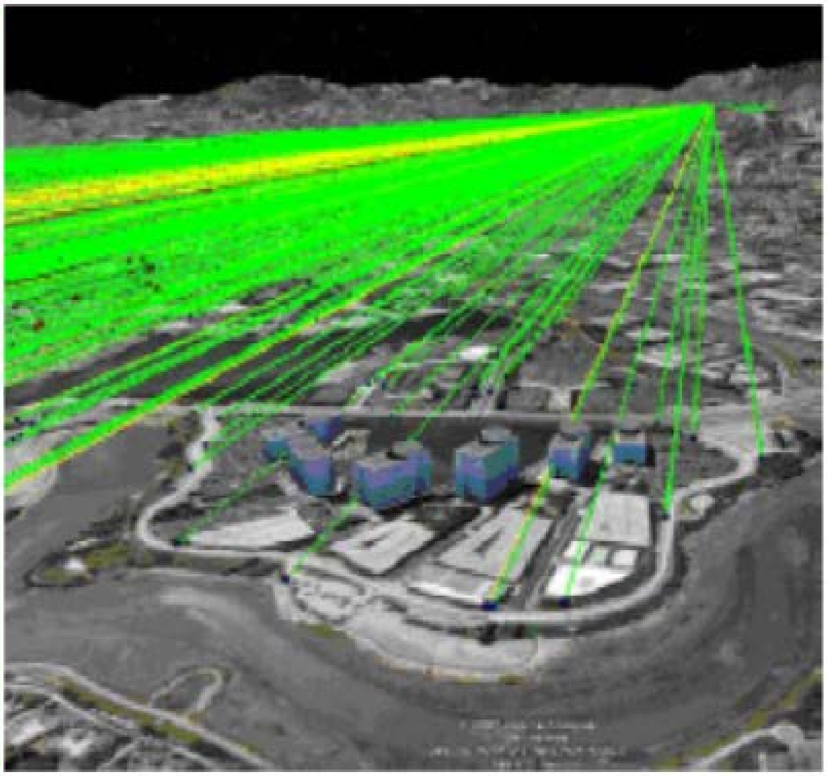
AMR/AMI FEASIBILITY STUDY



Submitted by:

MC Engineering, Inc.

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6/8/2015

Table of Contents

Executive Summary

MC Engineering was retained by the District to investigate the feasibility of installing either AMR (drive-by) or AMI (fixed base) meter reading technology. The study included investigating corresponding infrastructure needs pertaining to the District's existing meter population and investigating both capital costs and potential benefits from related investments. Workshops were held to review technology options and discuss non-monetary factors associated with new meter reading technologies and meter data management capabilities. A variety of software solutions were investigated and presented in the report along with AMR/AMI vendor offering descriptions for five leading technology solution providers.

Three primary alternatives were considered in the related business case analysis which included:

- Alternative 1: Install AMR system
- Alternative 2: Install AMI system and change out registers for meters older than 10 years
- Alternative 3: Same as alternative 2 with the added benefit of meter change outs for meters that have exceeded their useful life or are in the need of repair and/or replacement due to inappropriate typing

The estimated capital costs for Alternative 1, 2, and 3 are $2,403,677, $3,046,333, and $3,158, 955, respectively. Alternatives 2 and 3 for AMI improvements include additional costs of $476,805 for installing new registers on approximately 5000 meters to accommodate 1 cubic foot accuracy to facilitate leak detection capabilities through the use of new solid state registers. Alternative 3 includes increased annual benefits from decreased Real and Apparent Losses through programs for leak detection and replacement of meters with historically high usage.

The three business cases that were analyzed produced similar rates of return and simple payback periods for the AMR (Alternative 1) and AMI (Alternative 2) scenarios, both of which have payback periods in the range of 30 years which exceeds the useful life of the equipment. To the extent the District elects to factor in reductions in both Apparent and Real Losses, along with corresponding monetary benefits, the rate of return and payback period for AMI are more favorable. A summary of the financial analysis for each of the three alternatives considered in presented below in Table ES-1.

Table ES-1
Summary of Benefit Cost Analysis

EGWD Summary of Benefit Cost Analysis					
Scenario	**Capital Cost**	**Annual Benefit**	**NPV**	**IRR**	**Simple Payback**
1	$2,403,677	$89,236	-$49,208	2.75%	26.9
2	$3,046,333	$93,624	-$830,222	NA[1]	32.5
3	$3,158,955	$195,040	$1,333,321	NA[2]	16.2

[1]Unable to calculate Rate of Return due to low benefits relative to project capital costs.

[2]Unable to calculate Rate of Return due to high benefits relative to project capital costs and 20 year interest rate.

It is recommended that the district implement Alternative 2 or 3 for an AMI system to leverage the benefits of analytics it provides. Alternative 3 includes both higher capital costs and added benefits from replacing aging meters that are currently out of warranty or inappropriately typed or maintained along with actively reducing water losses through a combination of leveraging AMI technology and implementing proactive leak detection to repair leaking pipes. Despite the higher capital costs, the added benefits with Scenario 3 result in more favorable financial performance indicators by reducing water losses (Real and Apparent) while reaping the non-monetary benefits identified in the Tables 10, 11, and 12, in the main body of the report, prepared during Workshop No. 2.

AMI is becoming the industry standard for efficient water utility operations. This has become increasingly evident in the recent drought experienced in California. A well operating, fully configured AMI system and related software can drive water conservation programs and efficiencies at both the utility and customer level. Utilities are more able to track consumption for each account and customers are provided with in-depth insights into their daily consumption profile.

Aside from the monetary implications presented in the business cases above, the District should include weighing the more qualitative social, economic, and environmental factors when determining the viability of either option. When coupled with the goals of minimizing water losses, improving employee retention, and increasing customer satisfaction, there is a good case for moving forward with an AMI installation. The project viability can be improved to the extent costs are reduced through a combination of possible grant funding, reductions in installation costs for endpoint installation by District crews, and other non-monetary benefits.

Background

The Elk Grove Water District provides water service to approximately 11,784 residential and 512 commercial customers on the east side of SR 99 in Elk Grove, California. The District retained MC Engineering to evaluate the feasibility of investing in new water meter reading technology to replace the existing Touch Read meter reading system. The scope of work included evaluating and contrasting the merits of both an Automatic Meter Reading (AMR) drive-by radio read technology versus an Advanced Meter Infrastructure (AMI) fixed base radio reading system.

The District recently made efforts to improve the efficiency of their Touch Read system by optimizing the existing routes while adding additional meters to achieve the goal of metering all customer accounts which was completed in 2015. The AMI consulting RFP included answering several questions posed by staff and comparing the merits of AMI and AMR, related capabilities, and retrofit needs.

