? With 3 pressure zones, would more pressure information be valuable? **Discussion Outcomes:** • The City does have a hydraulic model that is generated by an outside consultant • Took 2017 actual data and grouped demands from all the addresses to nodes in the City model • Hard to pull the data so it's difficult to perform the model often • City is fairly accurate as it relates to the model .	**AMR** (PART) – Improve monthly consumption forecasts. **AMI** (FULL) **–** Using data to predict different types of behavior. More granular pressure readings could help with the model.
Enhanced Customer Service (CS)					
CS1	**Not scored see CS 3, CS 4, CS5**	**Customer Engagement**	• Customer engagement is a Utility's ability to communicate to their Customers in a timely manner (pre bill versus post bill) and using technology that customers use. • i.e., Online access to their account, from their smartphone, live chats • These factors allow a customer to ask questions and get timely response, get information about their bill and other water related programs, and arrange payment of services provided.	**Discussion Points:** • AMI in combination with customer portal allows communication before the bill is produced. • AMI changes how and when the City might communicate to customers (i.e., more proactively) **Discussion Outcomes:** • Most communications with customers happen now after the bill and are customer initiated. (i.e., Customer calls 311 for a service request or report a problem/emergency).	• Customer Engagement requires more than meter reading technology AMR – Customer engagement can happen monthly post bill. AMI in conjunction with a customer portal – changes customer engagement. Items such as hourly consumption can be displayed on the portal. High consumption/Continuous consumption is done pre-bill through a variety

			• Customer engagement is also about proactive communication with customers and leveraging technology that allows customers to be notified in a proactive manner.  	• Winnipeg has paperless billing - ~47,000 accounts registered for paperless • Customers billed quarterly; No monthly billing option for the customers but the City would like to see this option provided. • Prebill communication is the City sending postcards requesting a meter reading. • High/low communication is an actual letter that goes out. They do provide a courtesy call if the bill is extraordinarily high – 10K or more get the call. Low consumption – just a letter to request a re-read b/c the City assumes an error. • Service Requests • Final Reading – both the purchaser and vendor to take a reading and a photo and submit reading to the City through normal means. The City also has a program for the legal community to submit a reading. An IVR system is also available to phone in a final reading. • Shut-off requests go through 311. There's a service request that is provided to water services who does the actual shut-off. • Public Education for Conservation – nowhere near capacity. Winnipeg has really low water usage. • Major Leak (emergency) done through 311 and goes to Water Services •	of means as determined by the City including through the portal, phone-call, email, etc. Additional customer benefits offered through these channels include (potential) service breaks and vacation monitoring.
CS 2	**N/A**	**Not Applicable**	• N/A	• N/A	• N/A
CS3	**3**	**Customer Engagement** **Passive**	Customer Engagement – Passive - A customer facing business process that provides limited information in a paper format for the single purpose of water billing.	**Discussion Points:** • Utilities often start with lower levels of customer engagement usually defined as reactive responses to customer complaints or passive notices included on water bills. • As a utility starts to allow for on-line web access to water bills (for viewing and payment), this provides a more services/engagement to the customer; however,	**AMR** (FULL): AMR readings will support a passive engagement where the customer can decide to view their billable consumption. This level of engagement is usually driven more by the Customer Information System than the meter reading technology.

				the utility is reliant on the customer to initiate the engagement. **Discussion Outcomes:** • Winnipeg is already at this level of customer engagement.	**AMI** (FULL): Would achieve the goal on a passive customer engagement. But not really required.

CS4	**3**	**Customer Engagement**
		
		Interactive
			Customer Engagement – Interactive. A customer facing business process that provides information in a paper and digital format for the purposes of water billing, bill comparison to previous periods and payments data.	**Discussion Points:**
				• As a utility applies AMI technology that includes a customer portal, the engagement becomes more interactive.
				• Customers can access better consumption gradually (hourly buckets as compared to monthly) and potentially be sent consumption flags (continuous leak, intermittent leak) allowing them to better understand their consumption behavior.
				• The utility can also start to establish global leak flags that allow notifications to be proactively sent to all customer meeting certain consumption conditions (i.e., 500% of daily average consumption over a 5-day period) via the customer portal credentials (Email, text).
				
				Discussion Outcomes:
				• Winnipeg has some interactive features
				  • bill presentment
				  • Credit Card payments
				  • Financial Institutions (online/in person)
				• submit and track requests through 311
				• IVR
					AMR (PART): AMR readings will support a passive engagement where the customer can decide to view their billable consumption.
					
