City of Lawrence
KANSAS

City of Lawrence
AMI Assessment & Pilot Planning
September 16, 2016

Deliver to:
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Document History and Distribution

Revision History

Revision #	Date	Description of Change	Author
V1	8/12/16	First draft of report	K. Truschel N. Naassan
V2	9/6/16	Incorporate Lawrence edits and comments	D. Rankin N. Naassan
V3 - Final	9/16/16	Final Report revisions	N. Naassan

Distribution

Recipient Name	Date	Recipient Organization	Distribution Method
Mike Lawless	8/12/16	City of Lawrence	email
Mike Lawless	9/6/16	City of Lawrence	email
Mike Lawless	9/16/16	City of Lawrence	email

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Section A - Executive Summary

UtiliWorks Consulting, LLC ("UtiliWorks" or "UWC"), has been engaged by the City of Lawrence ("Lawrence" or "the City") to develop a business case analysis including alternatives, recommendations, and detailed implementation scope and budgetary estimate for the City's use in Advanced Metering Infrastructure (AMI) consideration.

The tasks underlying this effort include: identify project goals; assess readiness; develop the business case; and, identify potential operational gaps that could pose a challenge during implementation and beyond. UWC examined Lawrence's current utility operations, meter hardware and equipment, systems and software, and staffing. The information was acquired via data requests and through a series of onsite stakeholder interviews with respective departmental teams in March 2016.

This project aligns with three (3) key organizational goals identified by Lawrence: "Facilitate Resource Efficiency Savings and Resiliency of Water Operations", "Provide Outstanding Customer Service" and, "Embrace New Technology for Efficient Business Operations". These are discussed in detail in Section C. A key goal of this program identified by the Finance Department and Utilities Administration Division is to provide more options to interact with customers and operate within their budgetary constraints. A well-deployed AMI system can facilitate these goals.

Based on the results of a gap analysis and a deep dive into the CIS readiness, issues were identified by City Staff related to the existing functionality and processes underlying the City's CIS billing system that must be addressed for a successful AMI deployment. The results of the current state gap analysis are discussed in Section C – Findings with UtiliWorks' detailed review of the Current State of Operations included in Appendix VII.

UtiliWorks also worked with City Staff to identify functionality and operational expectations that would factor into the decision to share an AMI system with another utility. Meetings were held with two regional utilities (Wester and Black Hills Energy) and one AMI vendor. Based on the outcome of these discussions, the potential to "share" the AMI backbone with either of Westar or Black Hills Energy does not appear to be a viable option to pursue. Details are discussed in Section C.

The business case includes deployment of AMI, a Meter Data Management System (MDMS), a Customer Portal that will display hourly water usage to Lawrence customers, Acoustic Leak Detection, and Pressure Monitoring[1]. UtiliWorks reviewed all model assumptions with Lawrence staff. The underlying objective of the Business Case was to arrive at a realistic and conservative result – not to overestimate potential benefits and not to underestimate project costs. Details underlying the quantifiable benefits and estimated costs of this project are included in Section E – Business Case. Table 1 outlines key indicators of the project economics.

[1] Each technology included in the Business Case is outlined in more detail in Section E.

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Table 1: Business Case Results

	Scenario 1 – Base Case AMI/MDMS Meter replace (>10 yrs) 25% residential remote shut-off Distribution pressure sensors	**Scenario 2 – Self Install** Scenario 1 + MWFW software
Net Present Value ($Million)	$3.13	$3.90
Capital Costs ($Million)	$12.84	$11.76
Internal Rate of Return (IRR)	5.6%	6.6%
Payback Period	13 years	12 years
Return on Investment (20 Years)	36%	41%

In addition to those benefits that can be quantified and included in the business case analysis, the City has the opportunity to realize numerous intangible/soft benefits such as improved customer service, system planning capabilities, water conservation, and water demand management to name a few. While many of these benefits are not easily measurable, they are certainly real and achievable with the successful deployment of an AMI system. These are discussed in Section D.

AMI technology introduces great opportunities across the organization, but also brings new challenges. In order to prepare, UtiliWorks outlined our recommended approach to procurement and deployment of AMI technology including a Proof of Concept (POC) phase and project specific and ongoing operational staffing. This is discussed in Section G.

Based on our discovery efforts and findings, Lawrence appears to be well informed of the technology and well equipped to proceed with an AMI project. This conclusion is further supported by a positive business case that we also believe is conservative relative to the benefits that can be realized with a well-designed AMI program. UtiliWorks believes the estimated benefits used in the AMI business case are very conservative and expects that a far greater return on investment can be realized. Key Recommendations and Next Steps are outlined in Section H.

The work represented in this report does not constitute a detailed design effort, nor does it layout a customized project plan at this early stage. However, those will be needed at a later date to bring more definition and clarity to the effort. Wherever appropriate, this report flags where more detailed planning and design activities will be needed.

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Section B - Introduction

1. Purpose

The purpose of this assessment is to provide Lawrence with a business case; outline the quantitative and qualitative benefits that can be realized with an AMI program; and, to outline the proposed implementation roadmap. If the AMI project moves forward, this foundation will prepare Lawrence for the subsequent Procurement Phase as the system and operational requirements will be defined and documented for the Request for Proposals (RFP).

The pursuit of an AMI program that supports enhanced metering functions as well as potential future water distribution system applications requires a well-thought out plan prior to project commencement. A strategic assessment is needed to identify which platforms may be worth pursuing, how existing systems and assets can best be utilized for the long term, which technologies offer a best fit with the utility's footprint, and develop a plan going forward.

2. Background

The City of Lawrence is the sixth largest city in the state of Kansas and is approximately 35 miles west of the Missouri state border. The City is situated between the Kansas and Wakarusa Rivers and nearby Clinton Lake. The Utilities Department (Utilities) is one of many under the City of Lawrence Organization, which is run by a City Commission and City Manager. The mission of the Utilities Department is *"to provide this City we serve with an adequate supply of clean, safe drinking water and properly return this precious resource back to the environment so that its life-sustaining properties can be used for generations to come."* Figure 1 depicts the City's organization chart.

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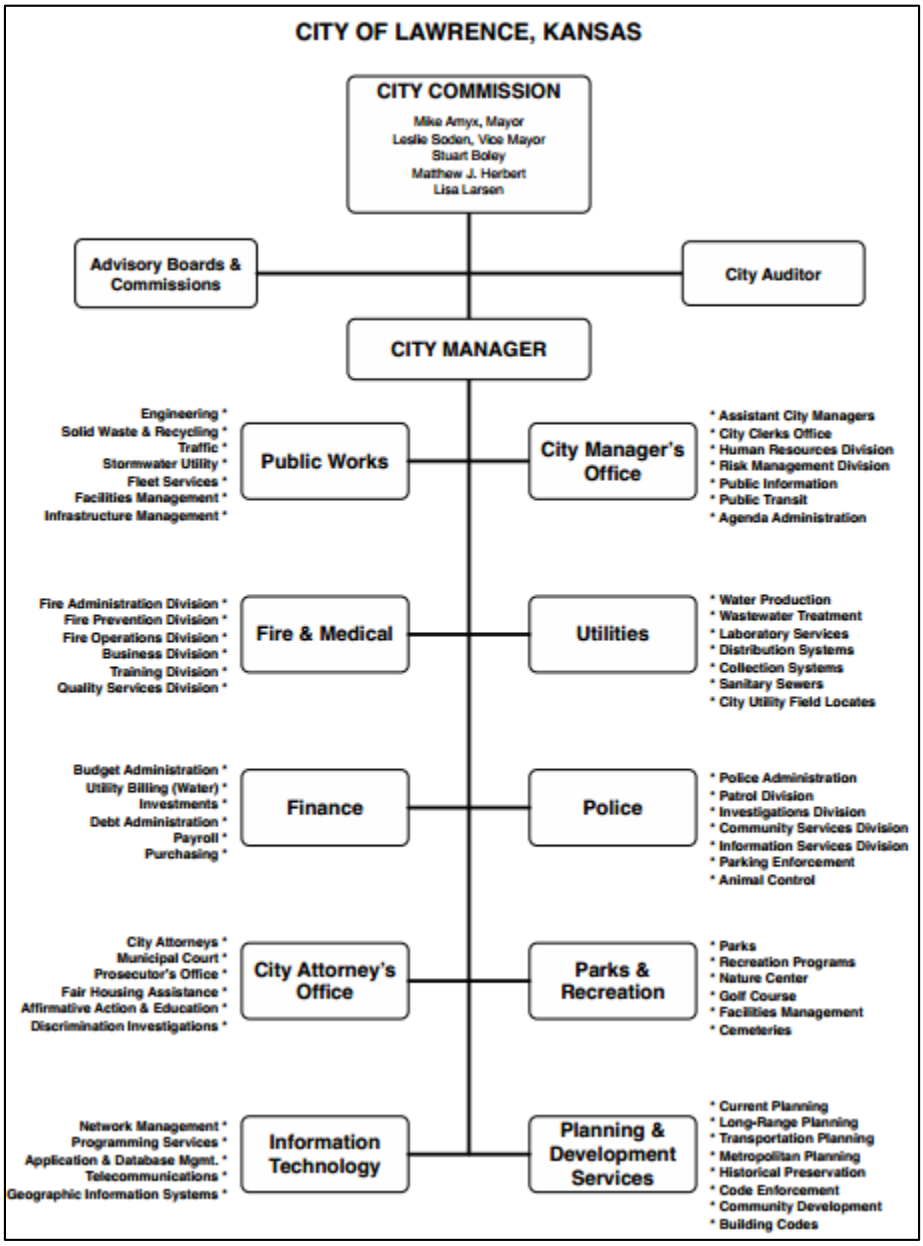
Figure 1: City of Lawrence Organization Chart



The Utilities Department distributes water across 29 square miles to 33,520 metered accounts, five Rural Water Districts (RWDs) and Baldwin City. The City has over 520 miles of water mains, which distribute four billion gallons annually. Raw water is supplied by Clinton Lake and the Kansas River. Utilities oversees water distribution, water treatment, water quality monitoring, and new construction. There is also a group embedded in the Utilities Department that handles customer service related to emergency notifications, service disruption calls and service requests for new meters, in addition to processing work orders within Utilities.

The City's Finance and IT Departments provide billing, meter reading, reporting and IT support functions to the Utilities Department. During the summer months, the Utility experiences a peak in change of service accounts due to a large number of transient residents that attend University

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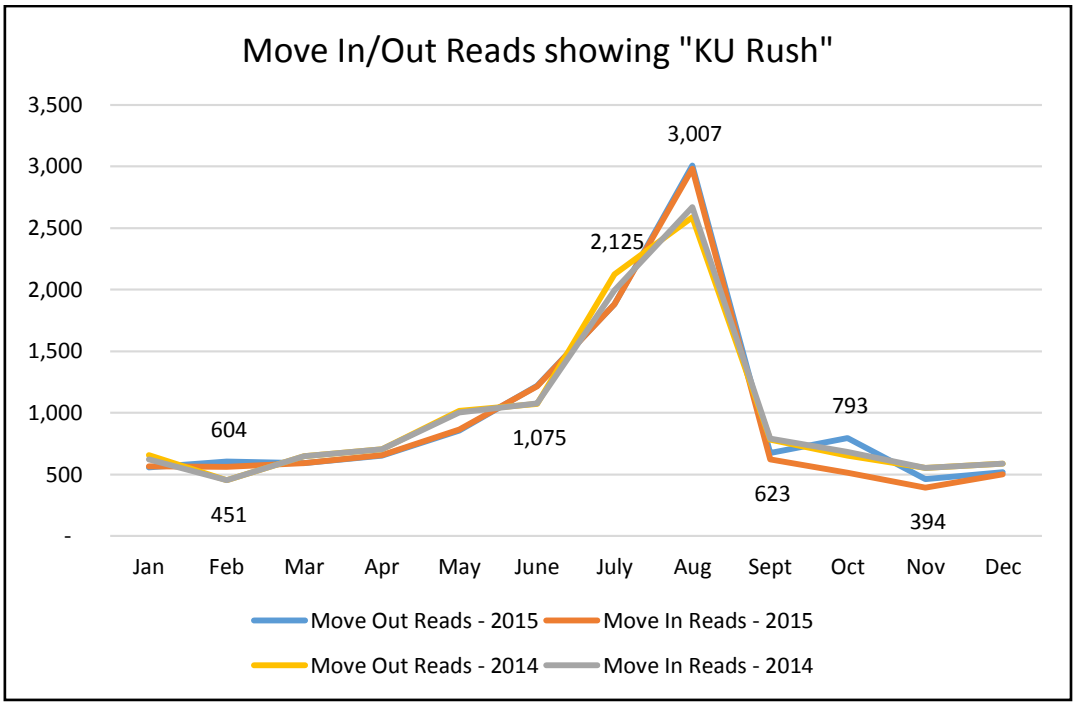
of Kansas (KU). The "KU rush" phenomenon, depicted in Figure 2, represents a significant strain on the Utility staff and resources.

Figure 2: Move In/Out Reads by Month for 2014-2015



3. Scope of Work

Per the issuance of the Notice to Proceed dated January 19, 2016 and under the direction of the Professional Services Agreement, Task Order 1, Project UT1507, UWC has performed an assessment and business case study to baseline Lawrence Utilities' operations and potential for AMI/MDMS implementation success. This Assessment report and associated business case effectively provides Lawrence with the first go/no-go decision point on whether to proceed with the AMI Project.

In order to effectively assess complex technology, UtiliWorks employs a proven delivery mechanism called the UtiliWorks Advantage™ detailed in Appendix IV. UWC's assessment approach facilitates the identification of the business drivers motivating the effort to undertake an AMI project. It also identifies the critical success factors to support implementation and risks that could undermine success.

The Assessment tasks performed and outlined in this report per the scope of work are as follows:

- Project Kickoff and Mobilization
- Technology Review Workshop
- Utility Goals & Objectives Workshop
- Current State Data Collection and Assessment
- CIS Compatibility Review
- Regional Utility Meetings
- Business Case/Return on Investment (ROI) Analysis
- Proof of Concept (POC) Plan

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- Recommendations and Next Steps

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Section C - Findings

1. Goals & Objectives

In order to better understand the drivers and interests to pursue AMI technology, UtiliWorks assessed the goals of the City of Lawrence from different vantage points. Our approach includes the review of high level goals identified by the City along with identification of the specific organizational goals of the utility. Ultimately, the intent is to correlate the Utilities Department goals with those of the City.

UtiliWorks reviewed the multi-year priorities established for various Departments and divisions outlined in the City's 2016 Budget. The priority goals and issues that are relevant to, and could be affected by, the successful deployment of AMI technology include:

- Increase energy efficiency across all operations, reduce fuel usage and substitute clean energy wherever possible (Admin)
- Streamline and simplify business practices (Admin)
- Timely replacement and modernization of computer equipment, with functional integration to other software applications and databases, including automated meter reading (Admin)
- Improve the collection of past due utility accounts (Utility Billing)
- Enhance ability of customers to sign up and transfer service online (Utility Billing)
- Maintaining the current level of service this Division provides based on the City budget constraints (Utility Billing)
- ...assure continuous distribution reliability and delivery of clean, safe water to customers (Distribution)
- Reduce the number of incidents of water distribution system leaks (Distribution)
- Prioritize and update the aging and deteriorating distribution system (Distribution)

In March 2016, UtiliWorks met with key stakeholders to brainstorm specific project goals and objectives. Representatives from across the Utilities, IT, and Finance Departments participated in this session, including staff from Engineering, Billing, Customer Service, Meter Reading, Finance, IT, Water Operations, and Water Quality. The discussion focused on key AMI technology developments and concepts underlying the current state of the industry. The staff were encouraged to raise additional goals that could be impacted by AMI.

The outcome of this workshop is depicted in Figure 2. This diagram outlines the City's departmental goals and objectives that were compiled and categorized by the team at Lawrence. The sections that follow contain more detailed discussion of how Lawrence can achieve these goals with a properly configured and well planned AMI/MDM deployment.

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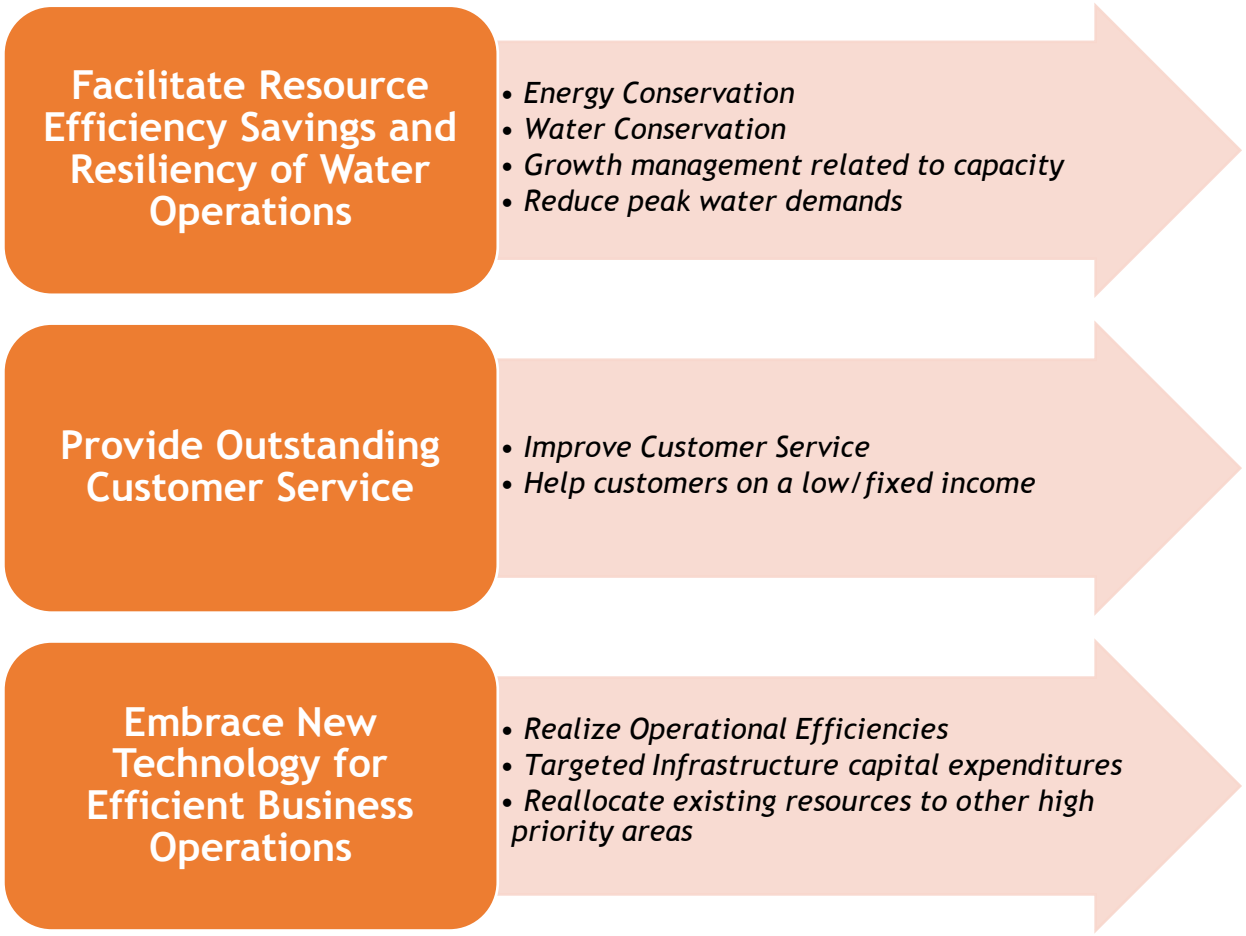
Figure 3: AMI Project Goals & Objectives



A. Facilitate Resource Efficiency Savings and Resiliency of Water Operations

An AMI system can help Lawrence attain resource efficiency savings by decreasing electricity and gasoline consumption. Significant cost and energy savings can be obtained from the reduced number of truck rolls for meter reading and field investigation activities. With automated reads, the Utility will eliminate the manual and AMR drive-by meter reading processes. In addition to these savings, the near-real time data supplied by an AMI network and resulting analytical capabilities will provide operations with the information that can help optimize water production at the WTPs. AMI technology can result in these cost savings, but also serve as an example of environmental stewardship by the City.

Conserving water resources available to the City today will ensure that these resources go farther in the future. Planning for future consumption also corresponds with improving resiliency of operations. As the City continues to grow, the water system capacity will be expected to meet these increased demands. Improving the availability and granularity of the data that is available for system planning will help to support the Utility in addressing future problems due to supply or other restrictions. Furthermore, with the Utility's interest in looking to leverage technologies such as distribution system leak detection and pressure monitoring, leaks and service disruptions

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can be targeted proactively, instead of reactively, by use of alarms and improved distribution system monitoring.

B. Provide Outstanding Customer Service

Customer Service is a priority area for the Finance and Admin Departments, as they strive to provide more options to interact with customers and operate within their budgetary constraints. Currently, the KU rush in the summer months presents a challenge for the City. As the customer base ebbs and flows based on a transient student population of over 23,000[2], the City strives to meet customer needs specifically related to move ins/outs. With an AMI network, the customer service representatives (CSRs) will be empowered to obtain meter reads remotely and provide customers with a more seamless experience during the move in/out process.

In addition, when engaging with customers directly via phone, the City's CSRs will have historical data available to resolve a higher number of customer inquiries on the first call and in a shorter amount of time. Additionally, the City can anticipate lower call volumes as customers will be empowered to view their consumption and setup automatic billing through a customer web portal. The portal will also allow for early identification and customer notification of leaks and high water use, in addition to billing history.

C. Embrace New Technology for Efficient Business Operations

As stated in the priorities established in the 2016 Budget, the City intends to pursue an automated meter reading system. The benefits that can be achieved with AMI technology can expand well beyond the meter reading efficiency gains. There are operational efficiencies to be gained from a deployment. The Utility Billing team will have improved accuracy of data available to help with customer rate development and for winter quarter average calculations. The City can also expect to see improved meter-to-cash with new policies around remote reads, remote shutoffs, and "soft-off" for move ins/outs. Finally, the AMI data will also help to improve financial planning and revenue forecasting with real-time consumption data now available.

2. Project Risks

As with any large-scale technology investment, the transition to AMI is not immediate and not without obstacles. The complexity involved with bridging multiple departments, a live billing system, and critical utility operations will no doubt lead to project hiccups. As part of the City's consideration for an AMI deployment, UWC recommends early identification and understanding of risks that may be inherent to the project so that they can be mitigated.

In order to start this conversation, UtiliWorks has listed those risks that we have directly observed to be barriers to the successful deployment and adoption of AMI technology. For each risk identified, we have also included corresponding mitigation strategies to pursue. As Lawrence proceeds with this effort, each risk should be prioritized by severity and tracked.

a. **Risk**: Lack of project team and internal stakeholder buy-in could lead to project failure.