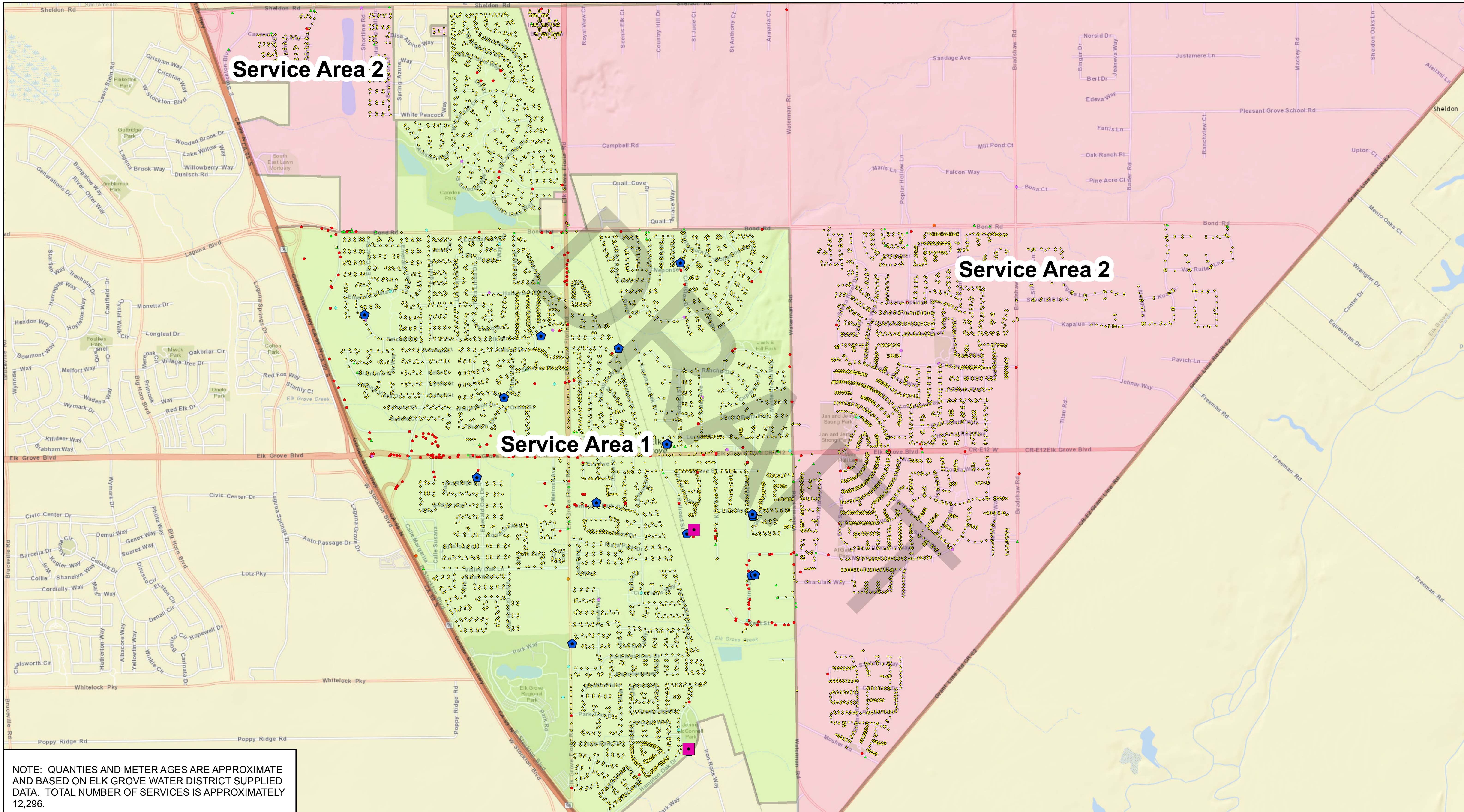
To complete the study, questionnaires were provided to staff to solicit input on current customer service, operations, and meter reading practices with a focus on potential efficiency gains that could be attributed to new meter reading technology and meter data management (MDM) capabilities. A summary of potential efficiency gains are presented in the sections that follow along with a comparison of AMI and AMR meter reading capabilities, meter data management functions, and a related business case for making an investment in AMR or AMI. Capital costs are compared for AMI and AMR and weighed against both monetary and qualitative benefits associated therewith.

Meter Population Statistics

As part of the investigations, MC Engineering solicited input in the form of historical meter billing data and related information on each customer meter. Table 1 below provides a breakdown by meter size category, the number of meters in each size category, and the relative amount of billed water for each category for the year 2014. A map of the various meters throughout the EGWD system is presented in Figure 1.

Table 1
Meter Population Size and Consumption History

2014 Meter Population Size and Consumption				
Meter Size	Meter Count	2014 Usage (HCF)	2014 Usage (Acre-Feet)	Percent of Billed Metered Consumption (HCF)
5/8” to 1”	11,834	2119810	4866	80.03%
1.5”	90	76146	175	2.87%
2”	327	255372	586	9.64%
3”	23	55961	128	2.11%
4”	19	75082	172	2.83%
6”	2	62038	142	2.34%
8”	1	4470	10	0.17%
Total System Billed Metered (HCF)		2,648,873		



NOTE: QUANTIES AND METER AGES ARE APPROXIMATE AND BASED ON ELK GROVE WATER DISTRICT SUPPLIED DATA. TOTAL NUMBER OF SERVICES IS APPROXIMATELY 12,296.

LEGEND

- 5/8" TO 1" METER
- 1.5" METER
- 2" METER
- 3" METER
- 4" METER
- 6" METER
- 8" METER
- SERVICE AREA 1
- SERVICE AREA 2
- PRODUCTION WELL
- WATER TREATMENT PLANT

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ELK GROVE WATER DISTRICT
AMI/AMR FEASIBILITY STUDY

Sheet Title:

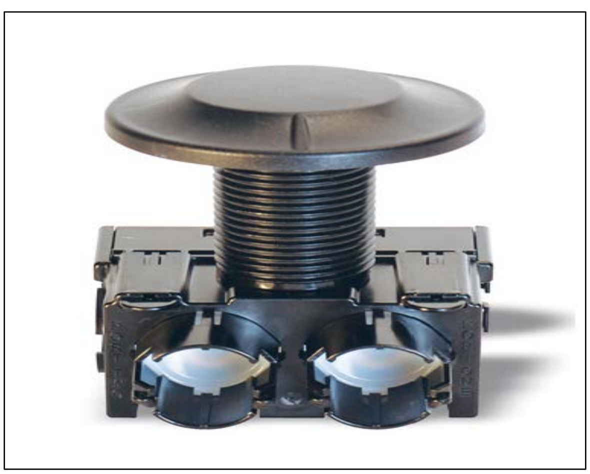
FIGURE 1 - District Wide System Characterization

Meter Retrofit Needs

The meters in the EGWD are well suited for conversion to radio read capabilities since they are currently read using a touch coupler that penetrates the meter box through a 1-3/4" diameter hole. When installing radios, the touch coupler is removed by unscrewing the nut at the base of the lid while a new meter transceiver unit (MXU) is installed in its place. Figure 2 below shows 2 examples of existing EGWD meter boxes with TouchRead technology. Figure 3 is a graphical representation of the MXU that will be installed in place of the existing TouchRead transceiver, assuming a Sensus radio is installed, along with a typical photo of an existing TouchRead meter box.

Figure 2
EGWD Typical Meter Boxes with Thru-pit Touch Pad

Figure 3
Sensus 520M FlexNet SmartPoint Radio Transceiver and Typical Installation