					Displaying consumption flags could enhance the level of engagement especially when a continuous leak flag could be displayed for a customer complaining of a high bill.
					
					Some interactive engagement but likely would fall short in several areas. Requires a portal.
					
					AMI (FULL): AMI technology would allow customers to view hourly consumption to better understand their consumption behavior. This would depend on the AMI vendor's ability to provide a consumption customer portal that would receive customers credentials from the existing customer portal or payment provider.
					
					Typically, the AMI consumption portal will include some global consumption alerts but may not distinguish between customer type or meter size (where consumption patterns may be significantly different).

					• Alerts and consumption views would allow more interactive • More advanced Portal is likely required

CS5	**3**	**Customer Engagement**
		
		Progressive
			Customer Engagement - Progressive A customer facing business process that provides information digital (paperless) format for the purposes of provide customers with water billing, bill comparison to previous periods, payments data, online payment, setting consumption alerts/alarms, consumption behavior analytics, and potentially online service requests.	**Discussion Points:**
				• As a utility moves towards "best in class" customer engagement, it allows:
				  • customers to personalize their own leak or bill notifications,
				  • provide workflows that help customers proactively investigate consumption,
				• consumption algorithms that can identify different types of consumption behavior (continuous overnight consumption, leaking toilet or irrigation system, on-even water ban violators) with a high degree of accuracy and provide workflows that help adjust this behavior.
				• Best in class (full function) [customer portals.
				• AMI functionality related to consumption, leaks.
				• Conservation program management.
				• Communications
				
				Discussion Outcomes:
				• Builds on the functionality provided by the City today for additional and proactive alarms (leaks), bill comparisons (similar households, previous periods), requests for shut-offs (snow-birds).
					AMR (ZERO): AMR readings system would have limited capabilities. Would not achieve a progressive engagement even with a customer portal.
					
					AMI (FULL): AMI technology and a best in class customer engagement platform would provide the "personalized" service through customize alerts, and resolution workflows.
					
					The customer engagement portal would be connected to the existing customer portal seamlessly through the passing of customer credentials, completely invisible to the customer.
					• Improve engagement from utility.
					• Improve engagement from the customer.

CS6	**(2) Important**	**Leak Detection – Small**	• Two types of customer side leak detection:
			  • Continuous / intermediate consumption over a period of time.
			  • Utility set threshold – amount of water per interval and the number of intervals where consumption occurs in order to "trigger" flag
				Discussion Points:
				• This type of customer side leak detection would allow customer to avoid large bills.
				• Water budget could help keep lower income customers with water bill affordability.
				• Functionality available in both an AMI portal and full-functional portal
					AMR (PART) – Would only do continuous leak detection. Need bill print adjustment or a portal to display.
					
					AMI (FULL) **–** A combination of AMI and customer portal will achieve this. AMI vendor

			• Customer set thresholds – as set by the customer will be different that utility set thresholds. • Water budgets • Provides the utility with an improved ability to respond to customer's high-water bill complaints. • AMR equipment includes algorithms that determine a continuous or intermittent leak. Different types of yes/no flags can provide a billing agent with indication that a leak has occurred at a property. • This reactive approach helps a utility better service its customers.	• Could reduce leak forgiveness dollars provided by the utility, payment deferrals and high bill complaints. **Discussion Outcomes:** • Expectation from the customer that if the utility can gather leak detection data that they should have access to it and the utility would notify customers of leaks. • Letters etc. would be a good option in particular if the seamless experience was not available –	portals and full-functional portals will provide will allow customer notification. Will provide hourly consumption data to use for consumption alerts that includes: • Continuous leaks over a utility defined period. • Intermittent leaks over a utility defined period. • High consumption (X% over daily average consumption) over a utility defined number of days. Utility defined threshold that eliminates customers with very small leaks from being notified.
CS7	**(1) Nice to Have**	**Leak Detection - Broken Pipe**	• Provides a utility with the ability to set global alerts to initiate customer service or field personnel to contact a customer because it appears a pipe has broken based on the volume of water going through the meter. • Would provide a "real time" alert if the consumption match ~80% of the service capacity for a 1 to 4 hour period.	**Discussion Points:** • Small leak detection might be setup to trigger over a few days vs. a broken pipe which could trigger a more immediate alarm because of extraordinary large flows. • Would this be of value? • How many broken pipe complaints would Winnipeg receive in a year? **Discussion Outcomes** • A handful of broken pipe complaints usually a result of somebody stolen the meter or extreme frozen services	**AMR** (ZERO) – Not applicable. **AMI** (FULL) **–** Set global leak thresholds and great alerts for when consumption meets 75% or greater hourly flow based on the service size. • Available on most • Bubble up/Wake up functionality would be important.
CS8	**(1) Nice to Have**	**Vacation Monitoring**	• Allow for a customer to set a vacation alert that will tell them if water is being used when it should not be. This would be setup through a customer portal which allows for an alert to be sent. • Customer established zero consumption alarm. • Where consumption exceeds a customer define amount, they receive an alarm.	**Discussion Points:** • Would this be of value to your customers? – **Discussion Outcomes:** • Decent population of snowbirds • Some customers advise the City of vacation plans • City does not shut off the water; It is up to the homeowners to prepare the home for vacancy	**AMR** (ZERO) – Technology does not provide enough data to achieve this functionality. **AMI** (FULL) – Customer driven zero consumption monitoring. Customers can set thresholds for alerts to be send to them. Alerts include: • Vacation/vacant notice