Mitigation Strategies:

- Leadership should demonstrate a strong understanding of project goals and develop an "elevator pitch" to show project support.

[2] https://oirp.ku.edu/sites/oirp.ku.edu/files/files/Profiles/2016/4-005.pdf

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- Internal project staff should be fully educated on the technical components of an AMI system and undergo thorough training prior to the Go-Live date.

b. **Risk:** Shifting politics due to revolving governing oversight could disrupt project progress or halt it altogether.

Mitigation Strategies:

- Build support from neighboring utilities and the City Commission. Though leadership may change, it is never too early to build support and educate these stakeholders.
- Participate in AMI industry workshops and conferences to understand best practices and industry standards.

c. **Risk**: Public concerns and hostility within the community due to a lack of public awareness and education concerning the AMI program. Customer buy-in is extremely important for an AMI/MDM system. Those customers that are "early adopters" will likely require a communication strategy for regular updates on project progress.

Mitigation Strategies:

- Launch a public awareness campaign in order to build support within the community and educate consumers on AMI/Smart Meter technology. Consumer education is needed regarding the merits of AMI and the societal benefits of utility modernization.
- If appropriate, host town halls to engage the customer community at grass-roots level.

d. **Risk**: Ongoing infrastructure or upgrade projects at the City compete for resources, especially in Finance and IT. Competing projects / Departments may require the same Subject Matter Experts (SMEs) or project leads.

Mitigation Strategies:

- Dedicate a Project Manager (PM) within the organization to keep the project on track and escalate any resource issues.
- Dedicate a Project Sponsor within the organization to work with and assist the PM with internal politics and escalate any resource issues.
- Establish a Steering Committee to provide the project team with an escalation point for issues that are unresolved or blocked.
- Dedicate one (1) key process owner for each of the following functions: billing, customer service, IT, meter reading, field support, and water system operations. This resource should be experienced, available for individual deep-dive sessions, and participate in the project from beginning-to-end.
- Minimize the large team meetings to only include kickoff, major review sessions, final presentations, and training in order to avoid too many meetings.

e. **Risk**: Inadequate resources to support the ongoing operations, maintenance, and data analytics of the AMI system. With the implementation of AMI, there will be new tasks related to system monitoring, reporting, exception handling. It is expected that a dedicated technical resource that is familiar with Lawrence processes will be required for this work. Additional resource(s) may be required to support the data analytics.

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Mitigation Strategies:

- Review staffing estimate provided in this Assessment and openly communicate any added responsibilities to the assigned staff.
- Undergo business process engineering efforts to ensure all staff is trained and transitioned properly to new roles.
- Hire (if possible) or reallocate technical resource(s) to the AMI project. Building and attracting the needed technical talent is a barrier to the full realization of system potential.
- Pursue a hosted or "managed on premise" system to ensure AMI and MDM systems are properly configured, managed, and supported.

f. **Risk**: Inadequate business processes for maintaining accurate meter characteristics / work orders in CIS.

Mitigation Strategies:

- Perform meter inventory survey/data collection, which Lawrence is currently pursuing. This should be complete prior to procurement phase in order to obtain accurate pricing and project timeline estimates.
- Establish a business process "owner" that will actively manage data integrity issues and formalize supporting business processes.
- Adopt formal business processes or procedures to ensure the correct ID's are captured for any equipment change outs performed in the field.
- Engage staff in educational sessions. It is absolutely critical that the Meter ID reflect the true meter body ID in the CIS in order to generate accurate customer bills once AMI/MDMS is deployed. All staff that update accounts or generate work orders should be informed of importance of tracking up-to-date meter ID, radio ID, and register ID, as well as active/inactive status of all service accounts.

g. **Risk**: The City is dependent upon a limited number of Innoprise CIS technical staff with limited availability to complete CIS/AMI integration activities.

Mitigation Strategies:

- The Innoprise support team should be regularly updated with AMI project status and notified of new software selections very early in the process.
- Pursue outside development support for current CIS application.
- While all major AMI and MDM vendors can integrate with Innoprise (see "CIS Compatibility Memorandum"), Lawrence may consider upgrading its CIS system to one that is better suited to handle Field Operations work orders and could integrate with the City's Lucity asset management software.

3. Regional Utility Meetings

UtiliWorks facilitated meetings with the City's electric utility, Westar Energy and natural gas utility, Black Hills Corporation. Separate initiatives were recently undertaken at both companies to deploy AMI to support their respective utility service offerings to customers in the City of Lawrence. The intent of these discussions was to assess the viability of "sharing" the existing AMI

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infrastructure and software as a way to reduce the overall capital and operating costs of the project.

UtiliWorks worked with City Staff to identify functionality and operational expectations that would factor into the decision to share a system. These key items are listed below:

- Access and control of customer data and usage
- Two-way communications to support on demand reads and remote shutoff
- Robust product offering and roadmap as it relates to water
- Backhaul support for other programs such as distribution system leak detection or pressure monitoring

Based on the outcome of these discussions, the potential to "share" the AMI backbone with either of Westar or Black Hills Energy is not a viable option to pursue for reasons further discussed below.

A. Westar Energy

Lawrence Staff and UtiliWorks met with Westar to discuss their AMI system in late February 2016. Subsequently in March 2016, L&G provided a system demonstration for the City via WebEx.

The Westar AMI project initially began as an Elster AMI deployment, but due to communication issues encountered during the pilot program in the Lawrence Division, the utility switched to a Landis + Gyr (L&G) system. There are some remnants of the Elster pilot equipment in the Lawrence Division; however, Westar is working to phase this out and switch all customers to the L&G network. The solution is hosted, with L&G monitoring and maintaining the "network as a service" for Westar. A separate Siemens MDMS is maintained by Westar, with meter data being sent over VPN from the AMI network every 2 hours.

According to feedback from the L&G team, they do not currently support any stand-alone water utilities, only combination utilities with the main focus on electric. In general, L&G has focused their offering and product development roadmap on the electric market with a limited focus on water. For example, remote shutoff functionality for water service is on the roadmap in 2017. Enhanced communications to support backhaul for water programs such as leak detection or pressure monitoring is presently set for 2018. This lack of focus on water would not best serve the City. Given that L&G does not currently offer a standalone water solution along with the vague roadmap of water products, UWC recommends that Lawrence not proceed with a shared AMI solution with Westar.

B. Black Hills Corporation

Lawrence Staff and UtiliWorks participated in a conference call with Black Hills Corporation to discuss their AMI system in March 2016. Black Hills provides electric and natural gas services to more than 600,000 customers across multiple states. The move to smarter metering came with the deployment of the Itron Automated Meter Reading (AMR) system starting in 2009. Given the wide deployment of the Itron technology throughout the Black Hills service area, it was a cost effective choice to transition to the Itron Choice Connect AMI system in 2013. That same year, the AMI system was deployed in the Lawrence natural gas service area. Similar to Westar, Black Hills maintains a separate MDMS, Siemens eMeter.

It became immediately apparent that the Itron system, as deployed, was lacking in desired functionality. While capable, the Itron system was not designed to deliver 100% two-way communications, but rather 70-75%. This system limitation would impact the ability to collect on-demand reads, collect move in/out reads, and perform remote shutoff. The expected cost savings from reduced truck rolls associated with each of these benefits would not be recognized.

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In addition, Lawrence personnel would not have direct access to the AMI database for security reasons. For example, in the event Lawrence would like to perform on demand functions, it would be necessary for Lawrence Staff to "email" Black Hills AMI system administrators.

Given the lack of robust two-way communications along with limited access to and control of data, UtiliWorks recommends that Lawrence not proceed with a "shared" AMI solution.

4. AMI Implementation Readiness

UWC examined Lawrence's current utility business processes, hardware and equipment, systems and software, reporting capabilities, and resources. In addition, team members across the organization shared barriers and constraints on their operations which could impact the implementation of an AMI system. The information for the current state assessment was acquired via data requests and a series of onsite workshops with respective departmental teams. The following Utility functions are key areas that are impacted by AMI/Smart Meter technology:

- Meter Reading/Field Services
- Utility Billing
- Customer Service (City Hall and Utilities)
- Water Operations
- Meter Shop
- IT Applications and Communications

Beyond their current operations, UWC asked team members across the organization to brainstorm potential constraints which could impact the implementation of an AMI system. This information was reviewed and analyzed in order to establish Lawrence's reference point upon which to identify anticipated gaps in technology or resources.

In general, Lawrence appears well equipped and well informed. UtiliWorks conducted a State of the Industry presentation to a large cross-section of staff members from the Utilities and Finance organizations. The staff was engaged during this onsite educational session, which reviewed AMI and supporting technologies. Involvement from these multi-disciplinary Departments will continue to be important if Lawrence proceeds with an AMI deployment. Management has also given much consideration to the project staffing needs and operational impacts.

Table 1 specifies key areas that indicate readiness and outlines UtiliWorks' observations of potential gaps specific to Lawrence that could impact a successful deployment.

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Table 1: AMI Implementation Gap Analysis

Potential Gap	Status
Designated AMI Project Owner	Lawrence plans to designate a Project Manager, Project Sponsor, and Steering Committee that includes representatives from across the organization.
Staff to support software and systems interfaces	City IT will identify a dedicated CIS/AMI project lead, who has been engaged throughout the assessment. Early coordination with Harris / Innoprise staff will be required for integration support.
Staff to deploy and support communications infrastructure	Yes, this will be a combined effort between Utilities and City IT Department. Specific roles/responsibilities to be fleshed out as part of assessment findings and recommendations.
Water meter test bench	Mobile testing only. Space in warehouse can be repurposed for a stationary test bench to support Proof of Concept phase (POC) testing.
Physical space/warehouse to support large scale deployment	City does have adequate space adjacent to warehouse that is available to host/stage deployment on City property.
Well maintained water meter characteristics in a database	The Innoprise CIS database contains suspect meter characteristic data (Meter ID may be overwritten with Register or Radio ID, depending on work order history). Manual entry required for all work order data, since there is no integration with Lucity. Audit underway.
Work Order Management System	The City is currently reviewing options for a more robust work order management platform with mobile capabilities that will be used to support an AMI deployment. The intent is to purchase in early 2017.
Meter box and lid field inventory	Asset inventory for meter box and lids not currently maintained. A complete inventory cannot be determined without a field audit.
Out of the ordinary water meter access/issues	There are some meters located in basements downtown and in ceilings. KU currently reads 72 deduct meters. City plans to discuss the project with KU to "retrofit" these deduct meters.
CIS that can interface with a MDMS	Currently using Innoprise that has the capability to interface with an MDMS, but will require customization from the Innoprise support team. There is concern that the Innoprise team will not have the resources, time, and personnel to commit to this effort. There is also concern with basic billing functionality. City Staff has expressed a strong interest in replacing the CIS and will proceed with a procurement effort this fall. Highlights from UtiliWorks CIS Compatibility Assessment are included in this Section.

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Customer communications	Considered a very high priority by staff to inform customers and establish a public awareness campaign. Currently looking into customer portal to deploy prior to AMI deployment, which could be leveraged for communications.

UtiliWorks recommends that the City conduct a field audit prior to deployment in order to collect/determine: meter/equipment specification and condition; meter accessibility; and, meter box/meter lid specification. This can occur as early as prior to RFP issuance in order to obtain more accurate pricing.

5. CIS Compatibility Assessment

UtiliWorks was asked to review the compatibility of the Harris Innoprise Customer Information System (CIS) with advanced metering technology/software as part of this SOW. The memorandum dated May 16, 2016 outlines UtiliWorks findings and recommendations to Lawrence on how to proceed. Excerpts are included below.

A. Findings

UtiliWorks reviewed the information compiled during discovery to assess whether Innoprise has the capability to support the data exchange required for billing and meter/radio asset synchronization. In general, Innoprise can support the necessary interfaces; however, there may be risks related to availability of Innoprise staff to build and test those interfaces. UtiliWorks also identified issues with certain business processes that require attention prior to deployment of an AMI system. Key findings are outlined below:

1. The Innoprise CIS can support daily uploads of billing data, but will require new development/configuration to support a new meter read interface with an MDMS. There will be Innoprise time and cost associated with the development of this interface. A commonly used read file upload format, MV-RS, is supported natively and already used with current meter reading processes.
2. The Innoprise system can support synchronization of meter information with an advanced metering system (i.e., AMI headend system / MDMS). The Innoprise developers have experience developing the interfaces with an MDMS, specifically Sensus Logic 3.4, and the functionality exists to support this within the application. However, there will be Innoprise time and cost associated with the development/configuration of the synchronization interface.
3. Innoprise staffing assigned to support the current development requirements of the City plus the additional development and time critical needs associated with AMI deployment may limit or be a potential point of failure for the AMI project.
4. The business process underlying a register replacement and an AMR radio replacement in the field does not currently capture the correct equipment IDs in the CIS. It is absolutely critical that the Meter ID reflect the true meter body ID in the CIS in order to generate accurate customer bills once AMI/MDMS is deployed. Staff within Finance and Utilities should immediately be made aware of the issues related to meter ID capture in the field and advised as to how to proceed with future work orders in both Lucity and Innoprise.

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Educational sessions on meter asset information management and work order processing should commence ASAP.

5. The City is lacking procedures on what fields are being tracked in the CIS UB module. It is important that the CIS serve as the system of record for meter characteristics and is available to synchronize with an MDMS. As noted previously, several data fields are currently available but are not utilized in the CIS. Some of these could serve as an appropriate spot for tracking new meter characteristic information.

B. Recommendations

The overall assessment is that Lawrence's current UB module in Innoprise can support implementation of an AMI/MDMS; however, there are system, business process, resource, and data integrity issues that were exposed in the discovery process that must be addressed. Key recommendations are outlined below:

1. A significant and immediate focus within the City's Utility Billing and Field Operations Departments on data integrity and system synchronization, including work order management, will ensure the meter-to-cash process remains intact during the transition.
2. Lawrence Utilities will need to proactively engage with other City Departments and Innoprise to establish priorities for the Innoprise development team. There will need to be a commitment from Innoprise that they will be able to support the work required to integrate AMI/MDM with the Innoprise CIS.
3. The Innoprise support team should be regularly updated with AMI project status and notified of new software selections very early in the process. In addition, sufficient notice should be provided to developers at Innoprise that will be involved in the development of future interfaces or changes in configuration given a history of competing projects may result in a slow development timeline for integrating new systems.
4. If Lawrence elects to proceed with AMI and Innoprise, UWC recommends a Proof of Concept (POC) phase where the new AMI/MDM systems are stood up in parallel with the existing meter reading software and business processes prior to full deployment. This will allow Lawrence staff the time necessary to conduct the systems integration testing with a select number of meters and ensure an accurate bill can be generated prior to full deployment.

In the event Lawrence elects to replace Innoprise, UtiliWorks recommends a thorough assessment of the business and system requirements and a formal procurement effort. To start, we recommend that Lawrence explore the vendor market and publish a Request for Information (RFI) to determine market players and establish budgetary cost. With regard to the relative timing of a CIS replacement versus an AMI deployment, there are benefits and drawbacks to starting one ahead of the other. UtiliWorks recommends that Lawrence determine the scope of a CIS replacement along with the expected cost to have adequate information to draw conclusions that will best fit the City.

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Section D - AMI Benefits

AMI technology fundamentally changes the meter-to-cash process. What is not easily recognized is that, depending on the supporting technology and business process changes employed, a Utility can realize even greater benefits through the proactive use of the data and information now available. Leveraging AMI technologies will significantly improve the measurement and management of utility resources and will bring direct benefit and value to customers.

The following section will outline the potential benefits that can be realized with the data yielded from an AMI system along with add-on technologies, such as remote disconnect and leak detection equipment. UtiliWorks worked with staff at Lawrence to derive the necessary data and assumptions in order to calculate the potential benefits and factored those conclusions into the business case analysis in Section E. The potential qualitative benefits that are more difficult to quantify are also discussed.

1. Quantitative Benefits

a. AMI Benefits

- **Meter Reading Reduction** – Elimination of on-cycle manual meter reading expenses, including staff time, fuel, and vehicle maintenance costs.
- **Customer Call Reduction** – Reduction of cost related to decreased number of customer calls. This reduction occurs from a combination of online usage information that would be available to a CSR to better respond to inquiries, in addition to customers having access to their information via Customer Portal. Customers would also now have the ability to configure usage notifications via text or email.
- **Re-Read Reduction** – Elimination of most check-read/skip/no-read field activities and expenses in reviewing skips report, creating the work orders and rolling a truck to collect the re-read. New billing routines will have a range of dates a read may be pulled to use on bill (e.g. read date or 2 days prior) and/or a read may be collected via On-Demand read functionality.
- **Move-In / Move-Out Reads and Turn Offs Reduction** – Elimination of most off-cycle read field activities when customers move in and out of a premise. Some of these move outs also require a turn off within current policy, and these will not be affected by AMI. The savings will result from new presentation of daily AMI reads and the ability to collect on-demand reads for those occurrences of move in/out that will move to a "soft off" policy.
- **Non-Pay Disconnect Reduction** – Reduction in collections labor and field activities for non-paying customers. The majority of trips to a premise can be avoided due to remote disconnect/connect capability of some AMI meters. The utility may also benefit from the reduction in bad debt when transitioning regular non-pay disconnect customers to a meter with remote disconnect capability especially with the introduction of Prepay service.
- **Billing Expense Reduction** – Reduction in billing service expenses associated with increased efficiencies. The new MDMS will contain advanced Validation, Editing, and Estimation (VEE) routines and accurate real-time and historical meter information. This can translate to fewer bill estimations, billing errors, and adjustments. Furthermore, a customer portal is expected to result in some customers choosing to opt out of paper billing. Thus, there are also anticipated benefits in postage and bill printing cost savings.
- **Lower Pumping Costs** – Reduction in the cost to pump raw water into treatment facilities and throughout distribution system. The cost reduction is anticipated as an outcome of more optimal distribution of water supply with the real-time AMI data that is available.
- **Water/Wastewater Meter Accuracy Improvement** – mechanical water meters experience a degradation of accuracy over time. This degradation is a function of several factors, such as wear, water quality, and throughput volume. This project represents an opportunity to

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replace older meters and realize lost revenue, on both the water and wastewater revenue streams.

- **Water Loss Identification Revenue** – Alarms triggered in the AMI software can identify meter tampering and product diversion. This is a valuable tool for any utility to identify theft in near real time as compared to monthly when the meter reader puts eyes on a meter. There is further revenue recovery for other non-billed water losses, such as meter malfunctions.
- **Meter Scrap Revenue** – Added revenue from scrap of old meters during replacement. Local market pricing is utilized for all scrap values and weight is determined by the number and size of meters to be replaced as part of the project.
- **Annual Meter Replacement Savings** – Eliminate current annual meter replacement spending for faulty meters by installing new AMI ready meters with long-term warranties. Any capital cost for new meters will be accounted for in the capital costs of the financial model, so this is added as a benefit to avoid any double counting of the meter replacement budget.

b. Water Distribution Pressure Monitoring

- **Distribution System Cost Reduction** – A significant savings can result from efficiency gains from proactive distribution system monitoring via pressure monitoring. Further savings are applied to a decreased annual cost of fixing leaks.

2. Qualitative Benefits

In addition to those benefits that can be quantified and included in the business case analysis, the Utility has the opportunity to realize numerous intangible/soft benefits. While many of these benefits are not easily measurable, they are certainly real and achievable with the successful deployment of an AMI system.

- **Improved Customer Service -** Due to the unique nature of the KU rush, staff and customers engage with each other over a particularly stressful time in the summer months. With remote read capabilities, the Utility will now be able to achieve a quicker turnaround of a change of service, which will reduce stress for staff and help improve customer relations over the long term.

- **Improved System Planning Capabilities -** Information that can be analyzed from an AMI system and other technology supported on the AMI network can facilitate the improved management and monitoring of water and wastewater system performance leading to better informed capital investment decisions. System engineering and maintenance programs can be supported with better, more frequent access to the more granular data that will be provided by the AMI system.

- **Improved Water Demand Management -** Through the use of interval consumption data, customers can more proactively and effectively manage their water consumption. The AMI system will enable Lawrence to model the overall system demand, identify customer leaks and facilitate proactive management of the industrial and residential customer base.

- **Meter Right-Sizing -** Data and alarms produced by an AMI system will provide the Utility with the ability to detect if a water meter is over or undersized based on the size of the meter and the water consumption history.

- **Unauthorized Use Detection -** Current generation AMI Systems provide flag or high priority alerts or reports for reverse water flow and tamper detection. This information will be of

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significant benefit to the Utility and should also facilitate reduction of unauthorized usage or theft.

- **Improved Safety -** Ensuring safety for both utility employees and customers is essential. With the introduction of automated meter reading, the Utility will have the ability to remotely read meters, initiate on-demand meter reads, and remotely disconnect/reconnect selective customers. This will dramatically reduce exposure to risky conditions on the road and at a customer premise, such as weather conditions, unfriendly pets, physically hard to access meters, and theft.
- **Reduced Carbon Footprint -** Reductions in truck rolls and drive time for Meter Reading and field activities related to non-pay disconnect/reconnect, re-reads, and move in/out reads will all contribute to a reduction in carbon output by the City.
- **Compliance with Future Legislative Requirements -** With the introduction of AMI, the Utility will better prepare itself to address legislative and/or state requirements regarding conservation and other resiliency-related issues.
- **Customer Water Leak Detection and early Notification** – An AMI/MDM system can identify customer leaks as they are occurring. Customers can be notified that they have a leak within their private plumbing system. This allows the customer to investigate and correct the leak before it causes a large monthly bill.
- **Customer Portal** – A customer portal allows customers to monitor their water usage and to establish their own thresholds for notification. They can review their past usage and identify the causes of undesired high water / cost.

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Section E - Business Case

The foundation of the Lawrence business case is implementation of a comprehensive AMI solution. This includes an AMI system, an MDMS with Customer Portal, and the necessary integration of these systems to produce an accurate bill. As part of this effort, the City plans to replace some meters and retrofit other meters so that all water meters are equipped with an AMI radio. UtiliWorks' approach when developing the model is to review the assumptions with the respective Utility Staff and ultimately arrive at a conservative result.

UtiliWorks developed a comprehensive financial model which represents the deployment of these technologies. This Excel-based financial model can facilitate changes to the underlying assumptions and examine various scenarios with relative ease. The model captures the Net Present Value (NPV) of the quantifiable capital and operating costs versus the achievable benefits outlined below:

- Capital Costs (i.e., AMI infrastructure, equipment, installation, software, professional services, etc.)
- Ongoing Operation and Maintenance (O&M) Costs (i.e., annual fees related to software hosting and licensing, staffing, etc.)
- Anticipated Benefits (i.e., potential operational savings, revenue enhancement, recovery of losses, etc.)