Field Survey and Related Findings

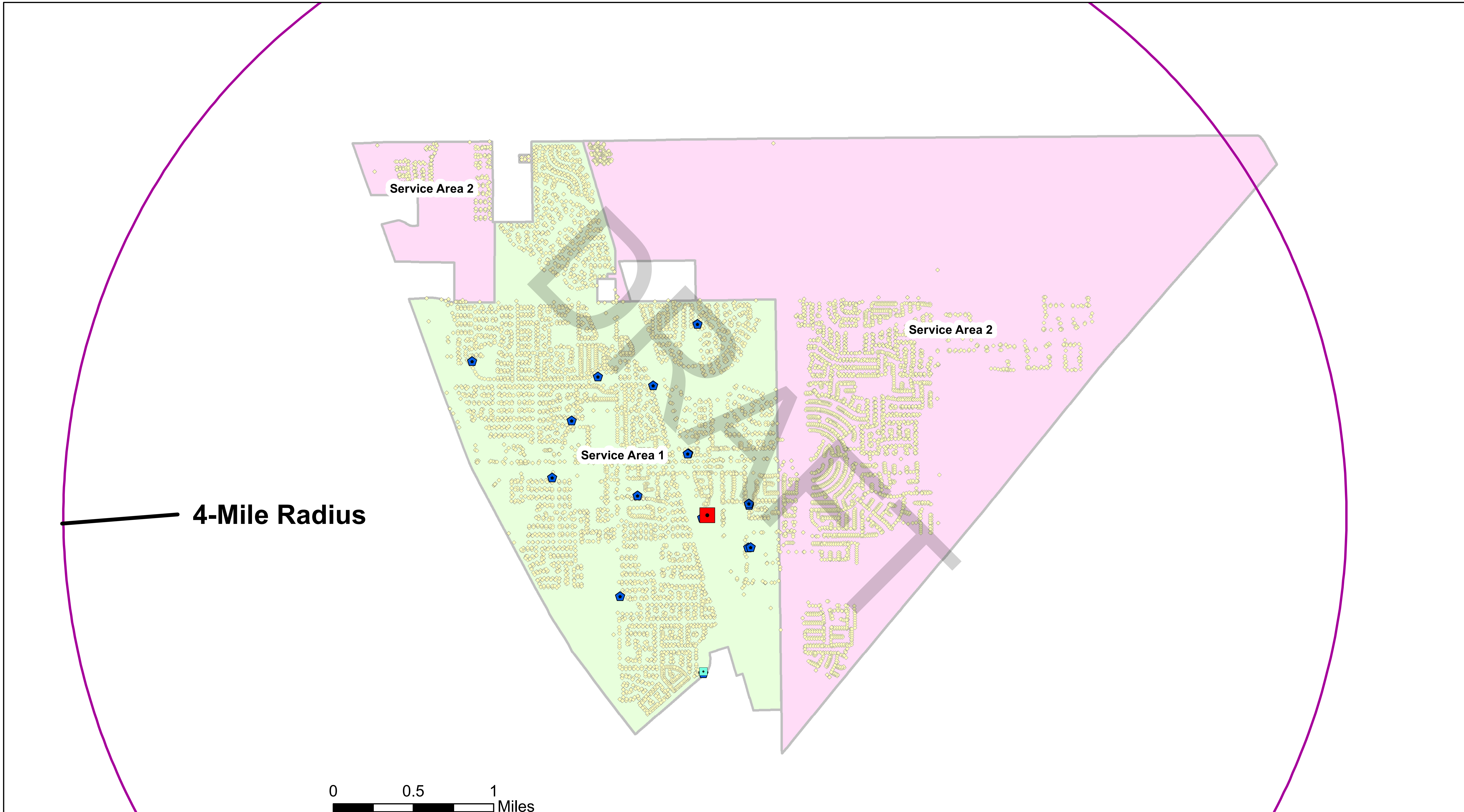
A field survey was conducted to document existing conditions within the EGWD system. A total of 22 meter locations were surveyed with meters ranging in size from 1-inch to 8-inch. The field survey consisted of documenting information such as meter type, meter size, meter serial number, meter condition, meter box type, meter box condition, meter box lid condition, and whether the meter lid had an existing TouchRead coupler. Pictures were taken of the meter, meter box, meter register, and relative location to the service address. When possible, flow was passed through the meter to observe the meter response time, whether the meter was registering low flows, and if the meter was functioning properly. Some of the findings of the field survey were presented in Workshop 2 and are summarized below:

1) All of the meter boxes and lids investigated were in good condition
2) All of the meters had an existing TouchRead coupler
3) 2 of the 22 meters surveyed were stuck and not functioning at all. Both of these meters are considered high usage meters based on the type of facility served
4) 1/3 of the meters surveyed were intermediate to large size Turbo meters. Turbo meters typically do not record low flow and are good candidates for testing and/or replacement with a more modern meter such as a Sensus Omni or a more accurate single jet meter.
5) One 8-inch Hersey compound meter did not respond to a low flow test which indicated a good potential for maintenance or replacement following a more formal test to confirm results.
6) In general it was determined that the District has good potential to recover Apparent Losses through a more detailed meter survey and testing program with an emphasis on repairing or replacing commercial meters, replacing existing turbo meters where appropriate, and focusing on meters that have exceeded their useful life.

Potential AMI Antenna Locations

The field survey also included determining possible locations for a potential future AMI tower/antenna and related collector. Four well locations were included in the field survey and while they are all viable candidates to be a potential location for the AMI antenna, a good location to consider would be the new 60' tower being built at the site of the existing Water Treatment Plant. As shown in Figure 4, a Sensus Tower Gateway Base Station (TGB) could be expected to effectively read meters within a 4-mile radius. Extending out from the water treatment plant it appears that one tower could effectively achieve this goal.

A variety of vendor solutions are described in more detail below. A more detailed propagation study would be required with each alternative prior to implementation and the number of collectors for other meter vendor AMI technologies will likely require significantly more antennas to effectively read all meters within the District.



LEGEND

- EXISTING METER LOCATIONS
- SERVICE AREA 1
- SERVICE AREA 2
- PRODUCTION WELL
- POTENTIAL ANTENNA LOCATION (WTP1)
- 4-MILE RADIUS
- WTP2

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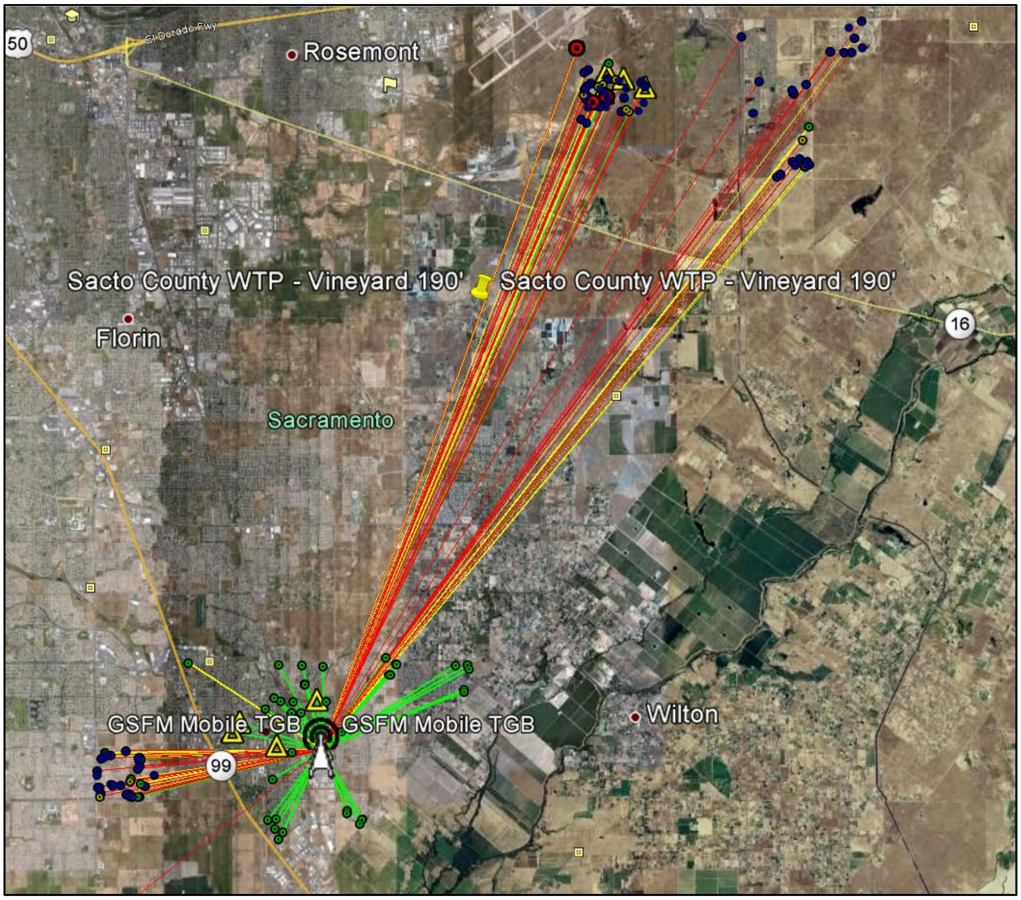
Sheet Title:

FIGURE 4 - Potential Antenna Location

Previous AMI Propagation Study

In April of 2010, Sensus performed a preliminary propagation study. A six corner approach was used and the study indicated that one tower would likely provide sufficient radio coverage for the entire district. Figure 5 below presents the extent and range of the TGB Antenna which read meters as far away as the Anatolia subdivision in Rancho Cordova located in the northeast portion of the figure.