				• For vacant homes, the water is turned off at the street if requested (low number)	• Customer driven zero consumption monitoring • AMI and Customer Portal would be critical
CS9	**(2) Important**	**Seamless Customer Experience**	• Single web application that allows customers to see payment history, consumption history, outstanding payables, make payments online, City programs, etc. • Single sign on for customers • Utility Branded	**Discussion Points:** • What are the costs of the existing – capital investment but no on-going • AMI Vendor Portals tend but they limit • Full functional application comes with additional costs (~$1.75 / cust /a) **Discussion Outcomes:** • Customer portal is built in house (IST App solution) • 74,669 Profiles, 83,877 accounts registered with ~47,000 active accounts. • Do not want different look and feel for the AMI portal. This is a “non-starter”. The City does not want 2 portals and applications with different “look and feel” – significant initiative within the City to have everything look and feel the same. • Preference is Dollars and consumption in a single application with SSO • Utility branded • SSO for city customers is important – citizen portal is being explored (getting scoped out now including for sure going to handle authentication also how to pass information from other portals to the citizen portal – i.e., seamlessly integrate to other portals) • Early in the discussions but citizen portal will be the main portal • Custom portal – does have a capital investment • Seamless customer experience is more essential than the scope – i.e., what is ultimately included in the AMI portal will be first driven by ensuring that seamless customer experience.	**AMR** (ZERO) – Customer Portal Technology typically not provided as part of an AMR implementation. **AMI** (PART) – AMI provides much of the data that feeds a fully functional customer portal. However, vendor provided Customer Portals generally focus on consumption data without the ability to deal with payments and payment history. AMI will not provide a seamless customer experience by itself but will contribute to the objective. **Fully Functional Portal** (FULL) – Provides complete consumption and payment functionality. Allows for much better outbound/inbound communication and allows for the seamless customer experience. It does come at an additional cost - ~$1.75/customer/year.

CS10	**(1) Nice to Have**	**Customer Service Requests / Program Sign up**	• Allows customers to make service requests through the portal (move in, move out, book an appointment, request a call back) • Program sign up allows customers to sign up to specific programs such as rain barrels, or conservation programs	**Discussion Points:** • This availability of this sort of functionality will be dependent upon the application chosen. • Generally, it is not available in AMI provided customer portals since they are more consumption focused. – **Discussion Outcomes:** • Functionality is currently available • Customer requests (move in / move out) are done through AVR; remaining through 311 • Water Service: Customers are to contact 311 to inquire about any of these services: ○ Water turn off ○ Water turn on ○ Contractor request for water main turn off/on ○ Hose lines	**AMR** (ZERO) – Customer Portal Technology typically not provided as part of an AMR implementation. **AMI** (ZERO) – AMI vendor provided Customer Portals generally focus on consumption data without the ability to handle customer service requests or sign up to programs. **Fully Functional Portal** (FULL) – Provides ability for customers to make requests through the portal as well as sign-up to programs.
CS11	**(0) Not Important**	**Online Customer Payments**	• Additional payment options can be provided to customers through the customer portal including: • Paid at Bank / In Person • Paid via credit card via Plastiq • Paid using on-line payment provider •	**Discussion Points:** • How does the City take payments now? • Would the City like to expand it's payment options? – **Discussion Outcomes:** • Winnipeg does have a project at the moment looking at online payment gateways to provide multiple payment channels with the intent it would replace Plastiq	**AMR** (ZERO) – Customer Portal Technology typically not provided as part of an AMR implementation. **AMI** (ZERO) – AMI vendor provided Customer Portals generally focus on consumption data without the ability to handle customer service requests or sign up to programs. Full Functional Portal (FULL) – Likely available depending on the application selected. Additional cost would apply.
Societal Benefits (SB)					
SB1	**(0) Not Important**	**Water Conservation Program**	• User consumption data to support: • Reduction of peak water demand	**Discussion Points:**	**AMR** (ZERO) – Not applicable. Technology does not provide enough data to achieve this functionality.