The City recently transitioned all meter readers (5) and field technicians (5) and one supervisor from the Finance Department to the Utilities Department. It is expected that with the deployment of AMI, the City will recognize labor savings associated with the meter reading, move in/out, and disconnect/reconnect functions that equates to approximately six (6) positions. The expected labor cost savings is offset in the model by the annual cost of three (3) staff that will be dedicated to AMI including two (2) AMI System Technicians and one (1) Data Analyst. These positions are anticipated to be three (3) of the five (5) positions that will staff AMI field operations. The underlying responsibilities for each role are discussed in more detail in Section F – Operational Impacts Analysis.

The Base Case assumes a third party will perform the meter/AMI radio installation. A second scenario was then explored to determine the impact of self-installation. This scenario considered the additional cost of Mobile Workforce Management software that would support a self-deploy and elimination of third party installation costs. This section outlines the business case results, project assumptions, and a breakdown of costs and benefits used in calculations. The detailed model inputs provided by Lawrence along with assumptions underlying the cost and benefit calculations are provided in Appendix I and Appendix II.

1. Results

The model provides a variety of financial metrics for Lawrence to evaluate the financial viability of the AMI project, including the Net Present Value (NPV), the estimated payback period and Return on Investment (ROI). Please see Table 2 for the summary of Business Case results based on deployment of AMI, MDMS, and Customer Portal in the following scenarios:

- **Scenario 1** – **Base Case**. AMI/MDMS deployment with full replacement of meters that are > 10 years old. For residential meters, 25% are estimated to be equipped with remote shut-off capability. This scenario also includes deployment of water distribution system pressure monitoring equipment.

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- **Scenario 2 – Self Install.** Scenario 1 (Base Case) with addition of Mobile Workforce Management (MWFM) software to support the mass meter change out and elimination of installation costs by third party contractor.

Table 2: Business Case Results

	Scenario 1 – Base Case AMI/MDMS Meter replace (>10 yrs) 25% residential remote shut-off Distribution pressure sensors	**Scenario 2 – Self Install** Scenario 1 + MWFW software
Net Present Value ($Million)	$3.13	$3.90
Capital Costs ($Million)	$12.84	$11.76
Internal Rate of Return (IRR)	5.6%	6.6%
Payback Period	13 years	12 years
Return on Investment (20 Years)	36%	41%

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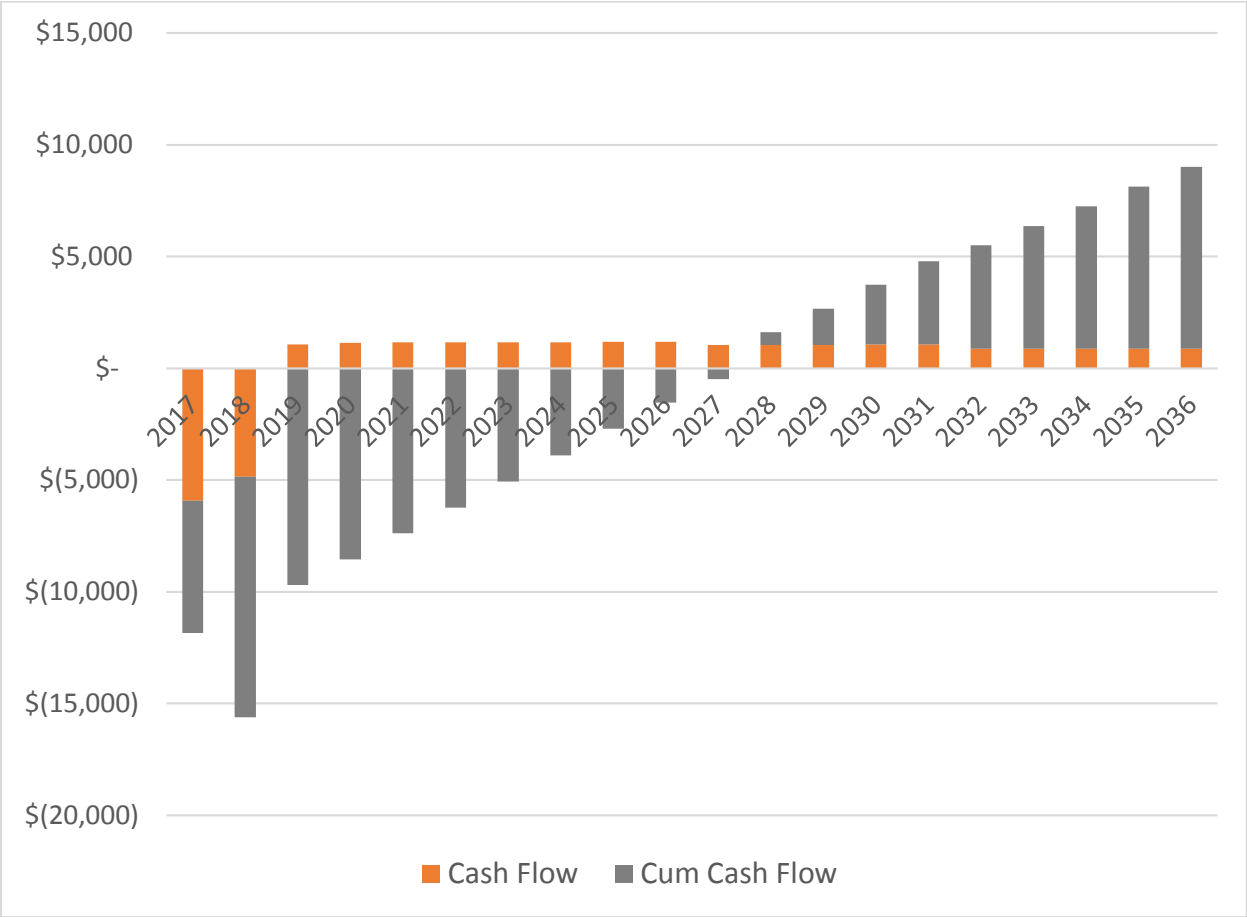
Figure 4: Project Breakeven for Scenario 2 – Self Install ($000)



2. Assumptions

In order to arrive at the business case results, UtiliWorks incorporated economic and project assumptions described in more detail below:

- The City will seek out third party services to host the AMI Headend, MDMS, and Customer Portal applications. Software hosting and maintenance fees are included as future operating expenses.
- 1.5-year deployment for third party installation (Scenario 1)
- 2-year deployment for self-installation (Scenario 2)
- 6-month deployment for add-on programs (Water Distribution Monitoring), which will begin 2 years after AMI project kickoff
- 25% residential water meters will be equipped with remote disconnect capability.

General model assumptions are listed in Table 3.

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Table 3: General Model Assumptions

Description	Assumption
Annual Meter Growth Rate	0.75%
Benefits Growth Rate	1.0%
OpEx Growth Rate	3.0%
Labor Growth Rate	2.5%
Consumption Growth Rate	-0.5%
Software Maintenance Escalation Rate	3.0%
Depreciation Period	20 years
Deployment Period (includes POC)	Scenario 1 - 1.5 years Scenario 2 – 2 years
Discount Rate	2.75%
Total Water Meters	33,760

3. Cost Estimate

UtiliWorks utilizes current vendor pricing to feed the cost model. Cost data are obtained based on recent market quotes from manufactures and suppliers, as well as UtiliWorks vendor database that reflects pricing obtained for recent projects. Some meter pricing was also included that was obtained directly from Lawrence. Given that pricing differs between vendors, UtiliWorks will present a blended price in the financial model. This method is used to ensure that Lawrence is provided with a conservative forecast of project cost and return. Actual pricing is anticipated to be slightly lower than these results, however, until proposals are received, actual project costs cannot be confirmed.

Based on the assumptions used in both scenarios, the total capital outlay is projected to be between $11.7 - $12.8 Million. Table 4 provides a summary of project costs. Note, these costs will not all be realized in the first year, but rather over the designated deployment periods that were discussed in the Assumptions section. Individual costs that make up each cost area can be explored in full detail in Appendix I.

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Table 4: Estimated Project Cost Summary

Cost Area	Scenario 1 Total Capital Cost ($)	Scenario 2 Total Capital Cost ($)	Scenario 1 Annual O&M Cost ($)	Scenario 2 Annual O&M Cost ($)
AMI/MDMS/Professional Services Costs				
AMI Network Infrastructure, Software, and Professional Services	$297,950	$297,950	$32,200	$32,200
MDMS and Customer Portal Software, and Professional Services	$250,000	$250,000	$40,800	$40,800
Program Management, Bus. Process, Integration Services	$1,026,224	$979,663	$0	$0
Utility Project Team	$202,500	$202,500	$234,000	$234,000
Contingency (8%)	$142,433	$142,433	$0	$0
Water Meters/Equipment/Installation Costs				
Meter Box Lids	$1,114,080	$1,114,080	$0	$0
Water Meters, Radios, and Registers	$7,777,191	$7,777,191	$0	$0
Installation Services / Equipment / Software	$1,098,016	$75,000	$0	$8,000
Contingency (8%)	$799,143	$717,302	$0	$0
Distribution System Pressure Sensors				
Pressure Sensor Equipment and Installation	$68,314	$68,314	$4,320	$4,320

4. Benefits Estimate

Lawrence responded to a series of data requests that support the underlying benefits assumptions. This was followed by two rounds of model assumptions and results review with key Utility Staff. All benefits quantified in the financial model are based on the annual operating expenses and capital budget costs for the City. Full details of the Benefits Assumptions can be found in Appendix II.

The estimated total benefits for the entire program range from approximately $27.9 - $28.1 Million for the 20-year forecast period. Both Scenario 1 and Scenario 2 produced the same benefits given that the difference between the two relates only to capital cost. Table 5 below summarizes all benefits areas, the value driver with key calculation assumptions, and value for the first year of full operation.

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Table 5: Project Benefits Summary

Benefit Area	Key Assumption(s)	Annual Benefit ($)
Water AMI/MDMS Deployment Benefits		
Meter Reading Reduction	95% reduction	$276,474
Customer Call Reduction	20% reduction	$9,690
Re-Read Reduction	95% reduction	$33,640
Move in/Move Out Read Reduction	90% reduction	$183,079
Non-Pay Disconnect Reduction	25% reduction in labor + 10% bad debt reduction	$50,530
Billing Expense Reduction	50% reduction of exception handling + 10% reduction of postage and bill printing costs	$234,842
Lower Pumping Costs	0.5% efficiency gain applied to Annual High Service Pumping costs	$2,000
Water Loss Identification	0.25% of 2015 annual consumption + other non-billed water losses	$54,865
Meter Accuracy Improvement Revenue	0.82% improvement applied to 2015 water consumption	$159,770
Wastewater Revenue Recovery	1.07% improvement applied from adjustment to aging water meters + loss identification	$180,193
Meter Scrap Revenue	Scrap value = $0.85/lb.	$74,459
Annual Meter Replacement Savings	83% of budget is replaced by capital costs of new AMI meters, which are already accounted for	$125,242
Distribution System Pressure Sensors		
Annual Savings	25% cost reduction + 10% conservation rate applied to recouped unaccounted for water loss	$136,035

It is important to remember, that while the business case results provide a fairly accurate estimate of the expected project costs and payback, this model represents a conservative estimate of the full value of an AMI project. Please refer to Section D – AMI Benefits (page 22) for an overview of other intangible benefits that are not easily quantified, but can be true benefits of the project.

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Section F - Operational Impacts Analysis

As the Utility transitions to new technology, there will be numerous operational impacts that require identification, definition and planning. Smart metering technology has the potential to touch the entire organization in some fashion. The volume of data that is available to Lawrence will be substantially larger than the norm from current state operations. This increased granularity and sheer volume of data is what opens up new value streams for the Utility, but these areas must be properly managed. A full description of the hardware, network and software that is included with an AMI system can be found in Appendix IV – Utility Operational Technology.

Lawrence has already taken strides to effect departmental changes that will support new roles and day-to-day responsibilities. This foresight will make the AMI deployment and transition to system support and maintenance a more seamless process for the City. If Lawrence elects to proceed with deployment of an AMI solution, the following operational areas will require attention during the next phases of this project:

- Personnel/Human Resources
- Business Process Re-Engineering
- Data/Information Processing

Each of these areas needs to be well defined in order to maximize ROI. The following sections will provide a high-level outline of the types of changes in each area that may be necessary as Lawrence moves forward.

1. Personnel/Human Resources

Once the system is fully deployed, the future state of operations at Lawrence will yield opportunity for new roles within the organization that deal directly with the systems and data from AMI. Lawrence will need to consider contracting, hiring, reassigning, or retraining personnel to support the operation and maintenance of the new technology. This will be addressed throughout the project deployment as new processes are defined. Additionally, much of the project staff can transition into new roles since they will be familiar with the tasks.

The management at Lawrence has already initiated a shift in personnel that will better prepare the City to deploy and support AMI. The City has transitioned all meter reader and technician staff from the Finance Department to the Utilities Department. Additionally, the City hired a new Billing Manager in the Finance Department as a result of the AMI discovery process.

The following is a suggested list of dedicated new roles to be created with the implementation of AMI:

- **Program Manager** - A Program Manager is typically the Project Manager at the Utility involved during the implementation phase. This person will have on-going responsibilities as the 'AMI Project' transitions into an 'AMI Program' during future state operations. The Program Manager will ensure that the proper system oversight and data QA functions are occurring as expected. This role will also keep their finger on the pulse of the AMI system at a higher level and track KPIs that may be monitored as part of future state operations.

- **AMI System Technician** - UWC recommends two (2) FTE resources to perform the tasks as an AMI System Technician. This staffing arrangement allows for a fully trained backup to be readily available, with extensive knowledge of the system. It is not necessary to hire to fill this role if Lawrence can identify internal staff that is interested and capable of fulfilling the responsibilities. These resources will be tasked with understanding the communications network, metering technology, systems and software during deployment in order to train and lead other staff members. Upon completion of full deployment, the AMI Techs will continue in a full time position and maintain focus on identifying, troubleshooting and

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resolving AMI issues, including dispatching field technicians and/or assisting with any field activity that may be required.

- **Data Analyst** - UWC recommends a Data Analyst to support, administer and use the AMI and MDMS system data and reports. This can be performed by one 'super user' or split between resources. It is also recommended to involve these team members throughout project planning and deployment so they are actively involved in the system configuration and training.

- **Billing Manager** - UWC recommends that the City dedicate a business process owner to the CIS and billing function. This individual will act as a focal point for the CIS and ultimately would be responsible for ensuring data integrity in the system and supporting business processes. As of August 2016, Lawrence created and hired this position.

In addition to new roles, there will be reduction and expansion of workload in additional departments. These Departments should consider hiring, reassigning and retraining personnel:

- **AMI Infrastructure O&M** - New equipment in the field for network communications and AMI related equipment such as collectors and backhaul will need to be monitored and maintained. This is commonly performed by those staff responsible for the Communications network or SCADA.

- **Meter Reading** - With the automation of the process, truck rolls to read meters, re-read meters, and perform move in/out reads, will no longer be required. With knowledge of the service territory and billing process, meter readers are well suited to become data analysts or field support staff. The needs of the City will shift to data management and exception handling. This offers the opportunity for retraining the meter reading personnel. It is important to keep key individuals involved in the deployment training activities to ensure that they are engaged on the project and continue to build analytical skills and knowledge of the AMI system.

- **IT Staffing Requirements** - If Lawrence elects to site the hardware and software on premise, there will be a need for dedicated system administration support for the AMI Headend and the MDMS. Vendors also offer a hosted solution that would shift certain system administration duties away from the City. Both options will require that IT staff monitor each database, ensure the interfaces are working properly, and assist the business users with troubleshooting issues that arise.

2. Business Process Re-Engineering

Advanced utility technology is highly integrated and especially sensitive to variances in the quality of data input, which requires adopters to practice strong discipline with regard to data integrity and maintenance processes. Due to the potential for disruption of business processes by technology, Business Process Engineering should commence in the design phase of the project and continue through project completion following a continuous improvement philosophy. Initial efforts during this Assessment to describe and quantify the current state business processes are a baseline for future business process re-design efforts.

Adoption of AMI technology requires significant re-design of current utility business processes to fully satisfy acceptance criteria and expected payback. It is often overlooked in terms of how critical business process design is to the success of any project. UWC recommends that the following business processes, at a minimum, undergo a complete current state process definition and mapping to provide the basis for future state process design:

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- **Move Ins/Move Outs** – Customer Service Representatives (CSRs) will be able to provide a higher level of customer service by scheduling the start and stop of service for customers. Remote meter reading capability will allow CSR's to capture the out/in read for water service with the push of a button. Existing business processes will need to be maintained along with development of new processes to manage remote reads. Decisions and permissions will need to be set up to support the personnel who will be authorized to perform this process from the office.

- **Meter Change Out** – The meter installation and configuration will be a new process due to the addition of AMI equipment. All staff involved in work order generation or completing the activity in the field will need to be trained on a new business process for a meter change out.

- **Billing Process** – The consumption validation process will change by having quality assurance processes set up in the MDM system for meter reads before the CIS receives the data. The AMI and MDM systems will be used earlier on in the data flow to identify missing reads, investigate, and resolve issues. Billing will continue to run its quality assurance processes and will remain as the last line of defense against inaccurate bills going to customers. Billing cycles and timing of reads may be changed upon the implementation of AMI.

- **VEE (Validation, Estimation, Editing) -** The meter reading process will be impacted the most of any business process in that it will require the development of an entirely new process. The management of the consumption data and its quality will become a daily responsibility. Resources will have to be assigned to monitor and manage exception reports to ensure the quality of the data that the billing function depends. The reassignment and training of resources will be crucial for the transition to a network based reading system. New processes will need to be developed for exception investigation and handling.

- **Customer Inquiries (High Bill Complaint)** – If Lawrence elects to implement a fully integrated Customer Portal, CSR's will be able work with customers to help them learn how to access detailed information on their own pertaining to bills, consumption and rates. Even without the deployment of a customer portal, the role of CSRs will move toward education and coaching which will pay dividends for both the Customer and the Utility over time.

- **Service Disconnect for Non-Payment** – Similar to Move-In/Out, CSRs will have the ability to use the capabilities of the system to remotely disconnect/connect service for non-paying customers. Process and policy development will be required to determine the best methodology for performing this activity, the workflow alterations, policy shifts and any other changes will be required to the process.

With more in-depth requirements development during the early stages of the project, other business processes will likely emerge that require adjustments along with identification of new processes that don't currently exist.

3. Data/Information Processing and Reporting

It is important to focus on the data and information that will be captured by the AMI system and stored in the MDMS in order to make the most of the investment. Decisions regarding what to do with the resulting expansion of data available to Utility staff is the most important driver regarding the design and configuration of the system. Both the AMI and MDM systems will offer more robust exception, troubleshooting, and diagnostic reporting options, along with alarms and alerts. However, it will be necessary for Lawrence to invest the time and effort up front to clearly define

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business requirements and understand the respective reporting capabilities of each system in order to maintain a manageable workload.

Specific interfaces will need to be developed via web services or secure FTP. Many systems can handle existing file formats, such as MV-RS, which is a typical meter read file format. The table below illustrates the data exchanges required to support billing and for the successful integration of a typical CIS and an AMI/MDMS.

Table 6: CIS / MDMS Integration

Purpose	File Generation/Source	Destination/Action
Billing Request File	CIS will generate list of meters to be 'read'	MDMS will receive the meter list to know what reads to send to CIS
Billing Response File	MDMS will send meter list that contains reads that have been validated	CIS will receive the meter list with reads to perform billing run
Meter Data Synchronization	CIS will generate list of account/meter changes based on completed service orders	MDMS will receive list and cross-check that meter asset information matches with CIS

As part of an RFP process, UtiliWorks recommends that Lawrence investigate thoroughly the underlying data retention, notifications, reporting and alarm functionality of all considered systems, ask for samples of any preconfigured reports, and verify that the system will facilitate customized development at the user level, if so desired.

Definition of reports and report distribution is a critical dependency to business process engineering. Once deployed, many of the reports will be business critical and will need to be reviewed by the Utility on a consistent, daily basis to ensure system functionality and data integrity. This activity should be undertaken as part of a continuous improvement program to maintain the business systems functionality of the overall system. The responsibilities within Information Processing most closely resonate with the staff that will fill the Data Analyst(s) and AMI Tech roles.

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Section G - Procurement and POC Implementation Plan

1. Procurement

If Lawrence decides to move forward with an AMI Implementation, the selection of the vendor/contractor is a critical step in acquiring a system that meets the business and long term needs of the City. It is important to secure vendors that are the right fit which, ultimately, saves you time and money. Below are some details on the steps to be taken to ensure the right vendor/contractor selection.

A. Requirements Development

UtiliWorks approach to the procurement of technology is premised on the need to identify tight, detailed specifications and requirements. In order to develop these requirements, we recommend conducting discovery and interviews with the project stakeholders to develop specifications based on Lawrence's business goals, objectives, current situation, plans for future changes and other necessary elements. The following topics should be addressed during this phase:

- Procurement Requirements – What are the rules your utility must follow?
- Business Requirements – What challenges/problems must you solve?
- Functional Requirements – What do you want this new technology to do?
- Integration Requirements – How do you want this new technology to interface with other systems?

B. RFP Development

Based on the requirements and functional specifications, an RFP is developed. This comprehensive document provides the vendor community with the essential information to prepare a robust response – specific to Lawrence. The Scope of Work (SOW) is incorporated into your standard RFP contract template and reviewed by all team members (including purchasing and legal) to ensure that the requirements are accurately reflected. If warranted, vendors should be pre-qualified prior to publication in order to narrow the number of responses to those that can truly offer a preferred solution.

C. RFP Management

On average, we recommend that the RFP response period for an AMI procurement last a minimum of six (6) weeks so that the vendor community has ample time to prepare thorough and thoughtful responses. Among the many tasks that must be managed once the RFP is released are: (a) advertising the RFP; (b) setting the agenda and leading a pre-proposal meeting; (c) receiving and responding to vendor questions; and (d) publishing any necessary addenda. This is also the time to prepare for the work in upcoming phases including, but not limited to; the evaluation process and criteria; reference checks; and, vendor contracting approval tasks.

D. Response Evaluation

As the responses are received, the evaluation process starts. Evaluating multiple RFP responses can be complex and time-consuming, especially when it comes to analyzing cost. When lining up the cost proposals side-by-side, it is common to discover that each vendor quote differs in some fashion, making it difficult to perform a direct comparison. This can be minimized by structuring the RFP properly to allow for cost-normalization.