Figure 5
April 2010 Propagation Study



Technology Considerations

Meter Reading Technology Alternatives

Water meters and meter reading technologies have evolved significantly over the past decade. These advances are being recognized and many utilities have converted from manual and touch read technology to implementing automated meter reading (AMR) or advanced meter reading infrastructure (AMI) solutions. Meters were predominantly read manually until around the early 1980s at which point water utilities began to install meters with solid state electronics that were able to accommodate the use of touch read systems. Beginning in the late 1990s and, in many cases still surviving as the preferred technology, new radios were developed that accommodated "drive by" AMR, thus eliminating the need to visit each customer location to read meters and providing an incremental reduction in the associated manpower requirements. More recently, the use of AMI systems has become a commonly accepted technology standard that provides even greater benefits and efficiencies.

Manual Read

District staff are not currently reading any meters manually. There are a number of disadvantages associated with reading meters in this fashion, the greatest being the amount of time required to complete a cycle. This approach requires meter readers to go to each physical location, lift lids, visually record register reads and enter them manually onto a handheld device. Some of the disadvantages associated with this method for meter reading include difficulty reading the meters that are often covered with dirt or submerged, increased potential for workman's comp claims due to injury, higher propensity for meter reading errors, and additional time requirements associated with having to drive or walk to each customer's meter location.

Touch Read

Currently, all meters in the EGWD system are read using a Sensus Touch Read system. Touch read technology offers benefits over manually reading meters because the reads are transferred electronically to a handheld device. By automating this process the meter reader can easily overlook anomalies such as a stuck meter if the handheld is not configured to alert to these conditions. The technology replaced manual reading for many utilities in the 1980s. Touch read capabilities accelerate the meter reading process and allow the meter reader to obtain an accurate reading even if the meter box is filled with dirt or deep within an underground pit or vault. It does not rely on radios and battery life like AMR or AMI. Additional efficiency gains were added to the current system in Elk Grove recently by optimizing the meter reading routes as part of a project with MC Engineering.

With the touch read system, meter reading data is downloaded to the utility billing office from handheld computers where it is used to generate customer bills. Although the meter reading process is accelerated with touch read technology, staff are still exposed to the elements and required to visit each physical location. Touch read does not offer as many benefits of radio reads with respect to an increasing number of meter data management capabilities and customer solutions.

Automatic Meter Reading (AMR)

Automatic Meter Reading is in many cases the preferred meter reading technology where topography creates issues with radio signals thus precluding the use of fixed base or AMI. AMR allows meter readers to drive within the general vicinity of a water meter with a device mounted in the vehicle to collect meter reads via radio transmissions. This greatly accelerates the meter reading process and it is estimated that one meter reader could easily obtain reads for all 12,300 meters within the District in one day with AMR.

AMR technology also improves employee health and safety by allowing staff to collect meter reads while remaining inside a vehicle. AMR minimizes the need for personnel to enter private property which is favorable for both customers and District employees. Some main disadvantages of AMR are that the reads are only available as often as the routes are read (i.e. monthly), there is no two-way communication capability, and real-time leak detection and alerting is not available. The incremental cost of installing a tower and moving to AMI is usually justified once all the radios are installed. The Sensus system currently relies on the 520M radio which can be used in both AMR and AMI applications. Given the flat topography and expected high performance of a fixed base AMI system in the EGWD, paying the incremental cost and installing an AMI system is recommended in this report as discussed further below.

Advanced Meter Infrastructure (AMI)

Advanced meter infrastructure (AMI) consists of "fixed base" antennas for intercepting radio reads from endpoints (meters), backhaul communications, and head end meter data management through an internet connected computer. AMI became the leading technology for reading meters in the early 2000s. To this day AMI has been gaining momentum and has been recognized by many in the industry as an important part of the future of water utility operations and management. Having survived several challenges associated with early versions of the AMI technology, the motivation for new systems has shifted from strictly considering labor savings associated with meter reading to emphasizing the benefits of the increased data availability and related meter data management (MDM) capabilities.

A variety of AMI systems are available today and, although similar in that meters are read from a fixed base, there are several important technology considerations. The most fundamental distinction has to do with the overall system architecture. The two basic structures are mesh (point to point), and star (point to multi-point) designs.

In a mesh system, meters communicate with each other and, in some cases, intermediate collectors, to convey meter reads to a common location where the data is transmitted back to the head end using a variety of options (typically radio or cellular communications). With meshed systems the meters can often communicate with each other and/or a variety of low power transceivers consisting of small antennas mounted on light poles, fire hydrants, or other strategic locations. Variables including the power of the radios in the meters, the type of frequency, and topography, often dictate the number of antennas needed for an AMI system. The number and type of collectors are important considerations, particularly since the collectors usually need a power source, communication medium, and potentially the acquisition of right-of-way or easements. Many organizations installing mesh type AMI systems have found that deploying a large number of antennas for the fixed base system is one of the biggest challenges.

With a star, or point to multi-point system, the collectors communicate with each end-point and may rely on a limited number of repeaters for receiving radio reads and polling or programming the meters remotely. Higher power systems often require fewer antennas but they may require greater heights and strategic placement to receive reliable readings.

Topography that provides a good line of sight from a central location is often conducive to cost effective fixed base designs. Mesh systems may have an advantage when peer to peer communications between meters can be used to offset limitations due to terrain, trees, buildings, and other obstructions. As a fallback, a hybrid approach that relies on both AMI and AMR transmitting capabilities may be the best approach in certain situations. In either case, the need to ensure good radio communications is of utmost importance.

Another major consideration with AMI system design is the level of communications between the head end and the endpoints that is accommodated by the system architecture. On-demand meter reads generally require two-way communications whereby the end user can query a meter and receive immediate feedback for up to date reads or re-programming. One way communications are typically based on the meter providing data to the end user on a pre-programmed interval. Other communications capabilities include:

- 1-1/2 Way: Full two-way communication between the controlling computer and the collectors but only one-way communication from the endpoint to the collector.
- 1-3/4 Way: A specific endpoint can be interrogated and respond but the endpoint cannot be reprogrammed through the controlling computer.
- 2-Way Variations:
    - Full two-way communication between the controlling computer and the endpoint but *only at scheduled intervals*, which prohibits interrogating a specific endpoint at will. This could be defined as "limited" 2-way communication.
    - Full two-way communication between the controlling computer and the endpoint. A specific endpoint can be interrogated and reprogrammed at will.

Regardless of the technology selected by EGWD, careful consideration should be taken to ensure compatibility with all existing meters. Experience has shown that having the same manufacturer for the meters and the AMI system has several benefits, primarily that there is only one vendor to look to when problems arise in the system. Given that the majority of the meters in the EGWD system are Sensus meters, a Sensus "Flexnet" fixed based AMI system was assumed for estimating purposes. If a Flexnet system is ultimately installed, EGWD will likely be able to read all of the meters in the District with one antenna. One antenna was thus assumed for estimating purposes. This should be confirmed based on an official propagation study that would form the basis of a contractual obligation for read reliability.

AMI vs. AMR Comparisons

There are several key considerations when assessing the merits of AMI and AMR technology. The table below lists various features and capabilities and compares the value provided by each technology. Items in green/teal are considered advantages whereas the red/rouge colored cells are considered disadvantages.