		Support	• Measure impact of conservation initiatives (Low flow device programs, top dressing, outreach programs, etc.) • There are a number of different types of water conservation programs that focus on changing customers' water consumption behavior. The types of programs that are implemented within a utility really depend on the challenges faced, customers groups (residential, commercial, and industrial) and the type of usage the utility is targeting (indoor usage, outdoor usage).AMI technology can promote water conservation by providing information to customers which enables them to change their behavior. • The greatest benefit - the ability to target customers meeting a specific consumption profile and to measure the affects water conservation programs have on reducing water consumption. As a result, program dollars can be better targeted and utilized towards programs that are proven to be the most effective.	• AMI By itself doesn't initiate conservations but does help support conservation programs and understand program effectiveness. **Discussion Outcomes:** • According to the City's document "Evaluation of Water Conservation Programs, Including Current and Future Water Conservation Needs TM #2" "…the amount of water produced by the City in 2016 was 37% less than the water it produced in 1990 even though the City grew by approximately 115,000 people over that period." • Winnipeg attributes the overall reduction in water consumption to a variety of factors including: ○ Water efficient technology (i.e., toilets and clothes washers) ○ Increased public awareness of water conservation ○ The adoption of new government regulations (Manitoba Plumbing Code)	**AMI** (FULL) – Hourly and daily consumption data can be used to support conservation initiatives. Hourly consumption data in combination with grouping and report functionality from an MDM water conservation program can be measured for their impact on water reduction.
SB2	**(1) Nice to Have**	**Climate Change** **CO2 Reduction**	• Some utilities want to reduce CO2 emissions through reduced truck rolls**.**	**Discussion Points:** • Will AMR or AMI support the City's Climate Plan? **Discussion Outcomes:** • The vast majority of the City of Winnipeg's meters are manually read now so reducing CO2 as it relates to meter reading is not a major driving force. • However, greenhouse gas reduction targets include a 20% reduction by 2030 and an 80% reduction by 2050 relative to 2011 levels. As a result, the City would not want to contribute to additional greenhouse gas emissions if avoidable due to meter reading.	**AMR** (ZERO) – AMR would require vehicles on the street collecting meter reads that aren't there now contributing to CO2 emissions. **AMI** (PART) – Eliminate the vehicles for meter reading purposes. AMI's effectiveness in helping tackle Water Loss Management, customer leaks and Apparent Losses results directly in energy savings. Further, the ability to understand customer demand patterns as well as system demands might change water pumping strategies and contribute to energy

					savings if water can be pumped during “off peak” times.

APPENDIX A: EXPANDED BUSINESS DRIVER ASSESSMENT

Table 29: Detailed Non-Financial Business Driver Assessment

Ref	Importance	Business Drivers & Description		Utility	Technology Assessment
Smart Cities (SC)					

SC1	**(0) Not Important**	**Smart Cities**
		
		Smart Lighting
			• Smart City applications start to move a water utility beyond the meter to cash process and potentially well outside the water utility functional area.
			• Smart street lighting:
			  • LED installs reduce energy needs
			  • Smart controls allow:
			  • Controlled Dimming
			  • Emergency lighting
			  • Outage notification
			  • Flat rate to metered consumption (pending measurement Canada approval
				Discussion Points:
				• Has the City explored “Smart City” type initiatives with other departments?
				• How many streetlights does the City have?
				• This business driver could impact the network technology being deployed
				–
				Discussion Outcomes:
				• City of Winnipeg does not own the streetlights…Manitoba Hydro owns them.
					AMR (ZERO) – Not applicable.
					