The result of the analysis is a ranking of the proposals based on the City's evaluation criteria and, ultimately concluding on a shortlist of recommended candidates. Preparation is necessary to customize the shortlist meeting agenda and outline any remaining questions for each shortlisted vendor. Following the shortlist interviews and prior to selection is the time to contact references, document their

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experiences and arrange site visits, so that Lawrence may obtain useful feedback on the shortlisted candidates from other water utilities.

As the evaluation process concludes, Lawrence will weigh the pros and cons of each shortlist candidate in order to arrive at a final selection of the optimal solution for the City.

E. Vendor Contracting

Once Lawrence has selected the vendor(s), contract negotiations can begin. This is typically a lengthy endeavor given the cost of the project, the details that need to be captured, and the approval process. UtiliWorks recommends a very thorough review of the vendor proposed SOW by the respective subject matter experts to determine whether the SOW is in compliance with Lawrence's technical requirements. The proposed contract(s) must also have a thorough review by legal and purchasing in order to negotiate terms that are as favorable as possible to Lawrence. It is important to memorialize very specific systems-acceptance criteria, along with detailing the rights and responsibilities of all parties to the contract.

2. POC Implementation Plan

Within the last few years, AMI as a technology has matured. There was a transition period from one-way communications from the meter to a collector to the introduction of two-way communications with the meter. During this transition, utilities were more apt to explore AMI through a working "Pilot". The intent was to test the technology to confirm it worked with the utility's service area configuration/topology/meter population. UtiliWorks advises our clients to take a different approach to AMI design and deployment. Specifically, UtiliWorks recommends a "Proof of Concept" (POC) as a lead-in to full deployment.

The underlying philosophy of a POC is to minimize risk and commit as little project funding as possible while reaching basic system functionality as early as possible in the project. This approach allows Lawrence to work with each vendor to identify and address issues, to test the necessary interfaces with other systems, and to design, develop and test the future state business processes prior to full deployment.

UtiliWorks held a Proof of Concept (POC) planning workshop with Lawrence in order to uncover POC goals and areas for further consideration. The implementation planning section that follows will communicate UWC's recommendation for how the project will be deployed, installed, and transitioned into operation, along with input from the Lawrence team on schedule, coverage area, acceptance criteria and testing. As a secondary goal, the phasing will help the Utility adapt to the new technology and begin to feel comfortable in new roles and/or utilizing new systems prior to full-scale deployment. Quality stage gates with acceptance criteria are utilized in order to gauge progress before proceeding with the next phase. Full detail on the UtiliWorks Advantage methodology can be found in Appendix III.

A. Project Phasing

With an enterprise project of this scope, it is important to measure the effectiveness of the implementation. This section will present suggested project phasing, which is a critical aspect of planning AMI and related systems. Performing work in this manner reduces the risk that the effort does not get off-track or otherwise proceed without the necessary prerequisite steps successfully completed. The business case, as presented, assumes a deployment duration ranging from 1.5 (installation contractor) to two (2) years (self-install) which can be adjusted depending on project financing, resource availability and other variables specific to Lawrence. The following sections describe the phases in more detail.

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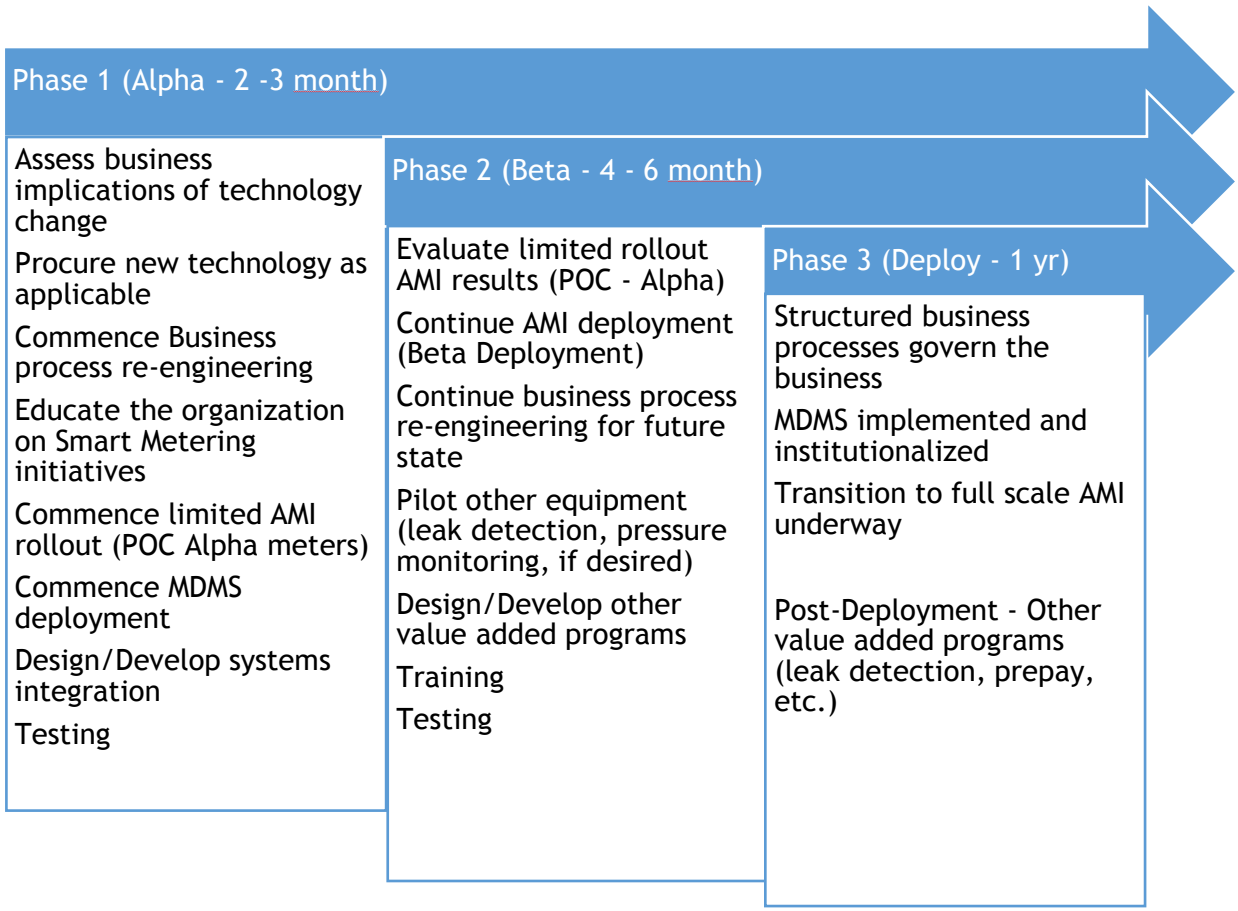
Figure 5: AMI Project Phases



i. Alpha Phase

The Alpha development phase begins with the "back end" of the system. A limited amount of metering hardware is deployed in a controlled environment during this phase (i.e., meter shop test bench). During the Alpha phase, any work required to create the backhaul infrastructure is coordinated and completed in preparation for the Beta phase of deployment. The phase also involves installation of the supporting systems, most typically the AMI headend and MDMS. Focus is dedicated on the integration of meter data from the AMI headend to the MDMS and back to the CIS. The goal is to produce a bill from automated meter data at the beginning of the Beta phase of development.

To minimize risk, the Utility plans to deploy a collector and handful of meters on a modified test bench in their warehouse. This test bench will be maintained as a "Meter Shop" for all future meter testing. Lawrence plans to test at least one remote disconnect meter, in addition to several standard water meter sizes. This setup will simulate the data streams of field-deployed meters in Beta and later phases. A quality gate exists at the end of the Alpha phase, specifying objective criteria to complete the Alpha phase and commence the Beta phase. Key Alpha phase requirements are outlined in Table 7.

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Table 7: Key Alpha Phase Requirements

1	Finalize identification of all collector sites and propagation study
2	Install and thoroughly test all functionality of 10-12 meters, radios, and equipment in meter shop (including RDM)
3	Installation and certification of Alpha collector(s)
4	Install and configure AMI headend and MDMS software to satisfy Alpha requirements
5	Foundational integration of AMI -> MDMS -> CIS
6	Integration and testing of Lucity or CIS and installation contractor's Work Order Management System

Based on feedback from Utility Staff and experience with similar sized deployments, UtiliWorks expects a 2-3-month Alpha phase for Lawrence. This is an opportune time to have the City's field staff train with an AMI vendor to learn about the new meter equipment and system diagnostics of collectors, endpoints, and other AMI network equipment that is deployed.

ii. Beta Phase

The AMI Beta phase begins with field deployment of a pre-determined quantity of metering hardware and the balance of the backhaul network infrastructure. Since the Beta phase cannot be entered into without a successful completion of the Alpha phase, basic meter reading functionality is available immediately. The goal of the Beta phase is to deploy remaining communications infrastructure, deploy a small meter population in the field, complete remaining systems integration, and streamline the communications process for work orders assigned to the installation contractor. During Beta, allowing routes to be moved to automated billing immediately upon route acceptance will be available, should Lawrence decide to do so.

As of the publish date of this report, the Beta POC has not been confirmed. Utility Staff stated their preference to include the Oread neighborhood for the Beta POC area; however, meter readers have suggested other areas that may be more desirable. The Oread neighborhood is located on a hill near KU and includes a variety of residence types (i.e. apartments with deduct meters, and single family homes). The Utility will also consider including a high-use customer, such as one of its serviced RWDs, for Beta POC coverage. The City will target less than 10% of the meter population, or approximately 2,000 meters for inclusion in the Beta deployment.

Because this is the first time meters will be deployed to customer locations, it is also a critical time to begin deployment of a Public Relations (PR) campaign to be developed by the City's Public Information Officer. The Utility's PIO will want to engage with the City to determine a strategy for messaging all communications related to the AMI deployment, and detail a PR plan for how and when to communicate with affected customers and internal stakeholders.

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Beyond the physical meter deployments, business process changes and improvements are tested during this Beta phase as well. Providing training prior to deployment, ensures all processes are debugged, provides the users time to adjust to new processes and procedures, and builds a familiarity with the new systems and methods to be employed during Future State operations. For an overview of which business processes UWC recommends including in this effort, see Section F – Operational Impacts. Several of these areas may be dependent on changing Utility policies as well. The CSR, Billing, and Field staff will need to understand opt-out, remote disconnect, and soft-off policies if these are to be offered as part of the changing business practices in an AMI project.

During the Beta phase, additional functionality is added and tested in stages, with the goal to complete system integration and documentation activities prior to user training and system acceptance testing phases. User training runs parallel with the end of the Beta phase, typically beginning approximately two months before the end of Beta. The goal of the user training phase is to provide a competent workforce that understands the concepts and operations of the newly deployed systems and methods. Another quality gate exists at the end of the Beta phase, which allows passage into the System Acceptance Test phase.

The Beta development phase is completed with System Acceptance Testing conducted by the Utility to verify that all requirements have been met by the deployed system. With support of UtiliWorks, City Staff work through all of the user scenarios factored into the system design through the use of test scripts, which are signed off and entered into the testing log, with errors and bugs being logged and resolved, then re-tested until complete. The successful end of a System Acceptance Test results in product acceptance and is the gateway to Full Deployment. Key Beta phase requirements are listed in Table 8.

Table 8: Key Beta Phase Requirements

1	Replace/retrofit 2,000 target meters in Beta POC area
2	Develop and test balance of systems interfaces
3	Develop and test Future State Business Processes (including any new policies/procedures)
4	Install, configure, test customer portal
5	End user training complete
6	User Acceptance Testing (UAT) complete/passed
7	Installation QA Procedure completed
8	99.5% meter read reporting within 3 days

Based on feedback from Utility Staff and experience with similar sized deployments, UtiliWorks expects a 4 – 6-month Beta phase for Lawrence. Consideration should be given to weather conditions for a start date, due to possible snow and ice. Staff will also be busy during the "KU rush" period from late May to August. The Beta phase is an opportune time to have the City's field staff train with contract installation crews to learn how to perform change outs and identify communication, or data-related issues in the field.

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iii. Full Deployment Phase

With all of the planning, preparation, testing, and training complete, full deployment is managed more like a construction project in contrast to the POC. The assumption is that full system functionality is available, with route acceptance to switch a meter from manual to AMI reads for billing. This approach has several advantages, including pushing back warranty start dates until functionality can be used, and the ability to realize the full benefit of deployed devices from the moment they are installed.

This phase should have the same weather and busy period considerations applied to planning as in Beta. The duration of this phase will hinge on Lawrence's decision on how many meters to self-install. If an installation contractor is used, it is anticipated that they could complete full meter change out within one (1) year. Full Deployment that is handled by an installation contractor is managed with the intent to minimize interruption to daily business processes in the back office. Regardless of whether Lawrence uses a third party, they will elect to retrofit the large C&I customer meters, since most of these are less than 15 years old.

Lawrence staff must play an active role in monitoring data and equipment installation quality throughout full deployment. Keys to full deployment success include the accurate recording and timely delivery of serial numbers, out reads, various meter characteristics, geographic co-ordinates, digital pictures, and install notes to the appropriate Departments and systems.

B. City-Owned Facilities and Assets

Lawrence has several assets that are suitable for the necessary AMI communications equipment. Priority locations include water towers, which will all have fiber by the early 2017. City-owned traffic signals are also a viable option for placement of equipment. Permits may be required from the Planning Department in order to perform installation. City staff will be available to help with site preparations and permitting as required.

During the POC Phase, there will be facility requirements to stage the deployment and house meter inventory. The Utility has an enclosed, gated area near the KAW WTP for which a vendor could be granted access. This space may be utilized for parking vehicles and staging equipment for installation. However, no physical building exists in this location. The addition of a temporary building for staging and warehousing will need to be included in an installation contractor's proposal for completing this work.

Whether Lawrence chooses to self-deploy after the initial POC phases or not, there will be significant warehouse space requirements for the pace at which the City hopes to deploy. Based on current plans, approximately 3,000 meters will be deployed each month during the Full Deployment phase.

C. Project Staffing

Some business cases depend on a relatively quick deployment of features. For example, decreasing the time required to deploy AMI endpoints can accelerate the ROI. Even in the largest utility, rapid deployment can place tremendous strain on internal staff already dedicated to existing business functions. UtiliWorks recommends that you actively engage staff from customer service to billing, engineering, IT, meter shop, operations/maintenance, and field services throughout the effort. Buy in and support is needed from the top down to ensure an efficient discovery process and smooth deployment. Staff augmentation is also a consideration given the added strain on resources already dedicated to existing business functions.

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In addition, the creation of a formal Steering Committee that meets periodically to address issues that are unresolved or blocked is critical given the multiple participants and organizations involved.

Based on UtiliWorks experience with the deployment of AMI technology, the roles discussed below are critical to facilitate project success. Table 9 provides a rough estimate of time required for each role; however, it should be noted that these estimates can vary.

Executive Project Sponsor (Internal)

In order to achieve success for any large-scale project, an Executive Project Sponsor is necessary to drive the initiative internally and lead the organization to achieve the project's vision. The Executive Project Sponsor should have overall responsibility of the project and have authority over project team members in order to ensure project management is on track and achieving project objectives. Upon project completion, the Executive Sponsor should stay engaged with the dedicated AMI staff and tangential business process leads to understand the success of the Project. This role should also strive to stay current on new technology or capabilities of the AMI system.

Program Manager (External)

A Program Manager experienced in leading complex integration projects is strongly recommended. This role is often contracted to a third party as the experience of repeated similar projects is often difficult to find within the utility. The Program Manager will engage with all teams involved in deployment and integration efforts during the anticipated project duration.

Project Manager (Internal)

A Project Manager within the Utility is recommended to drive the completion of efforts within the Utility and coordinate with the Program Manager and vendors to maintain project continuity. Post-implementation, the PM's duties will decrease. However, there will be ongoing duties related to Executive Level reporting and system oversight once the project is completed. This future workload should be considered when selecting a Project Manager internally.

Systems Integration Specialist (External)

With the deployment of AMI, systems integration is always a requirement to ensure the Asset Management/CIS/MDMS/AMI headend systems are synchronizing as anticipated. Although vendors provide some integration services, Lawrence will require an IT Integration resource to perform the required legacy utility-system interface development to support the project effort. It is anticipated this support will be required for approximately six (6) months during planning, design and POC implementation.

Communications Network Engineer (Internal)

This role will be responsible for working with the AMI vendor to design, implement and administer backhaul communications (and the underlying security) going forward with the AMI system. Some duties will likely include review of propagation studies for data collector deployment, establishing VPN access for vendors and modem configuration. It is anticipated this support will be required for approximately six (6) months during planning, design and POC implementation.

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Subject Matter Experts (SMEs)

Beyond those team members that are specified above, Lawrence will need to identify appropriate staff members from across the organization to represent their respective functional area and participate in workshops and meetings to support project implementation. Activities will include: weekly or bi-weekly project status meetings, design and planning discussions, coordination of meter and communication network installation, business process re-engineering, procedural development, training, system testing, quality assurance, and public relations campaigns. While utility staffing requirements will ebb and flow during the project, Lawrence can anticipate that SMEs will be involved throughout the planning phase and POC. Many of the SMEs will continue on in roles that are identified and discussed in Section F – Operational Impacts.

Table 9: Estimated Project Resource Requirements

Role	Avg. Time Commitment
Executive Project Sponsor	3 hrs./week
Program Manager (Consultant)	30 hrs./week
Project Manager	25 hrs./week
IT Integration Specialist	20 hrs./week
Communications Network Engineer	8 hrs./week
Subject Matter Experts (SME)	4 to 20 hrs./week

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Section H - Recommendations and Next Steps

1. Recommendations

Based on our discovery efforts and findings, Lawrence appears to be well informed of the technology and well equipped to proceed with an AMI project. This conclusion is further supported by a positive business case that we also believe is conservative relative to the benefits that can be realized with a well-designed AMI program. UtiliWorks believes the estimated benefits used in the AMI business case are very conservative and expects that a far greater return on investment can be realized.

Key recommendations are outlined below:

- UtiliWorks recommends that the City actively engage staff from across the organization throughout this effort. Buy-in and support is needed from the top down to ensure an efficient discovery process and smooth deployment.
- A plan and timeline to address CIS related issues as identified in Section C should be developed to understand potential impacts to an AMI deployment timeline.
- As discussed in Section G, UtiliWorks recommends a phased approach to deployment including a Proof of Concept to establish complete systems integration, training, new/revised business processes, and system acceptance prior to full deployment.
- Overlapping the POC, Lawrence will need to establish a Public Relations campaign to inform and educate customers of the coming changes and benefits they will realize from the program.
- A clear understanding of the ability of your staff to support the project as well as the ongoing operation and maintenance of the system will be valuable. Consider staff augmentation during the project given the added strain on resources already dedicated to existing business functions.
- Consider hiring, reassigning, or retraining personnel to support the operation and maintenance of the new technology once deployed.

Additionally, Lawrence is interested in pursuing add-on technology, such as distribution system pressure monitoring and a Pre-pay system, once the AMI Program is fully established. The data from the AMI system will provide basic decision support to the City for future project investments in these and other technology areas.

2. Next Steps

UtiliWorks recommends the following steps leading up to implementation for Lawrence to realize the benefits of an AMI system deployment:

1. Go/No Go decision
2. Seek City Manager and Council approval to proceed
3. Form internal project team with clear roles and responsibilities
4. Requirements Development – UtiliWorks can assist in taking this feasibility study a level deeper with the identification and documentation of the City's business and system requirements for an AMI system. The requirements that are developed with the City will be incorporated into the RFP(s) and provide the vendor community with the necessary information to prepare a robust response.