Table 2
AMR vs. AMI Benefits Comparison

Feature	AMI	AMR
Capital Cost	Added cost for tower, software, and server (or hosting service)	Lower cost (see business case analysis)
Recurring Costs	Backhaul communications fees (cellular), Higher technical support (IT costs), annual software and maintenance fees for collectors and servers	Limited recurring costs
Meter Data Availability	On-demand data (two-way communications with head end)	Monthly (or as needed based on drive-by schedule)
Customer Solutions	Enhanced Capabilities including: • Timely and accurate response to customer inquiries • Prompt notifications and alarms • Near real-time customer portal for increased awareness • Virtual "turn-ons" and "turn-offs" to reduce staff time	Limited Options for Viable Customer Solutions
Bill Date Flexibility	• Easily modified and spread out to eliminate one-time monthly work-load	Monthly (or as needed based on drive-by schedule)
Meter Data Analytics	• Accurate real-time data for modeling and planning purposes • Easily accommodates District Meter Areas (DMAs) • Enhanced Leak Detection	Limited to monthly consumption totals for subsequent analysis
Drought Response	• Real-time consumption data supports conservation pricing and enforcement of irrigation restrictions	Limited to monthly consumption totals for subsequent analysis

AMI and AMR Reliability Considerations

System reliability and data storage capability will vary by vendor. For example, a Sensus AMR system will typically include a new 520M MXU. The MXU can store from 1 week to one month of data depending upon data compression settings. For example, a register configured to read down to 1/10 of a cubic foot could result in approximately one week of storage whereas lower resolution will accommodate the greater storage intervals. For those installations with an iPERL meter, 39 days of storage can be achieved in the meter itself with 1 hour data resolution. For an AMI system using the Sensus TGB collector typical storage time is in the range of 30 days. Lastly, for the Sensus remote network interface (RNI) database server, Sensus typically provides up to two years of data storage. Downtime for the system would primarily be associated with loss of power to the collector. Those relying on a solar array would be subject to local weather conditions whereas collectors on grid power would be subject to the related utility power reliability and outage history. Battery backup for the collectors, to be relied on in the event of a power outage are typically sized for a minimum of three days of backup power.

Radio Communication Alternatives

AMR and AMI systems typically rely on either the 450 MHz radio spectrum or spectrums in the 900 MHz frequency range. These frequencies can either be licensed or un-licensed with the FCC. A primary license is provided with the Sensus AMI system thus accommodating up to 2 watts of power at the endpoint affording the opportunity to minimize the number of collectors and improve read rate reliability. Both Itron and Master Meter provide 3G cellular communications options. Costs for 3G cellular service can be up to $0.85 per read, thus adding considerably to the monthly costs for communicating meter reads. As the network providers transition to a 4G system the older 3G communications platforms will likely be obsolete. In general, radio reading technology using drive by or fixed base AMR in the 450 or 900 MHz frequency ranges will likely provide the lower long-term cost solution for systems with a large number of endpoints to read and communicate with on a regular basis. Cellular communications, on the other hand, can reduce initial capital costs and provide a viable solution to fill coverage gaps in service territories with a mix of urban, suburban, and rural geographies.

Examples of Leading Vendor AMI Technologies

As with any product, there tends to be a variety of options with a select few products distinguishing themselves as market leaders. For the purpose of this study, MC Engineering included analysis of 5 leading vendors with a brief summary of each technology discussed briefly below along with a picture of a typical endpoint and collector for each. A link to each vendor website is included in Table 4.

Aclara (STAR_select network): Aclara provides AMI solutions for the water, electric, and gas industry. Aclara MTUs transmit over the 450-470 MHz radio frequency over distances of about one mile, depending upon topology. The Aclara MTU is mounted under non-metallic lids. Multiple collectors would typically be required to effectively obtain reads from all endpoints within the EGWD service territory with an Aclara system. The MTUs typically communicates with at least three Data Collector Units (DCUs). These DCUs are typically mounted on utility poles or other convenient locations, some of which may need to include assets not belonging to the District and requiring a lease option and easement. Power to each DCU and backhaul communications from multiple units would need to be considered. This technology is often convenient for investor owned electric utilities, like PG&E, with established locations for providing power and mounting DCUs.

Itron (Water AMI Choice Connect): Itron water endpoints typically rely on their 100W ERT for transmitting data via a 900 MHz un-licensed frequency to a centrally located collector (CCU 100) coupled with their model 100 repeater units where necessary. The 100W can be connected to a thru the lid (TTL) antenna to improve signal strength. The 100 W is available with power outputs up to 1 watt. The 100W can communicate in both mobile (AMR) and fixed base (AMI) configurations. Itron is often used in conjunction with Badger meters but can be applied to others.

Sensus (Flexnet): The Flexnet AMI system by Sensus will typically rely on the 520M meter transmitting unit (MXU). The 520M MXU is presented above in Figure 3. The 520M transmits via an FCC primary use licensed 900 MHz frequency to a central collector with or without their metro repeater which is used in select installations where warranted by terrain, obstacles, or distance. The "M" in the 520M stands for migratable, meaning it accommodates both fixed-base and drive-by reading (AMR) capabilities. The primary license allows endpoints to communicate with up to 2 watts of power, thus accommodating longer range transmissions and fewer collectors than most competing products.

Mueller (Mi.Net): Mueller provides a variety of products for water systems including leak detection equipment, AMI, and related products. The Mueller AMI endpoint consists of their "Hot Rod" transmitter which is mounted on a PVC pipe under the lid. Range is limited to approximately 1200 feet. One innovative feature is their reliance on repeaters installed on hydrants that are used to boost signals for ultimately transmitting data to the head end. The Mueller repeaters typically consist of high capacity long-life battery packs with a 10-15 year life expectancy. The repeaters communicate with the Mi.Hub data collector with a range of 1 to 3 miles over a 900 mHZ radio frequency.

HOT ROD Transmitter

Neptune: Neptune utilizes the R450 System which is a two-way RF fixed network communications framework that operates in the 450-470 MHz licensed band. Using Neptune's R450 System, endpoints communicate with fixed network data collectors (DCs) which communicate to the host server via various backhaul options. The R450 MIU utilizes a C-cell battery that has a 20 year published warranty. The R450 utilizes a licensed frequency band with an output power between 100 mW and 1 Watt. Depending on environmental factors, the range of the system will cover multiple miles.

Master Meter: Master Meter has a variety of products that measure, collect and manage distribution system related device data. Their AMR system uses a standard Dialog 3G water meter register and Gridstream communication technology. Their Interpreter register design integrates the encoder register, RF transceiver, battery and antenna inside the register's stainless steel body - all "under the glass" for durable environmental protection in even the most harsh environments. The programmable design allows it to perfectly mimic the meter body's original register while delivering AMR technology without wires or connections.

AMI Software Options

All leading AMI vendors provide some level of meter data management software package for use with their standard AMI system. Rather than describe the various features for each vendor in detail a hyperlink is provided below to the website describing each vendor's standard offering. Additional, non-vendor specific, MDM solutions are described below under the section on Third Party Software Developers. Cost for vendor supplied software can be high, in some instances, and the add-on features such as customer portals for viewing monthly usage can often be provided by one of the third party software development companies at a lower cost. In all cases MDM software is quickly evolving and generally requires an investment in user specific configuration to provide the desired benefits which tend to vary for each utility customer. For more information click the hyperlinks below in Table 3.

AMI Vendor	Vendor AMI Software	Table 3, Hyperlink for Detailed Description
Aclara	STAR-prestige MDM	www.aclara.com/wp-content/uploads/309-R1-Aclara-STAR_prestige-MDM_12-14_R3.pdf
Itron	Water Analytics	www.itron.com/na/productsAndServices/Pages/water%20analytics.aspx#
Sensus	Logics	www.sensus.com/documents/10157/32152/Logic%20Meter%20Data%20Management%20Datasheet%20(DS-S-LOG-00-0112-01-A).pdf
Mueller	MiHost	www.muellersystems.com/docs/pdf2/MiHost11-09-2010.pdf
Neptune	R450/R900	www.neptunetg.com/Meter-Reading/The-N_SIGHT-Software-Suite/
Master Meter	MasterLinx	www.mastermeter.com/en/Masterlinx-Enterprise-MGMT-SW.html

Third Party Software Developers

A number of software solutions are emerging that leverage customer billing data using a cloud computing platform based on data fed from either real-time (AMI) or monthly (AMR) billing data. These solutions offer programming resources and software dedicated to meter data analytics that can be customized to interface with data files from the metered accounts for making better use of billing data, often more cost effectively than software provided by the meter vendor. Three examples are listed below along with highlighted features. A link is provided to the on-line company resources for complete information.