					AMI (PART) – Requires:
					• Additional LED lights
					• Light control devices
					• Software
					
					Smart City’s is manufacturer specific; the functionality is dependent on the manufacturers system.

APPENDIX A: EXPANDED BUSINESS DRIVER ASSESSMENT

Table 29: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
SC2	**(0) Not Important**	**Smart Cities Trans-portation**	• Using a single network to help with traffic control. • Uses advanced sensors / cameras for vehicle detection and counting and sends results back through the AMI network for traffic light management	**Discussion Points:** • Have there been any discussion with these other departments? **Discussion Outcomes:** • No current initiative • 750 red/green intersections (150 of 750 have streaming cameras); • Winnipeg transit working on getting a proprietary network	**AMR** (ZERO) – Not applicable. **AMI** (PART) – Requires: • Additional equipment specific with the ability to communicate across the chosen network.
SC3	**(0) Not Important**	**Smart Cities** **Public Safety**	• Using a single network to help with gunshot or earthquake notification.	**Discussion Points:** • Have there been any discussion with these other departments? **Discussion Outcomes:** • City does not foresee using the water network in this manner.	**AMR** (ZERO) – Not applicable. **AMI** (PART) – Requires: • Additional listening equipment
SC4	**(1) Nice to Have**	**Wastewater Monitoring**	• Using the network to monitor wastewater overflow. • Using the network to monitor tank and reservoir levels. • AMI Vendors have endpoints devices that can be connected to other control devices (different product that connects to water), Allows a 4-20MA connection	**Discussion Points:** • How is this done now? • Would there be any benefit to having an AMI network to connect to various wastewater alarms? **Discussion Outcomes:** • Wastewater meters at 75% of lift stations (mag meters, SCADA) • Would need flow meters to calculate the delta from outside sources that does not flow from homes and businesses; Different industrial zones and some use	**AMR** (ZERO) – Not applicable. **AMI** (PART) – Requires: • Additional equipment specific with the ability to communicate across the chosen network for peak dry and wet weather flows.

APPENDIX A: EXPANDED BUSINESS DRIVER ASSESSMENT

Table 29: Detailed Non-Financial Business Driver Assessment

Ref	Importance	Business Drivers & Description		Utility	Technology Assessment
				lots of water and expel back into the system whereas others use a lot of waters and do not discharge as much • Would help understand how different districts are behaving for the sewer model • Benefit to come from this is the City is mainly worried about the peak dry weather flow and peak wet weather flow – mainly the peak wet weather flow. If there is concern over a certain area the City will put a temporary meter in the area • Would help the City better model infiltration from manholes, weeping tiles, groundwater.	
SC5	**(1) Nice to Have**	**Smart Cities** **Water Quality Monitoring**	• Using the network to monitor water quality (pH, chlorine, etc.) • Still very much a field in development.	**Discussion Points:** • If devices were available, would more frequent readings be of value to the City? • Were there water quality complaints? • What type (colored, pressure, taste) – **Discussion Outcomes:** • City is required to test the raw water, treated water leaving the WTP, water leaving the three pumping stations, and at a minimum of 39 sites within the distribution system every week. • The City exceeds the minimum requirements by testing at 57 locations within the distribution system every week • City tests for additional parameters beyond the requirements of PWS-09-412-01.	**AMR** (ZERO) – Not applicable. **AMI** (PART) – Requires: • Additional equipment specific with the ability to communicate across the chosen network. Most AMI vendors have not released water quality devices yet. However, backflow and tamper data can be incorporated into a Water Quality Surveillance and Response System (SRS) providing indication of possible threats to water quality. https://www.epa.gov/sites/default/files/2021-03/documents/srs_ami_guidance_20210223_508_complete.pdf

APPENDIX A: EXPANDED BUSINESS DRIVER ASSESSMENT

Table 29: Detailed Non-Financial Business Driver Assessment					
Ref	**Importance**	**Business Drivers & Description**		**Utility**	**Technology Assessment**
SC6	**(0) Not Important**	**Smart Cities** **Garbage Monitoring**	• Monitor levels of a garbage containers • Respond to just bins that were full	**Discussion Points:** • Should we have a conversation with solid waste? **Discussion Outcomes:** • Not seen as important	**AMR** (ZERO) – Not applicable. **AMI** (PART) – Requires: • Additional monitoring equipment for garbage containers to send alerts through the network.