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5. System(s) Procurement – Procurement starts with the drafting and publishing of a comprehensive RFP to solicit proposals from equipment, systems, integration, and/or professional services vendors through to vendor(s) contracting. The steps include:
    a. Develop evaluation criteria to ensure an objective review of all proposals submitted
    b. RFP administration such as coordination of the Pre-proposal meeting and vendor questions
    c. Perform due diligence to arrive at a "short list" of candidates who are invited to the City to present their solution
    d. Perform reference checks and site visits
    e. Final scoring of "short list" candidates
    f. Vendor(s) selection
    g. Development of detailed system acceptance criteria to be memorialized in the executed contract(s)

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Appendix I – Capital Cost Estimate

Scenario 1 – Base Case Cap Ex

Water AMI / MDM	Quantity		Price		Total	Cost Start	Cost End
AMI							
AMI Head End Software License Fee	1	$	15,000	$	15,000	1/1/2017	6/30/2017
Network Infrastructure (Collectors, Repeaters, etc.)	1	$	150,000	$	150,000	1/1/2017	6/30/2017
AMI Water Meters, Registers, Endpoints & Lids							
Water Meter Lids - Replace	33,760	$	33.00	$	1,114,080	1/1/2017	6/30/2018
Hand Held Programmer	3	$	2,650.00	$	7,950	1/1/2017	1/31/2017
Water Meter Endpoints	33,760	$	90.00	$	3,038,400	1/1/2017	6/30/2018
5/8 inch	21,267	$	110.00	$	2,339,370	1/1/2017	6/30/2018
3/4 inch Remote Shutoff	5,403	$	300.00	$	1,620,825	1/1/2017	6/30/2018
1 inch	1,336	$	220.00	$	293,920	1/1/2017	6/30/2018
1 1/2 inch	70	$	550.00	$	38,500	1/1/2017	6/30/2018
2 inch	86	$	700.00	$	60,200	1/1/2017	6/30/2018
3 inch Turbine	16	$	530.00	$	8,480	1/1/2017	6/30/2018
4 inch Turbine	10	$	1,530.00	$	15,300	1/1/2017	6/30/2018
6 inch Turbine	-	$	3,735.00	$	-	1/1/2017	6/30/2018
8 inch	-	$	3,955.00	$	-	1/1/2017	6/30/2018
10 inch	-	$	5,239.50	$	-	1/1/2017	6/30/2018
Retrofit Registers	5,572	$	65.00	$	362,196	1/1/2017	6/30/2018
AMI Meter Installation Option							
Water Meter Exchange	28,188		$35.00	$	986,571	1/1/2017	6/30/2018
Water Meter Retrofit	5,572		$20.00	$	111,445	1/1/2017	6/30/2018
MDMS + Customer Portal Software							
MDMS + Customer Portal Software License Fee	1	$	100,000	$	100,000	1/1/2017	6/30/2017
Professional Services							
Program Mgt, Business Process/Change Mgt, Syste	1	$	1,026,224	$	1,026,224	1/1/2017	6/30/2018
AMI Vendor	1	$	125,000	$	125,000	1/1/2017	8/31/2017
MDMS Vendor	1	$	150,000	$	150,000	1/1/2017	8/31/2017
Other Costs - AMI							
Utilities PM	0.50	$	120,000	$	60,000	1/1/2017	6/30/2018
PR Campaign	1.00	$	75,000	$	75,000	1/1/2017	12/31/2017
Server	-	$	50,000	$	-	1/1/2017	6/30/2018
IT Integration 1/4 Time	0.25	$	150,000	$	37,500	1/1/2017	8/31/2017
Communications Network Engineer	0.25	$	120,000	$	30,000	1/1/2017	8/31/2017
Contingency	8%			$	925,077	6/1/2017	5/31/2018
Other 2				$	-		
Other 3				$	-		

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Water Distribution Pressure Sensors									
	Quantity		Price		Total		Cost Start	Cost End
Water Distribution Pressure Sensors									
Mobile Pressure Sensors (Hydrant)	10	$	2,225.00	$	22,250		1/1/2019	6/30/2019
Static Pressure Sensors (Pit Mounted)	8	$	2,933.00	$	23,464		1/1/2019	6/30/2019
Set up Fees	18	$	50.00	$	900		1/1/2019	6/30/2019
Software	1	$	10,490.00	$	10,490		1/1/2019	6/30/2019
Other Costs								
Installation	-	$	-	$	-		1/1/2019	6/30/2019
Professional Services	1	$	5,000.00	$	5,000		1/1/2019	6/30/2019
Contingency	10%			$	6,210		1/1/2019	6/30/2019

Scenario 1 – Base Case Op Ex

Water AMI / MDM								
	Quantity		Price		Total		Cost Start	Cost End
AMI Operations / Hosting Fees								
AMI Network Operations Fee	1	$	5,000	$	5,000		1/1/2018	N/A
Annual AMI Headend System Hosting Fee (SaaS)	1	$	27,200	$	27,200		1/1/2018	N/A
MDMS / Portal Support and Hosting Fees								
Annual MDMS / Portal Hosting Fee (SaaS)	1	$	40,800	$	40,800		1/1/2018	N/A
Other	1	$	-	$	-		1/1/2018	N/A
Utility Costs								
AMI System Technician (fully burdened)	2	$	72,000	$	144,000		1/1/2018	N/A
Data Analyst (fully burdened)	1	$	90,000	$	90,000		1/1/2018	N/A

Water Distribution Pressure Sensors								
	Quantity		Price		Total		Cost Start	Cost End
Annual Fees								
Annual Hosting Fee	1	$	4,320	$	4,320		1/1/2020	N/A
Utility Costs								
""	-	$	-	$	-		1/1/2020	N/A

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Scenario 2 – Self-Install Cap Ex

Water AMI / MDM	Quantity		Price		Total	Cost Start	Cost End
AMI							
AMI Head End Software License Fee	1	$	15,000	$	15,000	1/1/2017	6/30/2017
Network Infrastructure (Collectors, Repeaters, etc.)	1	$	150,000	$	150,000	1/1/2017	6/30/2017
AMI Water Meters, Registers, Endpoints & Lids							
Water Meter Lids - Replace	33,760	$	33.00	$	1,114,080	1/1/2017	12/31/2018
Hand Held Programmer	3	$	2,650.00	$	7,950	1/1/2017	1/31/2017
Water Meter Endpoints	33,760	$	90.00	$	3,038,400	1/1/2017	12/31/2018
5/8 inch	21,267	$	110.00	$	2,339,370	1/1/2017	12/31/2018
3/4 inch Remote Shutoff	5,403	$	300.00	$	1,620,825	1/1/2017	12/31/2018
1 inch	1,336	$	220.00	$	293,920	1/1/2017	12/31/2018
1 1/2 inch	70	$	550.00	$	38,500	1/1/2017	12/31/2018
2 inch	86	$	700.00	$	60,200	1/1/2017	12/31/2018
3 inch Turbine	16	$	530.00	$	8,480	1/1/2017	12/31/2018
4 inch Turbine	10	$	1,530.00	$	15,300	1/1/2017	12/31/2018
6 inch Turbine	-	$	3,735.00	$	-	1/1/2017	12/31/2018
8 inch	-	$	3,955.00	$	-	1/1/2017	12/31/2018
10 inch	-	$	5,239.50	$	-	1/1/2017	12/31/2018
Retrofit Registers	5,572	$	65.00	$	362,196	1/1/2017	12/31/2018
AMI Meter Installation Option							
Water Meter Exchange	28,188		$0.00	$	-	1/1/2017	12/31/2018
Water Meter Retrofit	5,572		$0.00	$	-	1/1/2017	12/31/2018
MDMS + Customer Portal Software							
MDMS + Customer Portal Software License Fee	1	$	100,000	$	100,000	1/1/2017	6/30/2017
Professional Services							
Program Mgt, Business Process/Change Mgt, Systems Integration	1	$	979,633	$	979,633	1/1/2017	12/31/2018
AMI Vendor	1	$	125,000	$	125,000	1/1/2017	8/31/2017
MDMS Vendor	1	$	150,000	$	150,000	1/1/2017	8/31/2017
Other Costs							
Utilities PM	0.50	$	120,000	$	60,000	1/1/2017	12/31/2018
PR Campaign	1.00	$	75,000	$	75,000	1/1/2017	12/31/2017
Server	-	$	50,000	$	-	1/1/2017	6/30/2018
IT Integration 1/4 Time	0.25	$	150,000	$	37,500	1/1/2017	8/31/2017
Communications Network Engineer	0.25	$	120,000	$	30,000	1/1/2017	8/31/2017
Contingency	8%			$	833,508	6/1/2017	12/31/2018
MWFM Software	1	$	75,000	$	75,000	1/1/2017	3/31/2017
Other 3	-	$	-	$	-		

Water Distribution Pressure Sensors	Quantity		Price		Total	Cost Start	Cost End
Water Distribution Pressure Sensors							
Mobile Pressure Sensors (Hydrant)	10	$	2,225.00	$	22,250	1/1/2019	6/30/2019
Static Pressure Sensors (Pit Mounted)	8	$	2,933.00	$	23,464	1/1/2019	6/30/2019
Set up Fees	18	$	50.00	$	900	1/1/2019	6/30/2019
Software	1	$	10,490.00	$	10,490	1/1/2019	6/30/2019
Other Costs							
Installation	-	$	-	$	-	1/1/2019	6/30/2019
Professional Services	1	$	5,000.00	$	5,000	1/1/2019	6/30/2019
Contingency	10%			$	6,210	1/1/2019	6/30/2019

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Scenario 2 – Self-Install Op Ex

Water AMI / MDM	Quantity		Price		Total	Cost Start	Cost End
AMI Opex / Hosting Fees							
AMI Network Operations Fee	1	$	5,000	$	5,000	1/1/2018	N/A
Annual AMI Headend System Hosting Fee (SaaS)	1	$	27,200	$	27,200	1/1/2018	N/A
MDMS / Portal Opex / Hosting Fees							
Annual MDMS / Portal Hosting Fee (SaaS)	1	$	40,800	$	40,800	1/1/2018	N/A
MWFM Opex Fees							
MWFM Software Maintenance Fees	1	$	8,000	$	8,000	1/1/2018	N/A
Utility Costs							
AMI System Technician (fully burdened)	2	$	72,000	$	144,000	1/1/2018	N/A
Data Analyst (fully burdened)	1	$	90,000	$	90,000	1/1/2018	N/A

Water Distribution Pressure Sensors	Quantity		Price		Total	Cost Start	Cost End
Annual Fees							
Annual Hosting Fee	1	$	4,320	$	4,320	1/1/2019	N/A
Utility Costs							
""	-	$	-	$	-	1/1/2019	N/A

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Appendix II – Benefits Assumptions

Scenario 1 & 2

Water AMI / MDM			Benefit Start	Benefit End
Meter Reading		Yes		
Meter Reading Cost	$	291,025		
Meter Reading Cost Reduction		95%		
Annual Savings	**$**	**276,474**	1/1/2018	N/A
Call Center - Bill Complaints and Questions		Yes		
Call Center Expense (Annual)	$	48,448		
Expense Reduction		20%		
Annual Savings	**$**	**9,690**	1/1/2018	N/A
Re-Read Reduction		Yes		
Re-Read Costs per year	$	35,411		
Re-Read Truck Rolls Reduced		95%		
Annual Savings	**$**	**33,640**	1/1/2018	N/A
Move In/Out Reads & Shut Offs		Yes		
Move In/Out Cost (Reads & Shut Offs)	$	203,421		
Reduced Truck Rolls to Collect Reads & Shut Offs		90%		
Annual Savings	**$**	**183,079**	1/1/2018	N/A
Non Pay Disconnect (Remote disconnect)		Yes		
Disconnect / Reconnect Labor Cost	$	139,137		
Disconnect / Reconnect Labor Cost Reduction		25%		
Bad Debt (Annual)	$	157,460		
Bad Debt Reduction		10%		
Annual Savings	**$**	**50,530**	1/1/2018	N/A
Billing Expense Reduction		Yes		
Billing Expense	$	712,806		
% time spent on validation, re-reads, analysis for billing reads		60%		
Reduction of Exception Handling, Billing Issues		50%		
Postage and Bill Printing	$	210,000		
Reduction of Postage and Bill Printing Cost		10%		
Annual Savings	**$**	**234,842**	1/1/2018	N/A
Lower Pumping Costs (i.e., Electricity Costs)		Yes		
Annual High Service Pumping Costs	$	400,000		
Electricity Cost Savings		0.5%		
Annual Savings	**$**	**2,000**	1/1/2018	N/A
Revenue Capture from Aging Water Meters		Yes		
Invoiced water (annual $)	$	15,946,131		
Inaccurate meter reading %		1.50%		
# meters older than 10 years to be replaced		28,188		
Total Meters		33,760		
Improvement		80.0%		
Annual Revenue Recapture	**$**	**159,770**	1/1/2018	1/1/2032
Water Loss Identification		Yes		
Estimated Annual Water Meter Tampering Cases		3		
Invoiced water (annual $)	$	15,946,131		
Theft Impact total consumption (AWWA average)		0.250%		
Other non-billed water losses (meter malfunctions)	$	15,000		
Annual Savings	**$**	**54,865**	1/1/2018	N/A
Wastewater Revenue Recovery		Yes		
Invoiced Wastewater ($/year)	$	17,991,437		
Revenue Recapture % based aging water meters/loss ID		1.25%		
Annual Revenue Recapture	**$**	**180,193**	1/1/2018	N/A
Water Meter Scrap Value		Yes		
Total Residential Meters		26,670		
Total Commercial Meters		1,518		
Residential Meter Weight (lbs)		3		
Commercial Meter Weight (lbs)		5		
Scrap Value per lb.	$	0.85		
One Time Trade In Revenue	**$**	**74,459**	1/1/2017	6/30/2018
Annual Meter Replacement Budget		Yes		
Average Annual Water Meter Replacement Budget	$	150,000		
Reduction Rate		83%		
Annual Savings	**$**	**125,242**	1/1/2017	N/A

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Water Distribution Pressure Sensors				
			Benefit Start	Benefit End
Water Distribution Pressure Sensors		Yes		
O&M cost related to water leaks (2015)	$	335,000		
Cost reduction		25.0%		
Total Cost of Water Produced + Purchased - 2015	$	5,228,484		
Unaccounted for Water		10.0%		
Conservation Rate		10.0%		
Annual Savings	**$**	**136,035**	1/1/2019	N/A

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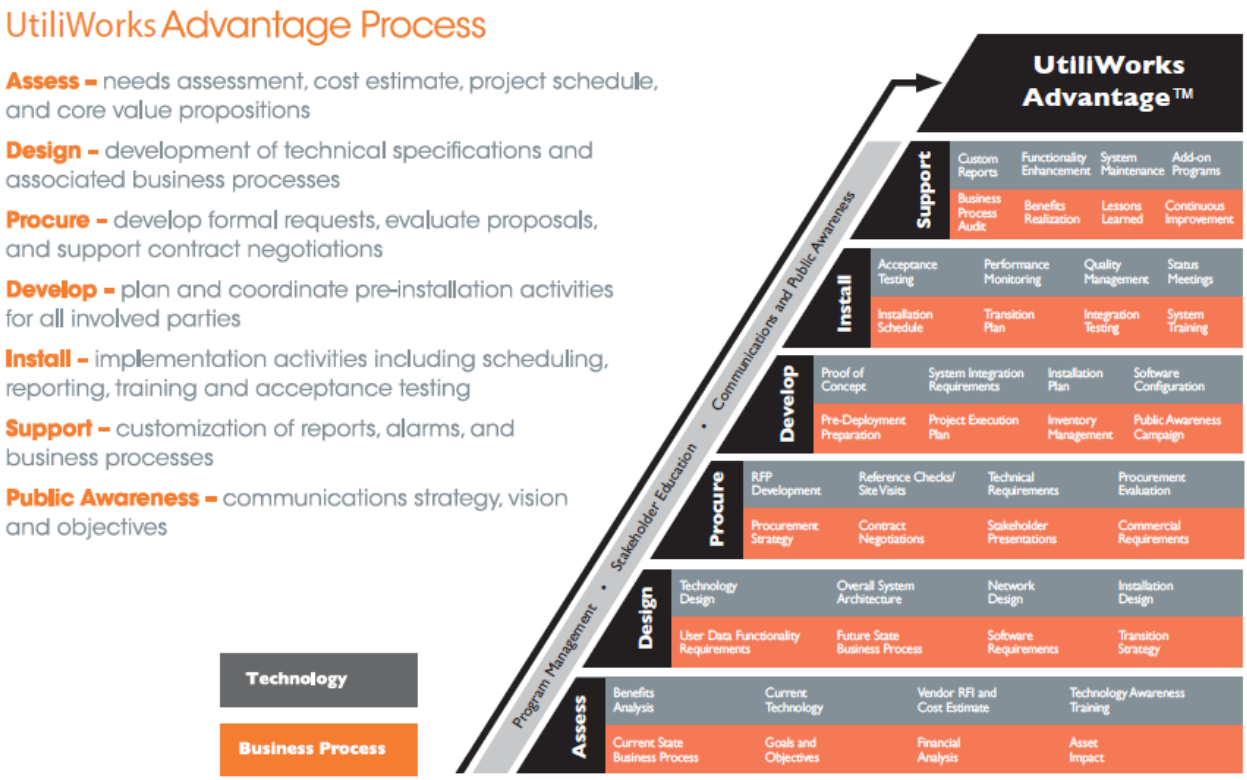
Appendix III – AMI Implementation Methodology

In order to effectively deploy complex technology, such as an AMI system, it is critical to have a well-devised implementation plan. UWC has developed a proven delivery mechanism for complex, technology implementations called the UtiliWorks Advantage™. This approach was specifically designed to clearly identify the project steps and highlight the inherent dependencies between technology and business process. The steps in this process are outlined in Figure 6.

Figure 6: UtiliWorks Advantage



This report is designed to meet the requirements of Step One – *Assess*. The feasibility study provides the first go/no-go decision point on whether to proceed with future project development.

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Appendix IV – Utility Operational Technology

During the last few decades, Operation Technology (OT) and Information Technology (IT) have been managed as two different domains by most industries, including utilities. However, as connectivity and real-time data becomes more prominent in the last few years, OT has started to adopt IT-like technologies. This convergence of IT and OT is expected to enhance performance and operational flexibility with the better optimization of data. Utilities in particular, can gain the most benefits in converging IT and OT. Water utilities require huge investment in infrastructure with many of these assets underground and in hard to reach locations. Controlling and monitoring these assets requires a network of utility workers to take readings, adjust pumps, control valves, and read meters.

Utilities have greatly improved their operational efficiencies through the combination of OT and IT in the form of SCADA systems. SCADA systems provide monitoring and control capabilities to towers, pump stations and control valves. They also provide analytical capabilities for operators to better understand system performance and identify trends and issues.

Utility metering was traditionally part of the OT world – while utility billing was traditionally part of the IT world. Now with advanced metering infrastructure, these two functions can be connected, bringing an end-to-end smart metering (meter-to-bill) to produce bills and provide information and insight into customer usage. Like SCADA did for water treatment and distribution, smart metering can do for customer service, billing and meter operations. Further, information from SCADA and advanced metering can provide new insights into system operations. This section provides a description of the relevant technologies that are transforming utility operations and improve performance and service to utility customers.

1. Water Metering Technology

A. History

Water metering has been conceptualized and thought of since the early nineteenth century, along with the growth of urbanization and industrialization. However, the application of successful water metering may have just started in the 1890s. The early water meters are read manually and are the traditional mechanical water meters. With the development of technology, water meter reading have been evolved from manual meter read, handheld meter reading, drive-by mobile reading, up to remote mobile reading with two-way communications capability. The water meter types itself have also expanded to include non-mechanical water meters as well. The benefits that can be realized with a two-way communication network between a water utility and its water meters via AMI have contributed to the demand for new water meter functionality. The water meter is not only a water consumption measuring device, but can also function as water leak detection point, or water pressure monitor.

An illustration of the water meter reading technology timeline is presented below:

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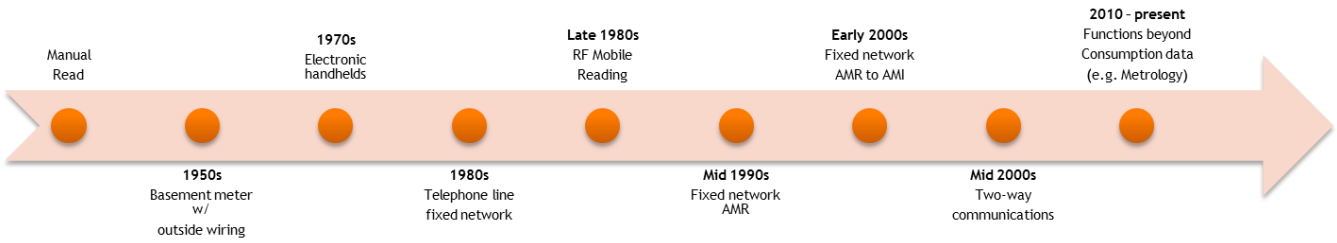
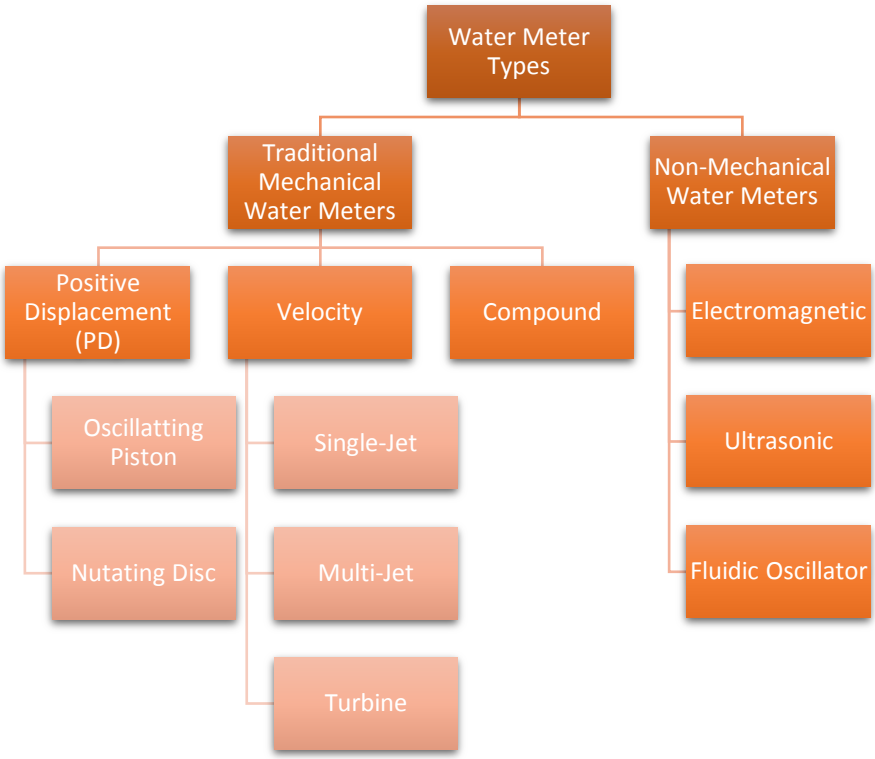
Figure IV.1: Water Meter Reading Technology Timeline



iv. Water Meter Types

The various water meter types available in the market, based by its flow-reading principal, can be categorized in the following chart.

Figure IV.2: Water Meter Types Breakdown by Flow-Reading Principal



a. Traditional Mechanical Water Meters

In mechanical water meters, the "mechanical" refers to the measuring element that is located inside the water meter compartment, which is being moved mechanically by the water flow which triggers the reading counter. Mechanical water meters can be separated into three different categories: positive displacement (PD) meters, velocity meters, and compound meters.

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Positive Displacement (PD) Meters

PD meters rely on the water flow to physically displace the moving measurement element in direct proportion of the amount of water flowing through the meter. The movement of the measuring element in part moves the magnet that drives the register dial.

Oscillating Piston

Oscillating or reciprocating pistons are assumed to be the oldest PD meters' design. They are available with multiple pistons, double-acting pistons, or rotary pistons. They are typically used in viscous fluid services such as oil metering, but can be used for residential water service and will pass a limited quantities of fine sand (200 mesh/74 µm). Oscillating piston flow meters are available in 1/2" to 3" sizes, and can measure flow rates from 1 to 65 gpm in continuous service with intermittent excursions to 100 gpm.

Water is drawn into one piston chamber, and discharged from the opposed piston in the meter. The pistons are cylindrical in shape and is punctured by numerous openings to allow free flow of the water. The measurement chamber is also cylindrical with a partition plate separating inlet and outlet. The piston, guided with a control roller within the measuring chamber, is moved by the water flow and the motion is transferred to a follower magnet (external to the flow stream). This magnet then drives a register, a transmitter, or both.

The internal parts of this flow meter can be removed without the disconnection of the meter from the water pipeline. These type of meters do require regular maintenance, to maintain the piston seal and to reduce slippage.