Aqua Hawk

www.aquahawkalerting.com

Aqua Hawk is a Web-based, customer portal solution for municipal utilities that use fixed base Advanced Metering Infrastructure (AMI) or Automated Meter Reading (AMR) systems. AquaHawk is a powerful customer service and efficiency application that water utilities can use to create a better customer experience. Some of the core features of the Aquahawk software include:

- Estimated bill to date calculations
- Usage threshold alerting
- Landscape watering guide
- Mobile device support
- Advanced leak detection notification
- Powerful graphic interface

Recent Reference: Dublin San Ramon Services District

Drop Counter

www.dropcountr.com

Dropcountr Software provides utility and software solutions in the form of their “Clear” software and related mobile apps, respectively. Clear is a powerful MDM solution that was co-designed with water utilities to provide analytics and a platform for customer engagement. The software provides a graphic overlay using Google maps as a background to display account locations and statistics. Some key questions easily answered include:

- Who were the highest users in the last month?
- Which accounts are trending upward on usage?
- How should we sort accounts by leak flags?
- How should we sort accounts by geography?
- How should accounts be filtered into accurate groups for messaging and follow-up reporting?
- How can we generate intuitive and detailed reports quickly?

The mobile app provides alerting and a convenient tool for establishing water budgets with solutions similar to those listed above for the Aqua Hawk software.

Recent Reference: Purissima Hills Water District

Water Smart

www.watersmart.com

One of the core features of the Water Smart software is to provide residential customers with personalized water reports that motivate and enable water use efficiency. Features include:

- A personalized home WaterScore every billing period
- Social norm-based, apples-to-apples comparison of water use with similar households
- Data insights to improve understanding of water use
- Customized, water-saving recommendations
- Targeted communications regarding investments, incentives, or other important utility messages

The emphasis for the Water Smart software is providing customers with benchmarks and comparisons to others within the community with similar landscape and occupancy characteristics. Many agencies have found that relying on social norms and comparisons is one of the most effective means for reducing water usage.

Recent References: City of Sacramento, East Bay Municipal Utility District (EBMUD)

Staff Workshops

Two key workshops were held with District staff to solicit input on anticipated customer service, billing, meter reading, and related operational processes that would potentially be impacted by the installation of a new meter reading system and related meter data management (MDM) capabilities. The first workshop, held on March 10, 2015 dealt with responses to a questionnaire submitted to staff to estimate current time spent on various functions such as processing high bill complaints, addressing move-ins and move-outs, etc. A list of related Customer Service impacts are summarized below in Table 4 along with anticipated reductions in staff time associated with each process that could potentially be attributed to implementing an AMR system. Related savings in field staff time for meter reading with an AMR system is summarized below in Table 5. Similar lists of related impacts and potential savings are summarized below in Table 6 and 7 for an AMI system.

Table 4
AMR Savings Analysis

Customer Service AMR Savings Analysis			
Customer Service Processes Affected by AMR	Approx. Staff Hours/Month	Estimated Percent Reduction Associated with AMR System	Annual Savings
On-Cycle monthly bill processing	30	25%	$4,140
On-Cycle Bill Exception processing	15	25%	$2,070
Call Center Activities and Customer Interface	160	20%	$22,080
Customer High Bill Complaints	1	80%	$442
Failed Meter Change-outs	3	25%	$414
Shut-offs and Turn-ons	10	15%	$828
Move-ins and Move-outs	5	15%	$1,242
Disconnect Checks	5	100%	$2,185
Delinquent Payment Processing	80	15%	$6,624
Theft	NA	15%	$0
		Total Annual Savings	**$27,993**

Table 5
AMR Field Staff Savings Analysis

Field Staff AMR Savings Analysis		
Parameter	Cost	Savings as a result of AMR
Meter Reading	$58,608	$55,766
Other staff impacts	$11,133	$5,567
District Vehicle Mileage	-	$0
	Total Savings:	**$61,333**

Table 6
AMI Savings Analysis

Customer Service AMI Savings Analysis			
Customer Service Processes Affected by AMI and New Meters	**Approx. Staff Hours/Month**	**Estimated Percent Reduction Associated with AMI System**	**Annual Savings**
On-Cycle monthly bill processing	30	25%	$4,140
On-Cycle Bill Exception processing	15	25%	$2,070
Call Center Activities and Customer Interface	160	25%	$22,080
Customer High Bill Complaints	1	80%	$442
Failed Meter Change-outs	3	25%	$414
Shut-offs and Turn-ons	10	15%	$828
Move-ins and Move-outs	5	15%	$1,242
Disconnect Checks	5	100%	$2,185
Delinquent Payment Processing	80	15%	$6,624
Theft	NA	15%	$0
		Total Annual Savings	**$31,489**

Table 7
AMI Field Staff Savings Analysis

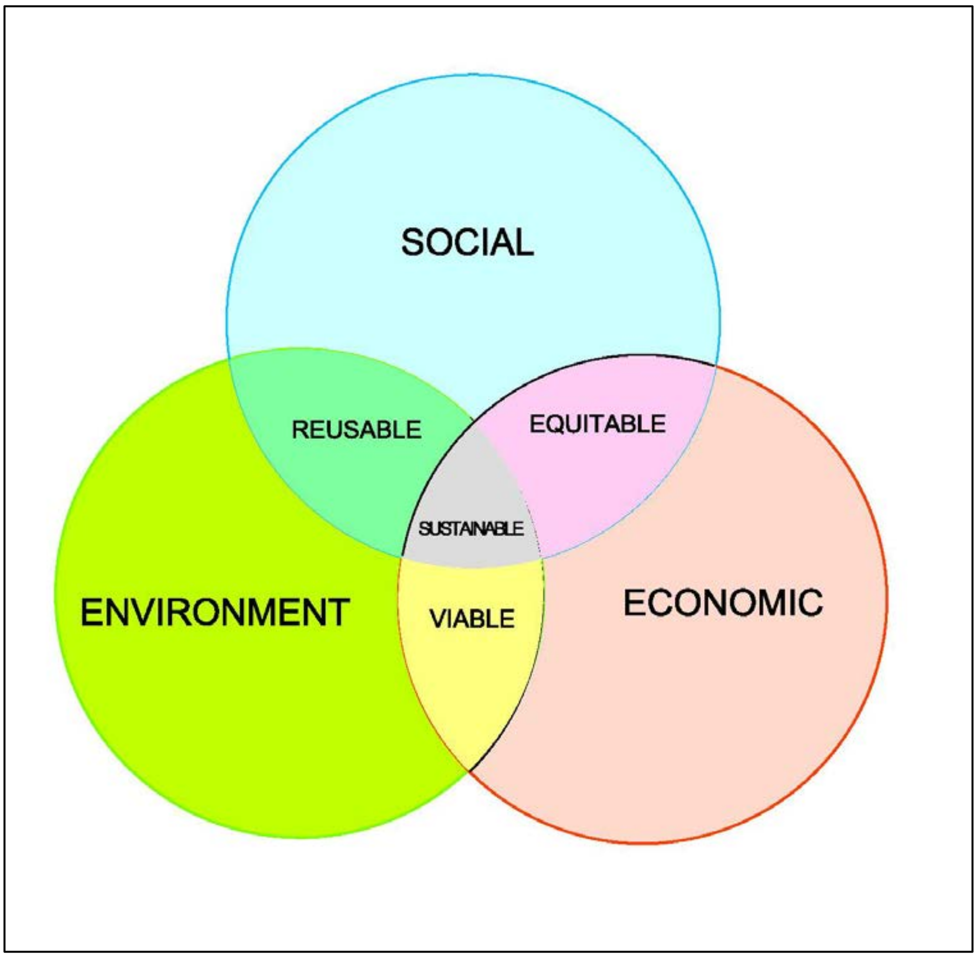
Field Staff AMI Savings Analysis		
Parameter	**Cost**	**Savings as a result of AMI**
Meter Reading	$58,608	$58,608
Other staff impacts	$11,133	$5,567
District Vehicle Mileage	-	$660.00
	Total Savings:	**$64,835**

A factor common to both AMR and AMI systems is a reduction in staff time for reading meters. In the case of an AMR system, staff will no longer need to touch each box and instead will simply need to drive within close proximity of the meter box to collect reads. Currently, the touch read process requires an average of 165 man hours per month to complete a meter reading cycle. With an AMR system it is estimated that this would be reduced to 8 hours each month. With a fixed base AMI system, the meter reading time would be virtually eliminated with the exception of re-reads that may occasionally occur. Potential for re-reads are considered a common factor to all meter reading strategies.

For estimating purposes, it is assumed that an AMR system would save approximately 157 hours per month valued at approximately $55,766 annually. Savings for an AMI system for eliminating meter reading is estimated at 165 hours per month or a savings of $58,608 annually. These savings, along with the monetary savings identified in Tables 6 and 8 above are used below in the related business case analysis for evaluating the feasibility of implementing either technology versus leaving the current touch-read system in-place.

A second workshop was held with staff on April 2, to review the non-monetary impacts that could be attributed to installing an AMI system. Some of the benefits listed would apply to both AMR and AMI technology and are noted as such in the summary worksheets found in Appendix A. This workshop was structured around three matrices designed to spur discussion and solicit feedback on what are referred to as "Triple Bottom Line" impacts. Those attributes are inter-related as presented in the Venn diagram below and they deal with the social, economic, and environmental impacts that implementing an AMI meter reading system might have on the District.

Figure 6
Triple Bottom Line Assessment Matrix



The Importance Ranking Criteria that were used to rank the impacts are presented in Table 8 below. These ranking criteria were developed based on staff input for each features listed in Tables 9, 10, and 11.

Table 8
Importance Ranking Criteria

Importance Ranking Criteria:	
1	Marginally Important
2	Should be Considered
3	High priority
4	Considered a Top Priority

The top ranking considerations from the triple bottom line discussion are presented below in Table 10 along with a brief description of the feature and notes made during Workshop No. 2 based on staff input.

Table 9
Top Ranking Considerations

TBL Category	TBL Consideration	Importance	Feature/Benefit Description	Notes
Social	Customer Service/Solutions (Leak Detection and Budgeting)	4	Two way meter communications, web portals, customer interface and alerting	Alerts can be linked to emails, automated phone calls, etc.
Social	Customer Satisfaction	4	Improved communications and billing practices for improved relations	Goal is to minimize truck rolls for customer visits
Social	Employee Satisfaction	4	Eliminating touch-read can improve employee satisfaction, minimize staff turnover rates, and reduce injury	-Frees 2 people full time from meter reading -Improves Safety -Eliminates backyard reading and dog threats
Social	Employee Changes	3	Re-allocation of staff and training on new technology	Staff can be re-allocated to proactive leak detection meter maintenance
Env./Econ	Water Use Efficiency	3	AMI allows the district to monitor target allocations during drought	Public perception of being monitored

	(Conservation Programs)		conditions along with providing customers with real-time data.	could cause concerns
Soc./Econ	Planning and Engineering	3	DMAs and usage profiles provide valuable data for infrastructure assessment	Cost to put in additional sub-metering must be considered

The highest ranking benefits for the triple bottom line matrix included enhanced customer solutions, better customer service, and improved employee satisfaction. Although these benefits are listed by a qualitative ranking only, each of these high priority items would have added monetary benefits if one were to consider the value of a satisfied customer and improved employee morale and retention.

Workshop No. 2 also included soliciting input related to potential risks that could be experienced with the adoption of new AMI meter reading technology. The top ranking considerations from the District staff perspective are listed below in Table 11 along with brief notes and mitigation measures discussed with staff.

Table 10
Top Risk Considerations

Operational Risks	Importance	Utility Implications	Notes	Mitigation Measures
Poor Vendor Performance	3	Extensive vendor support required (planning, implementation and operations)	District is dependent upon for support	Good contract language and good vendor history of customer service should be verified in advance
Loss of "Boots on the Ground"	3	Staff will no longer be visiting each meter which reduces field awareness	Currently feedback is provided on problematic accounts by meter readers	Analytics of AMI can help mitigate the loss of boots on the ground

Lastly, in the event the District elects to install radio read transceivers and a related AMI system with MDM functions, there are issues that will be presented during the implementation and data integration phase. These impacts are expected to be minimized to some degree by relying on seasoned District personnel to deploy the MXUs over a relatively short time period. The top considerations, from the District staff's perspective, are listed below in Table 12 along with a related notes and mitigation measure for each concern.

Table 11
Top Implementation Considerations

Implementation Considerations	Importance	Utility Implications	Notes	Mitigation Measures
Software Requirements	3	Billing, utility solutions, customer solutions, third party software	Leverage available customer solutions	Interview variety of software providers and verify TruePoint billing system compatibility with new system
Procurement Process and Financing	3	Funding by performance model, bonds, existing CIP, etc. affect ROI	no debt to be issued	Grant funding potential should be explored and capital costs prioritized against other projects in the CIP
Meter Data Management Strategy	3	Third party software support, customer solutions, GIS needs, etc.	Implement appropriate third party solutions	Interview a variety of third party providers and compare service and cost to vendor provided options

Business Case Analysis

The business cases that follow include three scenarios. The first scenario considers implementing an AMR system with some limited analytics in the form of a third party software customer solution and related analytics. This case assumes that drive-by meter reading of the entire meter population can be completed in one day. Under scenario 2, an AMI system is considered with the benefits from eliminating meter reading entirely along with a full host of related process improvements as identified above in Table 7. The third scenario is an extension of scenario 2 with the added benefits of a proactive leak detection program whereby 25% of the Real Losses are recovered and an estimated 50% of the Apparent Losses are eliminated through a proactive meter testing and replacement program. A more thorough discussion on each alternative along with the corresponding capital costs, anticipated benefits, and a business case are summarized below. Each scenario includes a discount rate of 1.00%, estimated annual inflation rate and operational cost increases of 3.00%, a rate of financing of 4.00%, and a 20 year finance term. Each scenario also assumes a capital contribution of $1,000,000. This contribution may be in the form of a grant or other financing mechanism.

Alternative 1, Install AMR System and Limited MDM Software Features

Under this scenario, the existing Touch Read pads would be replaced with radio transceivers and a third party software would be implemented to provide enhanced customer solutions and meter data management. This scenario has the benefit of reducing current meter reading times from 20.5 days to being able to read all meters in one day. Because the billing data will be compiled quicker and in a cohesive database format it is anticipated this will help accommodate the successful development of third party software solutions including a customer portal and easy access and manipulation of billing data for internal process improvements. No meter register retrofits were considered with this alternative. Table 12 below presents a summary of the costs associated with implementing an AMR system while Table 13 presents an overview of the Cost Benefit Analysis. For a more detailed breakdown of the cost estimate and the cost benefit analysis see Appendix C

Table 12
AMR Cost Summary

EGWD Preiminary Cost Estimate AMR System	
Bid Item	**Cost**
District-Wide	
AMR Implementation	$48,000
Transceiver Costs	$1,967,360
Additional Costs	$388,317
Total Cost	**$2,403,677**

Table 13
AMR Cost Benefit Analysis

EGWD AMR Cost Benefit Analysis			
Project Start Date:	2015		
Total Project Cost:	$2,403,677 (see note 5)	Discount Rate:	1.00%
City Annual Capital Contribution:	$0	Estimated Annual Rate Increase:	3%
Customer Funded Meter Contribution:	$1,000,000	Estimated Operational Cost Increases:	3%
Total Cost to Finance:	$1,403,677		
		20 year Net Present Value:	-$49,208
Rate of Financing:	4.00%	20 year Internal Rate of Return:	-2.75%
Term of Financing:	20	Simple Payback (years):	26.9

Alternative 2, AMI System without Reductions in Real and Apparent Losses

This option includes upgrading the current Touch Read system to an AMI system by installing radios in place of all existing touch read pads. The following items were taken into consideration when developing the business case:

1) Any meter that is 10 years old or older would need to be retrofitted with an updated register that is AMI compatible and capable of registering flows in 1 CF increments to facilitate AMI based leak detection. Older registers that may be AMI compatible typically only register down to 100 CF accuracy.
2) A new Transceiver would need to be installed in all 12,300 meters
3) A meter replacement program is not included in this analysis
4) Infrastructure repairs to leaking pipes are not included in this analysis
5) Leak detection or any other kind of water loss analysis is not included in this analysis

A draft cost estimate and a cost benefit analysis has been included with this study in Appendix C. A summary of the draft cost estimate and cost benefit analysis are presented below in Tables 14 and 15.