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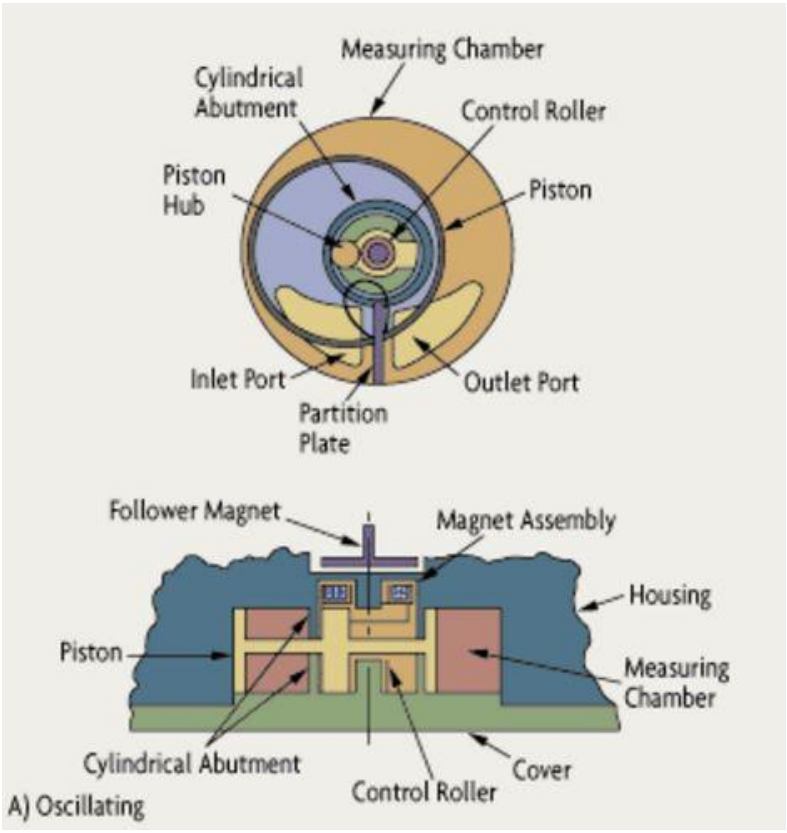
Figure IV.3: Oscillating Piston Meter Diagram



Nutating Disc

Nutating disc water meters are the most common PD meters and they are specifically designed for water service. Nutating disc meters are available in 5/8" to 2" sizes, suited for 150-psig operating pressure.

Water that comes through the metering chamber causes the disc to "wobble" (nutate) that turns a spindle, which rotates a magnet. This magnet then drives a register, a transmitter, or both. The rate of flow is proportional to the rotational velocity of the spindle because the flowmeter entraps a fixed quantity of fluid each time it is rotated.\

The meter housing is usually made of bronze because it must be nonmagnetic but can also be made with plastic for corrosion prevention/cost savings. Nutating disc water meters are specifically designed for water service, and meters with rubber discs will give better accuracy than metal discs due to the better sealing it provides.

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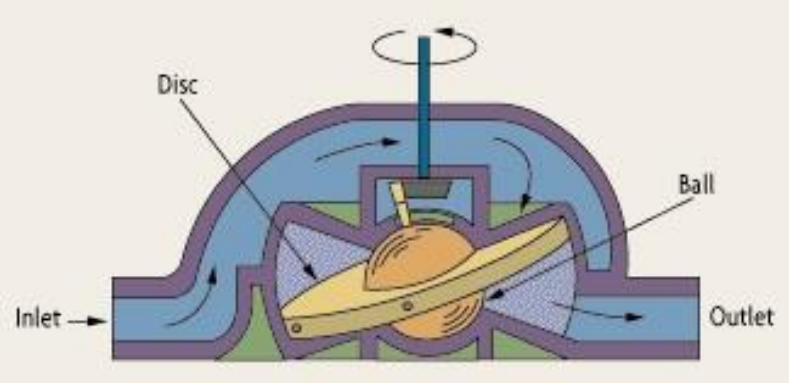
Figure IV.4 – Nutating Disc Meter Diagram



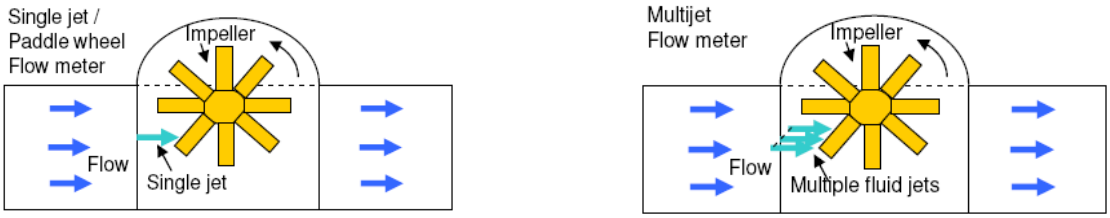
Velocity Meters

Velocity meters works on the principle that water passing through a known cross-sectional area with a measured velocity can be equated to volume of flow. Velocity meters are more appropriate to measure high flow water applications.

Single and Multi-Jet Meters

The water flow going through the single/multi-jet meters turns an impeller which rotates at a known speed compared to the water's velocity. Single jet meters utilize only one port to create a jet of water to make the impeller rotate, while multi-jet meters utilize multiple ports surrounding the internal chamber to create a jet of water. Multi-jet water meters are very accurate in small sizes, commonly used in 5/8" to 2" sizes for residential and small commercial customers. Single jet meters are also extremely precise and can provide a 100% accuracy from water flows as low as 1/4 gpm up to 180 gpm.

Figure IV.5: Single and Multi-Jet Meters Comparison



Turbine Meters

The turbine flow meter is a widely used measuring device, utilized in various industries measuring both liquids and gases. It is able to operate under a wide range of temperatures and pressures, however it is most effective in applications with steady, high-speed flows. In the water utility industry, it is typically used for high-volume commercial sites such as factories and large office complexes. It is also used as control meters for sections of a city and fire hydrants. Turbine meters can be used for water pipe diameters up to 12".

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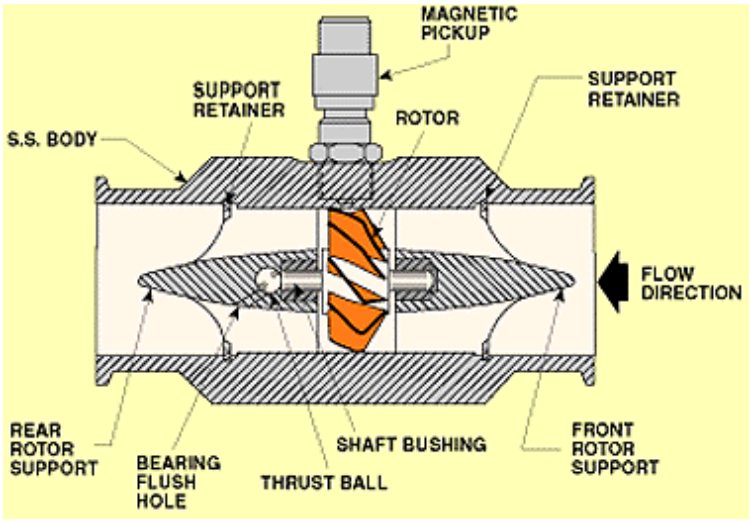
A bladed rotor is axially suspended in the pipe/meter. As the fluid flows through, the rotor spins at a speed proportional to the fluid's velocity. The rotation then generates a frequency signal which is sensed by the magnetic pick-up installed outside the meter pipe and is transferred to the applicable register/transmitter.

Figure IV.6: Turbine Meter Diagram



Compound Meters

In some cases, the ability to get accurate readings for both low flows and high flows is necessary. This can be achieved by using a compound meter, which has both PD meter (measuring low flows) and velocity meter (measuring high flows) installed together. A check valve arrangement regulates flows to each part of meter, depending on the volumetric flow.

Compound meters are available in the size of 2-8", capable of reading water flows from 2.5 gpm up to 4,500 gpm. The maximum operating temperature is 105^{0}F and maximum pressure of 150 psig.

Water flows through the single compound meter housing. If the water flow is high, the pressure differential will push down the check valve spring and cause the check valve to open and directs the flow to the typical velocity meter. Under low flow conditions, the pressure differential will not be able to push down the check valve spring thus the water flow is directed to the PD meter.

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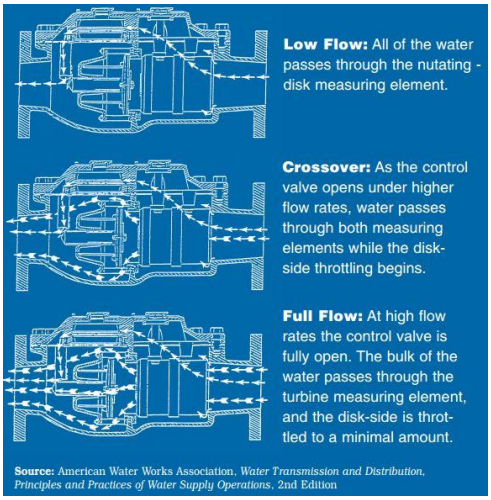
Figure IV.7: Compound Water Meter Principle and Visual Example



b. Non-Mechanical Water Meters

Mechanical water meters have been dominating the utility's measurement of potable water flow and consumptions for over 100 years. However, a new technology – non-mechanical metering technology – is emerging which promises a more accurate measurement at a decreased metering cost and increase in captured revenue.

Non-mechanical water meters (also known as "solid-state" or "static" meters) are defined as water meters where the only moving component is the water being measured. Because there are no mechanical measuring components, there is no mechanical friction causing component wear and increasing loss of meter accuracy over time. Besides the elimination of mechanical moving components, benefits of non-mechanical water meters include:

- Non-mechanical water meters do not require filters or strainers
- Reduced water pressure loss
- The water meter sensors can be buried in ground – not requiring specific water meter pit/chamber
- Elimination/reduction of routine maintenance and the need of installing a meter bypass

There are several types of non-mechanical water meters utilizing different principles, including electromagnetic, ultrasonic and fluidic oscillator technology.

Electromagnetic Meters

Electromagnetic water meters are designed based on Faraday's law of electromagnetic induction. Inside the magnetic flowmeter, a magnetic field is generated. Because water is conductive, it generates a voltage signal when passing through the meter and is captured by the electrodes located on the flow tube walls. The voltage generated is proportional to the velocity of the water and thus can be converted to the volumetric water flow.

Ultrasonic Meters

Ultrasonic water meters use sound waves to determine the velocity of water flowing in a pipe. Using the same principles as a Doppler radar, the flowmeter measures the wave frequency shift due to the flow of water. The transmitter processes signal from the transmitted wave and its

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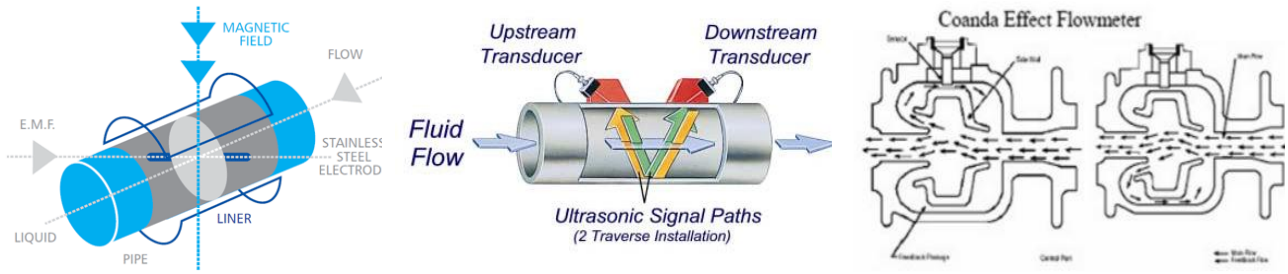
reflections to determine the flow rate of water. The disadvantage of ultrasonic meters is that it requires power to generate sound, thus requiring batteries and is subject to regular battery replacements at the end of the battery life.

Fluidic Oscillator Meters

Of the non-mechanical water meters, fluidic oscillator meter has achieved the greatest market penetration, evidenced by the fact that it is the only non-mechanical meter with its own AWWA standard (AWWA C713).

A special design of water flow chamber creates a fluctuating pressure sequence that causes the water flow to oscillate. The frequency of oscillations is proportional to the velocity of the water and thus can be converted to the volumetric water flow. At the moment, due to limited battery life and high cost, fluidic oscillator meters are not feasible yet for residential water customers market. However, as the technology evolves, this water meter technology may be more viable in the future.

Figure IV.8: Operation Principles for (a) Electromagnetic, (b) Ultrasonic, and (c) Fluidic Oscillator Water Meters



(a) (b) (c)

Non-mechanical water meters are predicted to eventually replace mechanical water meters in the future, however how long it takes for the transition to take place will depend on the water industry to develop more feasible technologies and utilities to recognize the advantages non-mechanical water meters offer.

B. <u>New Water Meter Technology and Features</u>

In 2011, the US Congress passed the Reduction of Lead in Drinking Water Act (RLDWA) and revised the definition of "lead-free" wetted surfaces of plumbing products (i.e. pipes, pipe fittings, plumbing fitting, fixtures including water meters) by lowering the maximum content of lead from 8% to a weighted average of 0.25%. These changes were set to take effect by January 4, 2014. Meter manufacturers have been designing their water meters to comply with the Safe Drinking Water Act, by using acceptable materials such as lead-free bronze alloy, lead-free copper alloy, or engineered polymer.

The water industry has embraced remote reading since the mid-1990s, utilizing automated meter reading (AMR) technology to capture customer's water consumption, either touch-based or drive-by. This has been made possible with absolute encoders that complement the water meter register. Absolute encoders are electro-mechanical devices that converts angular position of the water meter register (that captures the water flow reading) to an analog or digital code (ASCII format). These digital codes are then collected via AMR and converted to water consumption.

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The recent advancement in metering infrastructure technology have also impacted the water industry, particularly the two-way communication network commonly referred to as Advanced Metering Infrastructure (AMI). Utilities now have the ability to remotely capture meter reading data from the office, and the potential to send commands to the water meter for on-demand reads or remote shut off/turn on. The advanced absolute encoders that are capable of providing electronically encoded meter information are connected to the compatible meter interface units (MIUs), which are connected with the AMI network sending information back and forth from the meter to the utility and vice versa. A separate discussion of MIUs is available in a separate sub-section.

The advanced absolute encoders have new capabilities that are valuable when coupled with AMI technology. Moreover, absolute encoders have become the foundation of "smart" water metering. These new capabilities include:

- higher data integrity – better confidence in data accuracy
- high resolution (8 digits minimum) remote meter reading
- lower power requirements – longer battery life (some are even battery independent)
- true point-of-use leak detection
- tamper detection and reverse flow detection
- water conservation – high usage trigger

Remote water shut off is a relatively new development in utility meter technology that allows a utility to shut off a meter electronically or even throttle the meter down to allow a small flow of water so the customer can continue to flush a toilet. The most common use of this technology is to perform remote water shut off for delinquent customers – similar to electric utility, remote disconnect/reconnect. A remote water turn on can be executed after the customer pays their bills.

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2. Advanced Metering Infrastructure (AMI)

AMI is a transformational technology. This technology provides an excellent data collection platform, a bi-directional control network, and automates an expensive, and at times challenging business function. The deployment of an AMI system opens the door to a wealth of data previously unavailable to utilities and their customers. Previously, a customer's meter consisted of a simple read once/month. Once the data was collected, all but the largest customers with specially designed meters generated a single data element per month: a billing read. In contrast, AMI provides a steady stream of meter reading and diagnostic data at regular intervals, as well as event-driven urgent messages.

More granular usage data and system information can be transmitted digitally over the AMI network. If managed properly, this data can be used by many different applications, ranging from customer presentation of consumption profiles to usage of the data by engineering and operations to monitor system health and predict where upgrades to the system will have the most favorable return on investment.

An AMI system can be configured so that a customer service representative can request an on-demand meter read. By relaying that information to the customer immediately (over the phone or at the billing and collection location), issue resolution can be accelerated. An AMI system, along with the data it delivers, can facilitate numerous improvements; however, a solid plan to design and deploy the system and business process changes is essential to project success.

AMI implementation must be approached wisely in preparation for drastic changes in data volume, variety, and velocity. A successful path to AMI includes careful advanced planning and preparation regarding data distribution to all stakeholders involved.

A. AMI System Details

AMI systems allow meters to be read remotely from a central location through a fixed communications network. Today's AMI systems suitable for Lawrence are radio frequency based. Radio-based products operate on either licensed or unlicensed frequencies. A license covers the use of a specific frequency in a given area. The licensed band normally permits a higher power signal, which enables greater distance between the transmitter and receiver units. Unlicensed radio frequency systems operate under greater Federal Communications Commission (FCC) imposed frequency and power level constraints but with increased channel width and thus higher bandwidth capabilities. The same band can be shared by other devices using specialized modulation and frequency hopping techniques which make the systems inherently more interference tolerant.

The most advanced metering systems use one-way or two-way communications to get the data to and from the meter through a transmit/receive endpoint or meter interface unit (MIU) connected to the meter encoder/register. These MIUs talk to nearby collectors, also known as gateways or data concentrator units (DCUs). It is not uncommon for AMI systems to also use a series of network repeaters to ensure adequate communications. The collectors are then networked to the utility head-end system through a fixed communication backhaul network. This backhaul network typical uses an Ethernet transport and can leverage city fiber, radio systems, cellular modems or any combination. Communications between the meter and the collectors are specific to each vendor and use proprietary protocols. The components of an advanced metering infrastructure system are illustrated in the Figure below.

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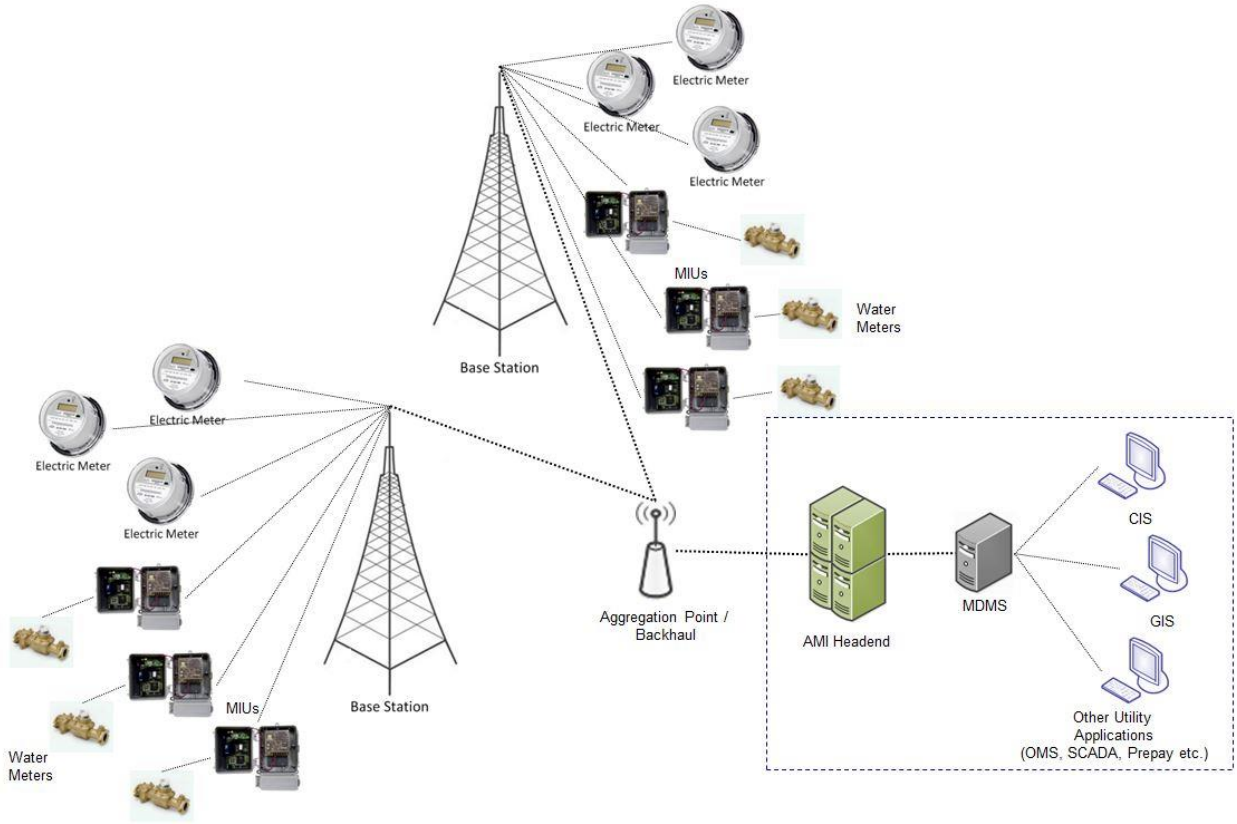
Figure 7: Sample AMI System Diagram (Point to Multipoint Network)



**The diagram above illustrates a point-to-point communication network, utilizing a radio frequency system. Although there are instances where the communication systems for electric and water are different and communicates to separate base stations/DCUs, in this diagram, both electric and water MIUs are presented communicating to the same base stations/DCUs. In future AMI network design, the network can be leveraged to support additional applications such as: distribution automation, demand response, SCADA 'lite', street lighting management, plug-in hybrid electric vehicles, etc.*

Many AMI systems collect interval (e.g., hourly or sub hourly) data. Two-way systems enable the system to collect on-demand reads, send control signals, firmware updates and time synchronization signals to the MIU at the meter. Other sensors, such as acoustic leak detectors, can passively gather information and send it along periodically. Actuators, such as remote shut-off valves, can be triggered in response to commands from the head-end software.

Typically, at pre-programmed intervals, MIUs at the customer premise transmit meter readings to nearby permanently positioned DCUs, which in turn relay the readings back to the head-end. Fixed network MIUs typically collect readings from the meter several times per day and transmit them at least once per day.

Most AMI systems rely on a relatively large number of low cost DCUs closely spaced on power poles or rooftops. The distance between the MIU and the data collector might be less than one mile. Other systems (sometimes referred to as "tower-based" AMI) use fewer more expensive collectors located on tall towers or buildings. These systems operate at higher power and the signals can propagate farther. The use of repeaters between MIUs and data collection units are common to fill in gaps and create a more uniform communications network.

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a. Point to Multipoint Networks

A point to multipoint connection refers to a type of architecture for fixed wireless data communications. A point to multipoint network configuration has a communication link between an “access point” radio and associated “remote” endpoints at the meter level. All meters can talk to the collector in this scenario and the collector can talk back to the individual meters. Thus, this scenario is classified as a two-way communication architecture. However, the meters cannot communicate to each other. In this setup, only data packets sent to the access point are acknowledged. Point to multipoint networks are licensed spectrum networks, and are classified as private.

b. Mesh Networks

One variant of fixed network AMI uses a mesh network. In mesh networks, MIUs (“nodes”) themselves serve as relaying devices for data and instructions. Information “hops” from MIU to MIU until the head-end destination is reached. These mesh networks are generally self-forming and self-healing. If the system will encompass electric, water and gas service, the combination network will allow meters to be routed to hop through the closest meter of any type.

Most mesh networks use low power transmissions in the unlicensed bands, and MIUs must be reasonably close together (typical ranges up to 1,000 feet). Using the relaying scheme, a data collector can cover greater distances than some networks that rely on local data collectors. However, each hop adds latency to the network, thus avoiding excessive hops with good planning of DCU locations is important.

Typically, AMI mesh network design is not recommended for a water or gas-only utility, as the power required for the daily multiple hops may cause the meter interface unit battery (at the water meter) to drain more quickly. It can be considered for utilities that have a combination of electric and water, as the water meter interface unit can communicate only to the nearest electric meter and have the electric meter interface unit (which does not require battery) perform the multiple hops to send data. This setup prolongs the battery life of the water or gas meter interface unit.

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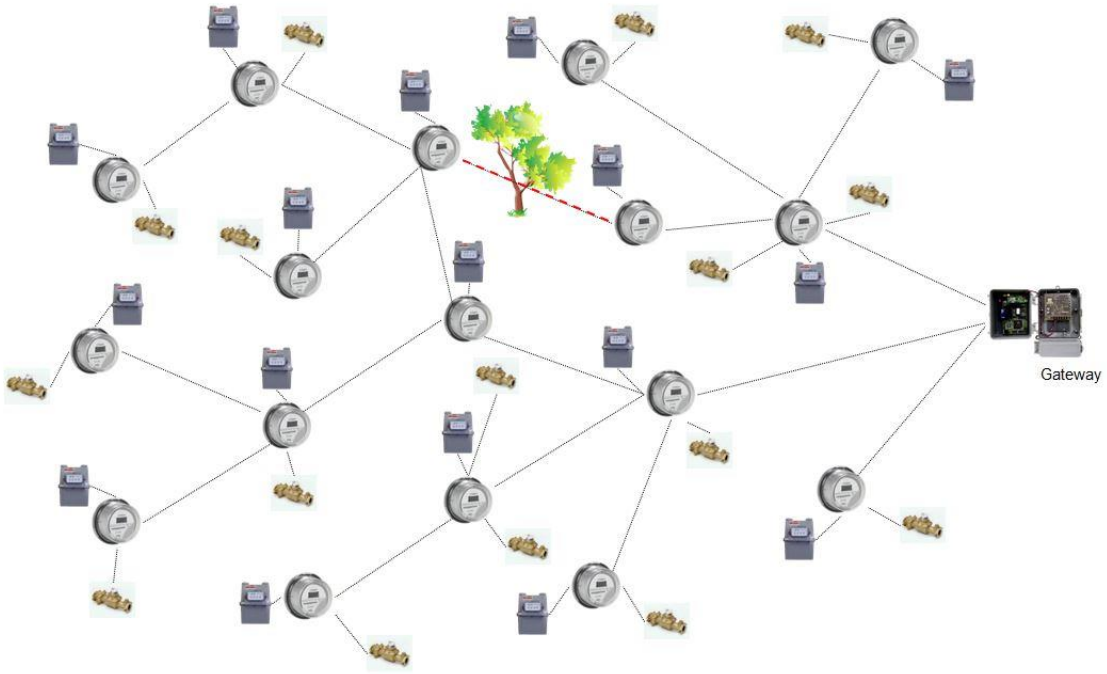
Figure 8: AMI Mesh Network Illustration



**MIUs in mesh networks communicates to each other, relaying data and commands. In the illustration above a tree is blocking/preventing one route of MIUs communication, causing the network to re-route the information hop to an alternative path until it reaches head-end. This describes the "self-forming" and "self-healing" capabilities of an AMI Mesh Network.*

Characteristic	Point-to-MultiPoint Network	Mesh Network
Spectrum	Operates on a private licensed spectrum Requires annual licensing fee Interference is minimal	Operates on a public unlicensed spectrum No annual licensing fee High chance of interference
Signal-to-Noise Ratio	Have a low noise floor Signal-to-Noise Ratio can be maintained at a high level	Have a high noise floor Signal-to-Noise Ratio can rapidly reduce when high noise levels are generated in shared frequencies
Signal Range (Coverage)	Can use higher level of output (US) to extend range	Range is limited due to one watt of power output limit (US) Remediated by locating points close together
Latency	Signal moves through few or no mid-point nodes, latency is minimal	Signal has to go through multiple 'hops' which increases latency Hops can be reduced by adding more backhaul
Communicated Data Retrieval	Higher risk of losing communication with endpoint due to relying on one communication path AMI network needs to be designed carefully to ensure full coverage	"Self-forming" and "Self-healing" capability – network can re-route information to an alternative communication path
Infrastructure	Higher cost of collectors Less complex/requires less equipment	Lower cost of collectors (Gateways) More complex/requires more equipment

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c. Meter Interface Units

The MIU either interrogates the encoded register of the meter, or accumulates electronic pulses corresponding to consumption from the meter, and transmits this and other information (such as identification numbers or tamper flags). Most MIUs are equipped with some tamper resistant features and may generate electronic "flags" if tampering occurs, such as a cut wire, a tilted meter, a tilted register, etc.

Most of the leading electric meter vendors have their own electric meters designed with their MIUs incorporated in its meter casing ("under-the-glass"). However, as is the case with water meters, the electric meter vendors have provided their meters' compatibility to integrate with different MIU brands.

Water meter registers are connected to stand-alone MIUs using a cable. Stand-alone MIUs are sometimes square or rectangular boxes, a few inches on each side and usually not more than two inches thick. The circuitry is usually encased to resist corrosion. A cast iron lid and supporting ring of a water meter pit will diminish transmission signal strength. For fixed AMI systems, the MIU should be mounted with its antenna protruding through the iron lid, or a composite lid may be used. AMI ready meter lids can be purchased or a hole can be drilled in a current cast iron or concrete lid so the MIU can fit.

MIUs are equipped with lithium (lithium-thionyl chloride or Li-$SOCl_2$) batteries designed to last 10-20 years, depending on the MIU model and its frequency of transmission. If the MIU is set to transmit above certain design parameters, the battery will wear out prematurely. For example, an MIU designed to transmit a simple reading twice per day will run down its battery quickly if reprogrammed to transmit every 15 minutes. MIU batteries are generally not field replaceable. MIU warranties are typically tied to battery life. For an initial period, manufacturer's warranties will replace the MIU with a new MIU for no cost (equipment only). Past a certain age, manufacturers will replace the MIU under a pro-rated warranty at a cost based on the "list" price. All AMI/AMR manufacturers use batteries from the same few providers and have generally comparable life and warranty periods.

d. Data Collection Units and Backhaul

Data collectors are typically mounted on light or utility poles, rooftops, or on top of water tanks. Depending on the vendor and local operating conditions, they may be configured to use AC electrical power or DC solar cells.

Transferring information from data collectors to the AMI head-end requires a wide area network (WAN). AMI vendors do not typically provide the WAN. Instead, they work with the utility to identify and use locally provided telecommunications facilities. Backhaul may be accomplished over fiber, radio frequency systems or cellular networks.

Cities will sometimes develop in-house multi-function wireless communications systems (e.g. SCADA, AMI, Workforce Management, etc.) to further leverage investment. Backhaul over commercial networks such as cell phone service or private, proprietary, or dedicated networks will generally require monthly service charges.

B. Meter Data Management System (MDMS)

It is advised for utilities to have MDMS implemented hand-in-hand with the implementation of AMI. With AMI, utilities will receive a vast amount of data, however without a proper data management system the data will be rendered meaningless as no appropriate action can be taken. An MDMS will be responsible for AMI data cleansing, calculating, providing data persistency and disseminating metered consumption data. The partitioned data will then can be utilized by different utility

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technology functions (i.e. billing, customer service, operational, outage management, water leak detection, etc.) to inform and make better decisions, and this is where the true business value of an AMI system is realized.

MDMS is essential and complimentary technology for AMI if predicted gains in the business case are to be realized. AMI systems generate an amount of data that exceeds both the capacity and analytical capabilities of both CIS and AMI system environments, which are not designed for this function. Typically, the MDMS requirements are shaped by needs in the electric power utility, as it has a higher complexity in managing the commodity (as electricity can rarely be stored) while MDMS requirements for water utility are subsets of the MDMS requirements for electric utility – from functional and performance/scalability standpoints.

Currently available AMI headend systems typically store data for one (1) to thirteen (13) months. The MDMS database, analytics and complex event processing (CEP) engines provide functionality bridging the gap between the AMI headend and other business systems within the Utility. The MDMS is designed to analyze and manage the large data volumes generated by AMI, and to serve this data to other systems as needed. By virtue of design, it will become the system of record for meter consumption data.

The storage and capability of the analytic engine of the MDMS also makes it an ideal nexus for combination of SCADA and Meter Data. Data can be extracted from SCADA historians for offline queries and use in other analytic tools, or read-only views into SCADA Historian databases can be created for real-time queries and to avoid data replication. This is optional, but highly recommended as the value is quite high and the incremental cost to implement is quite low.

The MDMS provides tiered data storage for multiple years of interval data, and provides advanced analytics, reporting, and complex event processing based on meter interval data. In addition, the MDMS:

- Validates meter reading data based upon utility configured validation rules
- Reporting engine delivers preconfigured and ad-hoc reports to users
- Provides validated billing determinants to CIS

Certain functionality offered by MDM systems can overlap with functionality offered by AMI systems. During the RFP and requirements definition phase of the project, it is necessary to establish the specifics of what that functionality is for each system and why the use of one system would be more advantageous than the other.

In order to provide customers with access to their historical consumption data, configurable alerts, and push notifications, a web-based portal should be procured as a companion product to the MDMS. It is common for the MDMS vendor to offer this functionality; however, the underlying requirements definition along with a design effort will be necessary. Figure IV.11 below provides a detailed look at the data flow throughout the resulting AMI/MDMS system.

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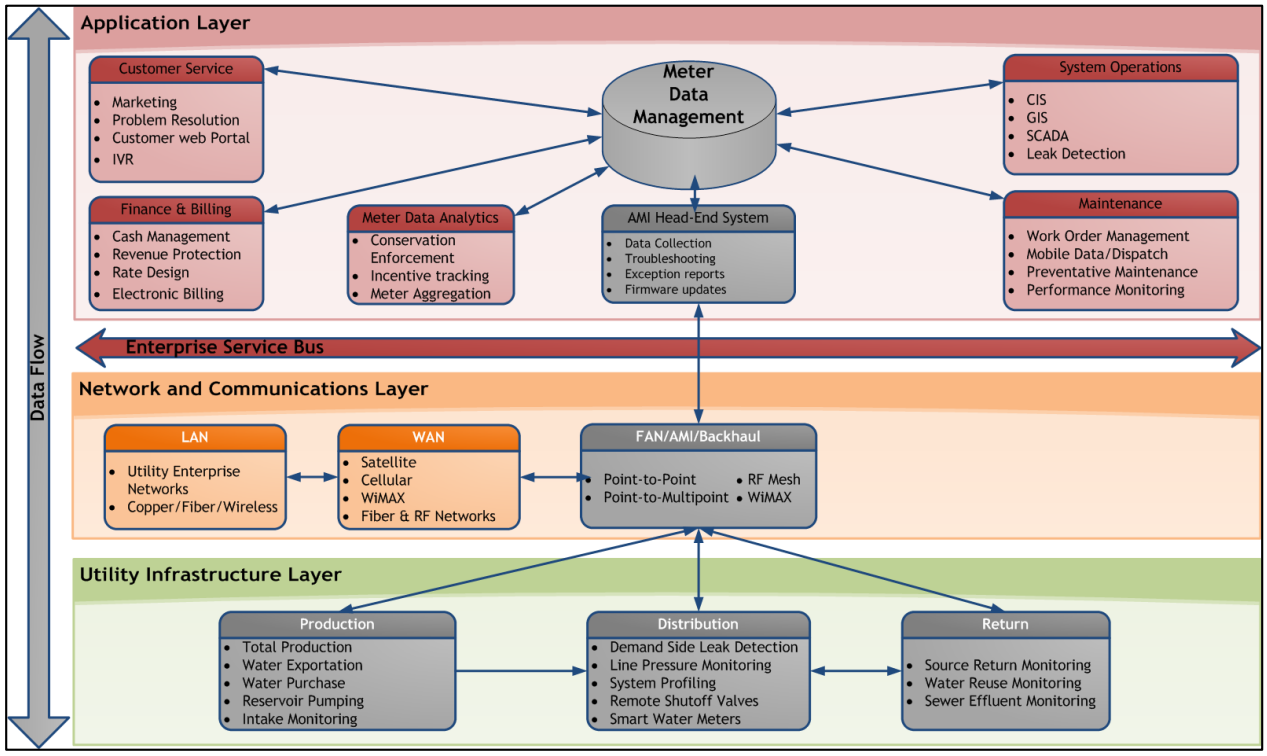
Figure IV.11: AMI/MDMS Data Flow Diagram



C. Information and Cyber Security

The reliable availability of the United State of America's critical infrastructure – such as the electric grid and water supply infrastructure – is essential to the wellbeing and security of the country. Utilities are making concerted efforts to identify and address security risks across electric, water and gas utility system assets and their connectivity points. Especially with an implementation of advanced metering infrastructure, these industrial control systems (ICSs) are vulnerable to cyber-attacks. This include attacks to steal customer personal information/energy consumption behavior, and to the utility infrastructure controls itself.

In 2009, the Wall Street Journal reported that spies hacked into the US electric grid and left behind computer programs that could disrupt services. In Harrisburg Pennsylvania, 2006, foreign hackers penetrated security of a water filtering plant through the internet. The hacker planted malicious software (mal-ware) that affected the plant's water treatment operations. Unauthorized changes to programmed instructions in local processors could lead an individual remotely taking control of a utility's distribution, resulting in disabled service or worst-case scenario, terrorism activities.

Utilities can reduce vulnerabilities from cyber-attacks or events by following the steps below:

1. Identify systems that needs to be protected
2. Separate systems into functional groups
3. Implement tiered defenses around each system
4. Control access into and between each group

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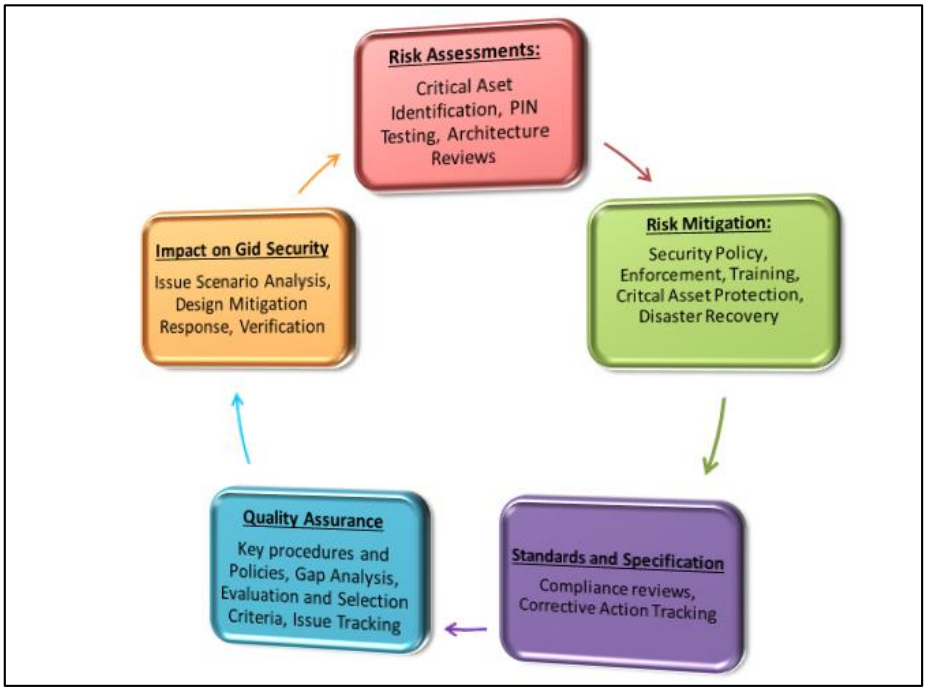
There are various standards that utilities can refer to regarding cyber security. In January 2016, the Federal Energy Regulatory Commission (FERC) issued a revised Critical Infrastructure Protection (CIP) reliability standards for electric utilities. The updated standards provide guidance in preparing for cyber security, including cyber security training once a quarter for large utilities, closing unneeded networking ports, and developing procedures for the storage information. Water utilities can refer to American Water Works Association (AWWA)'s Water Security Roadmap. Another useful resource for all utilities is the Department of Homeland Security (DHS)'s Industrial Control Systems Cyber Emergency Response Team (ICS-CERT, https://ics-cert.us-cert.gov/). The ICS-CERT works to reduce risks within and across all critical infrastructure sectors by partnering with law enforcement agencies and the intelligence community and coordinating efforts among Federal, state, local, and tribal governments and control systems owners, operators, and vendors.

It is recommended for every utility deploying or implementing an advanced metering infrastructure (AMI) to have IT resources on staff not only to maintain the AMI network system, but also trained with cyber security issues and understand how to mitigate the anticipated risk. Given the practical need to secure the utility system infrastructure, manage costs effectively and achieve compliance with regulations, utilities must adopt a life cycle approach (Figure IV.12) to cyber security.

Figure IV.12: Cyber Security Life Cycle



D. Water Leak Detection and Pressure Monitoring Technology

Alongside an AMI network implementation, a sophisticated acoustic water leak detection and pressure monitoring system will improve the water leak detection efforts. The implementation of advanced/smart meters will provide granular real-time data to the utility with information which will indicate potential customer-side leaks, illustrate high water use translating to possible waste, and identify theft of water use for accounts that are not considered active by the utility. The ability

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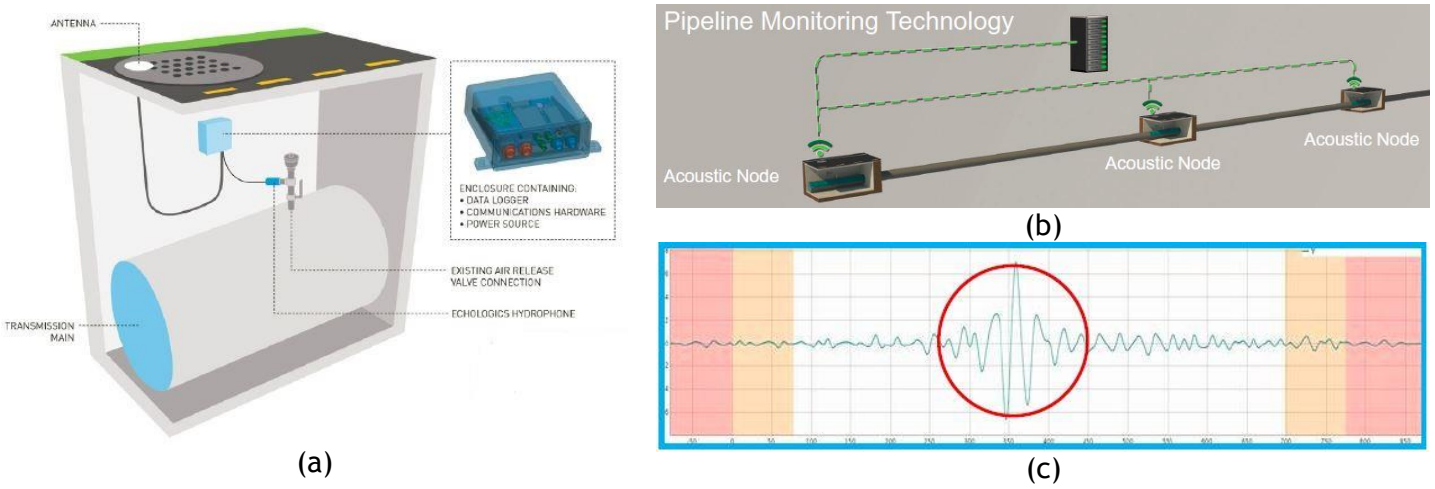
to produce and analyze interval data by the AMI and MDMS will also allow the utility to proactively identify leaks or water mismanagement.

The two technologies that the utility can leverage for the purpose of water leak detection are:

1. Acoustic sensors - By attaching an acoustic sensor to the AMI or AMI endpoint, the utility will be able to monitor its distribution system along with customer service lines to get complete system coverage. The acoustic sensor will monitor pipe conditions, looking for changes in the sound that travels down the pipe. The sensor has been designed to listen for a certain frequency range that represents the frequency a leak would produce. The sensors will leverage the AMI communications network to provide a snapshot of its system as often as it obtains the network reads. This leak detection system should be integrated with the AMI utility management platform established by the utility.

Figure IV.15: Acoustic Leak Detection Technology



**Images adopted from National Institute of Standards and Technology (NIST)'s Case Study – Las Vegas Valley Water District Water Leak Detection. Figure (a) illustrates location of acoustic sensor/node in the distribution, (b) illustrates multiple acoustic nodes monitored in real time, (c) presents a detected increase of acoustic signal compared to the normal acoustic noises in the water main, indicating potential water leak.*

The acoustic nodes/loggers are deployed throughout the areas of the water distribution system and provides continuous monitoring of leakage. There are logger types that can be permanently fixed on the main pipe and loggers that can be repositioned/moved around, retained in a place with a strong magnet. Leak detection using acoustic method is pretty straightforward: sound waves detected by the sensors is converted to electric signals and are sent to the management software. An increase of voltage levels compared to the baseline indicates a potential leak in the system. The position of the leak can be estimated from the time delay when the sound wave arrives to the two sensors in between. The time delay, correlated with other information such as distance between sensor, pipe material, velocity of the sound wave, enables the leak detection software to pinpoint the location of potential leak in the system.

2. Flow or pressure change - This technique relies on the assumption that an abnormally high rate of change of flow or pressure at the inlet or outlet of a distribution section is indication of the probably the occurrence of a new leak. If the flow or pressure rate of

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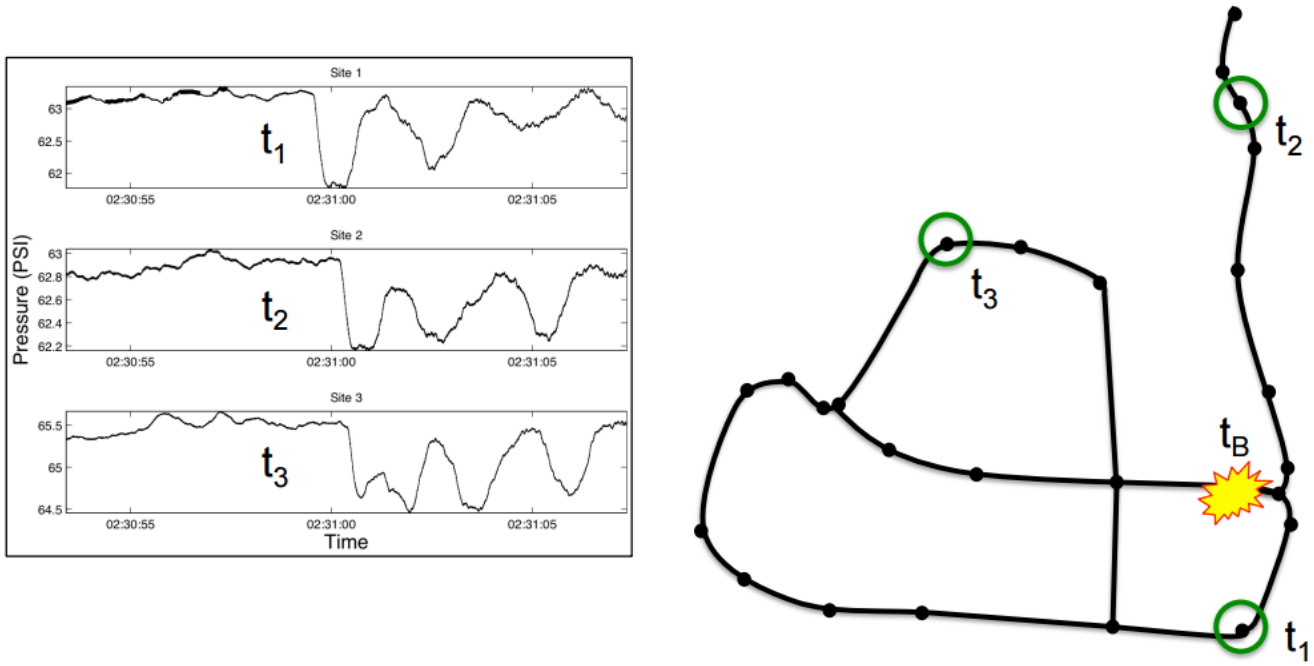
change is higher than a predefined limit within a specific time period, then a leak alarm is generated and further investigation and subsequent repairs are triggered.

A remote pressure monitoring system can be deployed in parallel with an AMI network deployment – leveraging the communication infrastructure. The pressure sensors are installed throughout the distribution area, typically two sensors per district metering area or pressure zone – ideally at high pressure and low pressure zones. They can either be installed into the distribution main or placed inside a meter vault. The pressure sensors can typically measure pressure from 0 to 200 psig and transmitted securely to the utility office where it is monitored.

Pressure monitoring technology purpose goes beyond just water leak detection. An accurate, real-time pressure monitoring allows the water utility optimize the system operation and reduce the duration and disruptions of repairs and maintenance. Accurate pressure data and management allows water utilities to:

- Reduce leakage which in turn reduce cost (supply and energy)
- Reduce customer complaints
- Reduce unaccounted for non-revenue water
- Prevention of potential infrastructure failures related to pressure fluctuations
- Improve public health and safety (loss of pressure can allow ground water to contaminate distribution system)

Figure IV.16: Water Burst Detection with Pressure Monitoring Technology



**Graphic and illustration adopted from Whittle et. al., 2013, Sensor Networks for Monitoring and Control of Water Distribution Systems. Graphic on the left side presents the pressure vs travel time from three points of the system, t_1, t_2, and t_3 as described in the figure on the right. Meanwhile t_b indicates a potential burst/water leak which was detected by a drastic loss of pressure as can be seen in the graph. Using the same principals as acoustic leak detection, location of potential leak can be pinpointed by correlating the travel time, wave speed and pipe properties.*

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Leveraging the AMI network, water leak detection technology can be monitored in near real time and allow utilities to be proactive and locate leaks and fix them before it goes on for years, causing significant water and revenue loss.

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Appendix V – AMI Vendor Matrix – Water

Water AMI Solutions

	Aclara STAR (3300 Water MTU)	Sensus - Flexnet	Badger - Orion (BEACON)	Neptune - ARB Fixed	Itron 100W	Itron - Openway Riva	Mueller-MegaNet	Mueller-Mi.Net	RG3- Tesla 4	Metron Farnier - innov8-VN
Water MIU Attributes										
Meter to Collector (RF, PLC, Cellular, etc.)	RF	RF	RF/Cellular	RF	RF	RF	RF	RF	RF	Cellular
Meter to Collector Architecture (Mesh, P2MP, Hybrid)	P2MP	P2MP	P2MP	P2MP	P2MP	P2MP	P2MP	P2MP	P2MP	P2MP
1 or 2 Way (Meter to Collector)	2	2	2	2	2	2	2	2	1 or 2	2
FCC Licensed	Y	Y	N	Y	N	N	Y	N	N	Y
MIU Freq (MHz)	450-470	901-901.5 940-940.5	902-928	450-471	923-926.8	902-928	136-174	902-928	902-928	
MIU Power (Watts)	0.75	2	1	1	>1W	0.66	2	1	1	
Firmware Upgradeable via Network	N	Y	Y	Y	Y	Y	N	Y	Y	Y
Max Transmit Interval (per/day)	4	6	4	4	6+	12	5	1	1	1
Battery/MIU Warranty Term (years)	20 Pro	20 Pro	20 Pro	20Pro	20 Pro	12/20	10 Pro	10 Pro	25	20 Pro
Network Performance Guarantee			10 yr 3rd party cellular							
Data Logging	Y	Y	Y	Y	Y	Y	N	Y	Y	Y

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Appendix VI – Major Water Meter Product Matrix (Latest Offerings)

Manufacturer	Meter Type	Size	Typical Flow Range (gpm)	Accuracy	Application	Compatible AMR/AMI Systems
Badger Meter	Nutating Disc	5/8 - 2"	0.25 - 170	±1.5% normal flow, 95% low flow (@ 0.25 gpm)	Residential, Industrial	Aclara, Badger, Itron, Mueller, Neptune, RG3, Sensus
	Ultrasonic	5/8 - 2"	0.05 - 160	±1.5% normal flow, ±3.0% low flow (@ 0.05 gpm)	Residential, Industrial	
Elster AMCO	Electromagnetic	2 - 12"	1 - 5500	±1.5% normal flow, 95% low flow (@ 0.25 gpm)	Commercial, Industrial	Aclara, Badger, Itron, Neptune, Sensus
	Fluidic Oscillator	5/8 - 1"	1 - 50	±1.5% normal flow, 95% low flow (@ 0.125 gpm)	Residential	
Neptune/ Schlumberger	Nutating Disc	5/8 - 2"	0.75 - 160	±1.5% normal flow, 95% low flow (@ 0.125 gpm)	Residential	Aclara, Badger, Itron, Neptune, RG3, Sensus
	Ultrasonic	5/8 - 1"	0.10 - 55	±1.5% normal flow, 97% low flow (@ 0.05 gpm)	Residential	
	Nutating Disc (submeter applications)	5/8"	0.50 - 20	±1.5% normal flow, 95% low flow (@ 0.25 gpm)	Residential (e.g. Apartment Complexes)	
	Turbine	1-1/2 - 10"	4 - 6500	±1.5% normal flow	Commercial	
	Compound (Turbine+Nutating Disc)	2 - 6"	0.50 - 2000	±1.5% normal flow, 95% low flow (@ 0.125 gpm)	Commercial	
Master Meter	Ultrasonic	2 - 12"	0.50 - 5500	±1.5% normal flow, ±5% low flow (@ 0.016 gpm)	Commercial, Industrial	Aclara, Badger, Itron, RG3 Sensus
	Oscillating Piston	5/8 - 2"	1 - 160	±1.5% normal flow, 95% low flow (@ 0.125 gpm)	Residential, Commercial	
	Multi-Jet	5/8 - 2"	1 - 160	±1.5% normal flow, 95% low flow (@ 0.25 gpm)	Residential, Commercial	
	Turbine	2 - 12"	4 - 8800	±1.5% normal flow, 95% low flow (@ 2.5 gpm)	Commercial, Industrial	
	Compound (Turbine+Multi-Jet Disc)	2 - 6"	1 - 1200	±1.5% normal flow, ±3% low flow (@ 0.25 gpm)	Commercial, Industrial	
Metron Farnier	Single Jet	5/8 - 6"	0.088 - 1000	±1.5% normal flow	Residential, Commercial	Aclara, Badger, Itron, Mueller, Sensus
	Single Jet (Industrial applications)	6 - 8"	6 - 2800	±1.5% normal flow	Industrial	
Mueller/ Hersey	Nutating Disc	5/8 - 2"	0.5 - 160	±1.5% normal flow, 95% low flow (@ 0.125 gpm)	Residential	Aclara, Badger, Itron, Mueller, Neptune, RG3, Sensus
	Electromagnetic	3 - 12"	2.75 - 8800	±0.4% normal flow,95% low flow (@ 0.5 gpm)	Commercial	
	Turbine	3/4 - 6"	1 - 1300	±1.5% normal flow	Commercial	
Sensus	Electromagnetic (>1")	1-1/2 - 24"	0.7 - 33400	±1.5% normal flow, 95% low flow (@ 0.3 gpm)	Residential, Commercial, Industrial	Aclara, Badger, Itron, Mueller, Neptune, RG3, Sensus
	Electromagnetic (<=1")	5/8 - 1"	0.18 - 55	±1.5% normal flow, ±3.0% low flow (@ 0.025 gpm)	Residential	
	Turbine (Floating Ball)	1-1/2 - 3"	0.5 - 500		Commercial	
	Turbine (Floating Ball, large residential applications)	1-1/2 - 2"	2 - 200	±1.5% normal flow, -5%/+1.5% low flow (@ 0.75 gpm)	Residential	
	Oscillating Piston	5/8 - 1"	1 - 50	±1.5% normal flow, 95% low flow (@ 0.25 gpm)	Residential, Commercial, Industrial	
Zenner	Oscillating Piston	5/8 - 2"	1 -160		Residential, Commercial, Industrial	Aclara, Itron
	Multi-Jet	5/8 - 2"	1 -160		Residential, Commercial, Industrial	
	Turbine	1-1/2 - 12"	3 - 8800		Commercial, Industrial	
	Compound (Turbine high flow, proportionately sized meterlow flow)	3 - 8"	4 - 1600		Commercial, Industrial	

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Appendix VII – Current State Operations

1. Meter Reading/Field Services

At the time of UtiliWorks discovery effort, the Field Services team and Meter Readers reported to the Finance/Utility Billing Department within the City. Since that time, these two teams were transferred and now reside within the Utilities Department. There is a single Field Supervisor who oversees five (5) full time meter readers and four (4) temporary readers (during the KU rush) along with five (5) Field Service Representatives (FSR). The meter readers collect monthly reads for four (4) billing cycles / 93 routes.

Duties performed by the FSRs include disconnect of service, collect move in/out reads, verify-offs and re-reads. There is also some overlap between the meter readers and FSRs with regard to certain tasks such as re-reads. A majority of meters currently deployed in the field are manually read, but approximately 1,300 are AMR-equipped. There is a combination of Orion, Schlumberger, and Ramar endpoints deployed in the service area.

The majority of water meters (33,440) are pit-set with 226 located in vaults. The City has a few meters located inside of buildings, in the basements, or ceilings in their service area. The majority of meter lids are cast iron. Pit sizes may be 18", 20" or 36". The cold temperatures in winter can lead to frozen meters for the City. Foam inserts are sometimes used to keep the temperature warmer inside the pit. Other reading issues include pits that are full of water, or meters that may be tilted.

Staff approximates that there are 500 delinquent turn-offs completed each month. The City leaves a delinquent notice on the door when the premise is visited for service turn-off. Currently, this is a source of strain on FSRs, as they must accept payments at the door if offered. A minimum payment of $100 or notice of bankruptcy must be received by the City in order to avoid turn off.

Based on review of the data and feedback from Staff, it was confirmed that the CIS does not accurately reflect the meter characteristics. The suspect data, which may include register ID or ERT ID, has been populated in the field reserved for meter ID. Meter age and installation dates are also not properly maintained as a result of the two (2) work order systems that do not have an automated interface (Lucity and Innoprise).

The City developed and instituted a formal meter replacement program in 2013. The replacement criteria are based on a combination of AWWA research, meter manufacturer recommendations, and field testing of water meters. The parameters established for water meter replacement based on meter size are outlined below:

- For water meters 1" and smaller, water meters will be replaced when the volume registered through the meter exceeds 2 million gallons or age of the water meter reaches 20 years.
- For water meters 1 ½" or larger, water meters will be replaced when the age of the water meter reaches 15 years.
- For water meters 6" or larger or for rural water districts, water meters will be tested annually for accuracy. If testing indicates accuracies outside of the AWWA recommendations, the water meters will be calibrated and re-tested. Upon re-testing, if the testing still indicates inaccuracy, the water meter will be replaced.

The KU campus is the largest single customer and is served via a single 12-inch master meter. KU also owns and currently reads 72 hard to reach deduct meters that measure the volume of

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water that does not enter the City's wastewater collection system. Lawrence would like to leverage an AMI system to assist KU in acquiring these deduct reads which would ultimately automate this process.

2. Utility Billing

The Utility Billing team is comprised of three (3) staff members, including a supervisor, within the City's Finance department. The City recently created the position and hired a new Billing Manager. Duties including billing, meter service orders, and meter read exception handling. Read estimations and Hi/Lo exceptions are generated by routines in Innoprise CIS. There are several reports used regularly by Billing Staff including: Cut Off List, Eligible Collection Report, Credit Balance Report, View Upload Read Reports (daily), and Re-read Performance Report. Occasionally, bills will be estimated in the event of weather emergencies.

Approximately 33,600 bills are generated monthly; however, this number is often higher during the KU rush period. KU has approximately 22,000 undergraduate students with a high rate of transiency. The full customer breakdown of accounts served by Lawrence is shown in Table 10. Note that Multi-family represents accounts that have a single meter with multiple dwellings and are charged a different rate. Rural water districts are other water utilities outside the City that are supplied with water via the City's distribution system.

Table 10: Account Classifications

	# Accounts	%
Residential	29,988	90.40%
Multi-family	798	2.41%
Commercial (includes KU)	2,050	6.18%
Industrial	82	0.25%
City No Charge	245	0.74%
Rural Water Districts	9	0.03%

Bills are generated weekly with a service period that ranges between 28-30 days. Billing units are hundred gallons. The bill due date is 21 days out from the bill date. Any bill not paid becomes delinquent on the 22nd day following the bill date. A late fee of 2% of past due balance is charged on day 25. There are 4,460 delinquent notices generated each year. If the bill is still unpaid by day 40 following the bill date, a delinquent turn-off service order is issued and water service will be turned off by a field services representative. There is a $25 trip charge and $25 turn on charge applied in the case of turn-off.

The billing department currently manages several manual processes. For example, re-reads are collected by the meter reader or FSRs and populated in a spreadsheet. The re-read spreadsheet is maintained by the meter reader supervisor and is returned to the billing clerk upon completion. The billing clerk enters and reviews the re-reads prior to pushing it through to a bill.

Another manual process is the billing of KU. The billing clerk currently receives a spreadsheet from the Utilities Department that includes the KU meter readings for the master meter and all deduct meters on campus. The sum of the deduct reads is then subtracted from the master meter consumption to obtain the wastewater usage for billing. The result is then entered manually into CIS as a totalized read for purposes of billing the University. Other manual billing adjustments are applied from a winter quarter averaging stormwater calculations spreadsheet,

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a return check database and solid waste database, which are also maintained separately from the CIS. The City also has three (3) customers that remit meter reads via email, which requires manual entry each month.

3. Customer Service

Customer service is divided among a group within City Hall (Customer Service) and a group within Utilities (Utilities Admin). The Customer Service group contains 10 full-time staff and 3 part-time. They handle new services (move-in/out), walk-ins, payments and most customer inquiries. The average customer call will take 3-4 minutes to resolve. The top 3 customer inquiries include:

1. Bill inquiry – "Why is my bill so high?"
2. Service shut off - "Why is my service turned off?"
3. Payments – "Did you receive my payment?

All bill payments are handled by City Hall Customer Service. Customers have many options to pay their bill, but a majority are paid by credit card or check. Payment options include: mail, online (through Citizen Access or Paymentus), phone/IVR (Credit Card), drop boxes (at City Hall and grocery store), City Hall counter, ACH, or in person if a field services representative has been dispatched for delinquent notice.

The Customer Portal (Citizen Access) shows bill history and current bill with due date. This portal also allows for online payment. The City offers the ability to place a start/stop service request for move in/outs via the City of Lawrence website. This web form issues an email, which triggers a CSR to create a service order. Based on the 2016 budget goals, the City plans to consolidate all online interaction with customers in one place and would like to provide a website where customers can "initiate, transfer, terminate, and pay for services on a 24/7 basis."

The Utilities Admin customer service group issues work orders for new physical meters and handles customer calls related to unplanned service disruptions and water main breaks. New service requests will initiate a work order directly in Lucity, which is assigned to the Field Operations team to complete the work. Upon completion, the work order is sent by email from the Utilities Admin team to Utility Billing so that the new meter to be entered into the CIS, as no direct integration exists between Lucity and Innoprise. There were 194 new service requests in 2015. Typically, Utilities Admin calls can be resolved in under 5 minutes, though there is higher variability in call length within this department. A majority of call volume is simply transfers to Utility Billing for billing-related inquiries.

4. Water Operations

The Water Operations staff oversees treatment of water and wastewater, distribution of water, and collection of wastewater throughout the City. This includes the transmission of water to adjacent Baldwin City and the RWD's. The SCADA system (WonderWare) controls the pumps at the WTP and WWTP plants, valves at the water towers booster pumps and lift stations (33) in the system. Water Operations staff monitor pressure at 2 booster pump stations, and measure flow at 2 locations. Staff wants to increase the number of locations monitored for pressure and flow with the implementation of AMI.

The City's water is supplied by Clinton Lake through contract with the Kansas Water Office (KWO) for 4.8 Billion gallons/year, and the Kansas River through water rights with the Division of Water Resources (DWR) for 8.2 Billion gallons/year. The Kansas River water rights include 6

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active well sites. Total raw water usage is 4 billion gallons per year, or approximately 1/3 of available supply. There are 2 water treatment plants (Kaw and Clinton WTP), which have a combined capacity of 41 MGD. All output to the distribution system is metered, with annual calibration. Any meters that are 6" or larger, including the RWD meters, are calibrated annually.

The distribution system contains 520 miles of water mains and two pressure zones. There is no zone metering in place. The City has a looped system with 16" and 24" transmission mains, 12" arterial lines that cover a square mile in town, and 8" as the standard residential main size. The in-house pipe crew targets 15,000 feet of main replacement each year, all of which are plastic or ductile iron pipe (DIP). Over the past 3 years, there have been approximately 125-150 main breaks per year. A system flushing schedule (from bi-weekly to 6 months) is used to ensure water quality throughout the system.

The wastewater collection system contains 33 miles of forced main and 419 miles of gravity main. In 2015, the City handled an average of 8.2 MGD in wastewater volume. Operations oversees the Kansas River WWTP, with a total capacity of 65 MGD. Construction is underway on the 2.5 MGD Wakarusa Biological Nutrient Removal (BNR) WWTP to be in operation by late 2017/early 2018.

For distribution system oversight, there are daily operations reports and monthly production reports available. Water system losses are estimated to be 10%, but the engineering staff find it difficult to get true quantities due to the lag time between operational data and billing/consumption data. City engineers currently use a hydraulic model for more long-term system planning. For example, they will perform calculations in-house to check for the effects of adding a new development connection.

There is also a dedicated Process Analytics team (ATAD) that is made up of 13 Utility staff and 2 consulting firms. This multidiscipline team refines decision processes for system controls throughout the water and wastewater treatment processes. They are tasked with utilizing system data and enhancing analytical capabilities within the organization.

5. Meter Shop

The meter shop and warehouse functions are located in the same building for the City. There is no formal "meter shop," but 2 mobile testers are utilized for testing meters in the field. The smaller tester can test meter sizes ranging from 5/8" to 8", whereas the larger tester can test 10" or larger meters. An old test bench exists in the warehouse, but is not currently used. There is formal testing program, which includes testing of meters 6" and larger annually and calibrating the meter testers once per year. Testing is typically only performed on meters 1 ½" or larger. The City will occasionally send small meters that cause regular high bill complaints back to the manufacturer for testing. Old meters are scrapped, but may have gaskets or registers replaced if the meter body is still functioning.

Work orders are generated in Lucity for the field staff. Requests that are generated from Utility Billing will be emailed or called into the Utilities administrative staff, who relay the work orders to the field staff and generate the work order in Lucity. Often, there is data lost in the translation and duplication of manual effort. Field staff utilize a mobile application to update and complete Lucity work orders, that are then transferred to the CIS by way of the Utilities administrative staff.

The annual meter replacement cost in 2015 was $150,000, and all meter purchasing is handled by the Utilities Warehouse. This group monitors inventory levels based on min/max. Inventory is received and sorted in the warehouse. The City is considering adoption of bar code scanners

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for inventory tracking, but the work order management system, Lucity, does not currently handle this technology. Annual audits show that inventory losses to be less than 1%.

6. IT/OT Applications and Communications

IT support is provided by the City's IT Department by 11 full-time and 2 part-time staff. This team manages the communications, networks, servers, security, help desk, data management and GIS capabilities for the entire City. Typically, most applications and hardware are managed by the IT team on premise. Microsoft SQL database applications are preferred and virtual servers are supported on VMware version 6.0.

There is a fiber network throughout the City, in addition to internet, AT&T, Verizon, Wide-Open-West (WOW), and other communications. There is internet redundancy throughout the City between KanREN and WOW. Cybersecurity programs and disaster recovery plans are in place to protect City networks and data. All servers are backed up to redundant, remote sites.

Within the Utilities Department, there is an ongoing project to capture GIS shots for all metered accounts. Lat/long coordinates are stored in Lucity, along with meter attributes, but these are not properly tracked in Innoprise. GIS is synchronized weekly with Lucity and will be the source for lat/long, register #, meter #, and radio # post-AMI deployment. Additionally, the water utility staff support their Wonderware SCADA system in-house.

Table 11: City of Lawrence IT/OT Systems

Function	Name of Application	Manufacturer
CIS/Billing	Innoprise	Harris
Accounting/Financial/Purchasing (ERP)	Innoprise	Harris
Meter Reading - Walk by	MVRS	ITRON
Meter Reading - Remote Read	Orion	Badger
Work Order Management (Utility Billing)	Innoprise	Harris
Work Order Management (Utilities Department)	Lucity	Lucity
Asset Management	Lucity	Lucity
Asset Management	ArcSDE	ESRI, Inc.
GIS (Internal)	ArcSDE	ESRI, Inc.
GIS (External)	ArcGIS Server	ESRI, Inc.
GIS (External)	ArcGIS Online	ESRI, Inc.
SCADA	Wonderware	Schneider Electric
VOIP Phone System	CUCM	Cisco
Call Center Software	UCCX	Cisco
Customer Web Portal	Innoprise (Citizen Access)	Harris
Reporting	SQL Services Reporting Services	Microsoft
IVR	Selectron	Selectron
Local Area Network (LAN)		Cisco
Wide Area Network (WAN)		Cisco

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Emergency Notification System		
Automatic Vehicle Location (AVL)	Network Fleet	Network Fleet
Hydraulic Model	Currently Bentley WaterGEMS but moving to InfoWater	
Payment Processing Software	Creditron	
Utility Billing Printing & Distribution	ABData	
Data Lake	Pi	OSI Soft
Sewer Inspection Cameras	Possum	

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