Table 14
Base AMI Cost Summary (Alternative 2)

EGWD Preiminary Cost Estimate Base AMI System	
Bid Item	**Cost**
District-Wide	
AMI Implementation	$112,250
Register Retrofit Costs	$476,805
Transceiver Costs	$1,967,360
Additional Costs	$489,918
Total Cost	**$3,046,333**

Table 15
Base AMI Cost Benefit Analysis (Alternative 2)

EGWD Base AMI Cost Benefit Analysis			
Project Start Date:	2015		
Total Project Cost:	$3,046,333 (see note 5)	Discount Rate:	1.00%
City Annual Capital Contribution:	$0	Estimated Annual Rate Increase:	3%
Customer Funded Meter Contribution:	$1,000,000	Estimated Operational Cost Increases:	3%
Total Cost to Finance:	$2,046,333		
		20 year Net Present Value:	-$830,222
Rate of Financing:	4.00%	20 year Internal Rate of Return:	See note 7
Term of Financing:	20	Simple Payback (years):	32.5

Alternative 3, Install AMI Concurrent with Proactive Leak Detection and Meter Accuracy Improvements

This alternative includes the same options as identified for Scenario 2 with the addition of the following items:

1) Implementing a proactive leak detection program with a goal of reducing Real Losses by a minimum of 25%. The estimated added benefits for this component is valued at 25% of the value of assumed Real Losses for Service Areas 1 and 2 combined.

2) Strategically replacing meters with high historical usage and meters in conjunction with a proactive meter targeting, testing, and replacement program with the goal of eliminating 50% of the Apparent Losses. The estimated added benefits for this component is valued 50% of the value of assumed Apparent Losses for Service Areas 1 and 2 combined.

A draft cost estimate and a cost benefit analysis has been included with this study in Appendix B. A summary of the draft cost estimate and cost benefit analysis are presented below in Tables 16 and 17.

The cost of upgrading to an AMI system and reducing losses is estimated at approximately $3.5 M and the simple payback based on operational efficiency gains, increased revenues, and recovered water is 18.1 years.

Table 16
AMI Cost Summary (Alternative 3)

EGWD Preiminary Cost Estimate Full AMI System	
Bid Item	**Cost**
District-Wide	
AMI Implementation	$112,250
Meter Installation	$95,040
Register Retrofit Costs	$476,805
Transceiver Costs	$1,967,360
Additional Costs	$507,500
Total Cost	**$3,158,955**

Table 17
AMI Cost Benefit Analysis (Alternative 3)

EGWD Water Meter Full AMI Project Cost Benefit Analysis			
Project Start Date:	2015		
Total Project Cost:	$3,158,955 (see note 5)	Discount Rate:	1.00%
City Annual Capital Contribution:	$0	Estimated Annual Rate Increase:	3%
Customer Funded Meter Contribution:	$1,000,000	Estimated Operational Cost Increases:	3%
Total Cost to Finance:	$2,158,955		
		20 year Net Present Value:	$1,307,271
Rate of Financing:	4.00%	20 year Internal Rate of Return:	See Note 7
Term of Financing:	20	Simple Payback (years):	16.2

Benefits of AMI on Water Conservation

AMI facilitates water conversation through a two-fold approach, one focused on improved utility operations and a second that is based in increased customer awareness. When coupled with the appropriate meter data management software capabilities, AMI provides powerful tools for water purveyors to look at the system as a whole, easily identify anomalies, and manage water losses in real time. By employing a customer portal with alerting capabilities, customers are able to quickly analyze their individual water use, set targets, and improve their overall awareness of behavioral impacts on water use.

Real time consumption data can be analyzed by the water utility to compare differences between system input volume and customer consumption while using this same data for a variety of other enterprise-wide solutions. The proliferation of real time data allows investigations to be conducted to pinpoint where the Real or Apparent losses are occurring while identifying locations where the system is stressed throughout daily operations. Policies aimed at reducing water use during critical irrigation periods can be readily analyzed and enforced using AMI by comparing base line consumption with irrigation use and easily flagging accounts in violation of target consumption goals and drought response programs.

The ability to record hourly data is exclusive to AMI technology. Unlike AMR which only provides one monthly read, the more granular AMI data provides customers with the ability to truly understand daily consumption patterns. The benefits of this improved customer engagement have less tangible metrics to assign, although these should not be discounted. Most individuals are concerned with water conservation and the analytics provided by AMI allows them to address their water consumption throughout the day as compared to a monthly snapshot. Customer complaints of high water bills are often more easily resolved. By providing actual data related to consumption for irrigation, showering or other habits the related behaviors can be revised in response.

Conclusions and Recommendations

AMI is becoming the industry standard for efficient water utility operations. This has become increasingly evident in the recent drought experienced in California. A well operating, fully configured AMI system and related software can drive efficiencies and facilitate water conservation at both the utility and customer level. Utilities are more able to track consumption for each account and customers are provided with in-depth insights into their daily consumption profile. Given the importance of measuring and tracking water usage, minimizing losses, and increasing efficiencies, it is recommended that the District consider implementing an AMI project.

When compared to many similar sized utilities, the EGWD meter reading, customer service, and field crews are operating relatively effectively using the existing touch-read system. The preliminary water audits, field investigations, and staff workshops indicate that improvements can be made through improved meter reading to reduce non-revenue water and improve operational efficiency. The three business cases presented above produced similar rates of return and simple payback periods for the AMR (Scenario 1) and AMI (Scenario 2) alternatives, both of which have payback periods in the range of 30 years which exceeds the useful life of the equipment. To the extent the District elects to factor in reductions in both Apparent and Real Losses, along with corresponding monetary benefits, the rate of return and payback period for AMI are more favorable. A summary of the financial analysis for each of the three alternatives considered in presented below in Table 18.

Table 18
Summary of Benefit Cost Analysis

EGWD Summary of Benefit Cost Analysis					
Scenario	**Capital Cost**	**Annual Benefit**	**NPV**	**IRR**	**Simple Payback**
1	$2,403,677	$89,236	-$49,208	2.75%	26.9
2	$3,046,333	$93,624	-$830,222	NA[1]	32.5
3	$3,158,955	$195,040	$1,333,321	NA[2]	16.2

[1]Unable to calculate Rate of Return due to low benefits relative to project capital costs.

[2]Unable to calculate Rate of Return due to high benefits relative to project capital costs and 20 year interest rate.

As indicated above, installing AMR has lower capital costs than either of the two AMI options which is expected. The relatively high difference in cost between Scenarios 1 and 2 ($642,656) is due to both the added cost for AMI infrastructure and, more importantly, the added cost to retrofit an estimated 5,019 registers in order to have solid state registers with 1 cubic foot accuracy on all existing meters. This added cost for register retrofits, estimated at $476,805, was determined based on the install date being more than 10 years old as obtained from the District's GIS data. Additional confirmation of the number of existing mechanical registers should be completed along with verification of the District's commitment to having leak detection down to 1 cubic foot accuracy. Replacing these older registers concurrent with the endpoint installation is recommended since there will be economy of scale for both labor and materials.

It is recommended that the district implement Alternative 2 or 3 for an AMI system to leverage the benefits of analytics it provides. Alternative 3 includes both higher capital costs and added benefits from replacing aging meters that are currently out of warranty or inappropriately typed or maintained along with actively reducing water losses through a combination of leveraging AMI technology and implementing proactive leak detection to repair leaking pipes. Despite the higher capital costs, the added benefits with Scenario 3 result in more favorable financial performance indicators by reducing water losses (Real and Apparent) while reaping the non-monetary benefits identified in the Tables 10, 11, and 12 above during Workshop No. 2.

The business cases reflected above include a negative number for the net present value for alternatives 1 and 2 along with a negative return on investment for both alternative 1 and 2 when assessing these options from a net cash flow perspective. Alternative 3 includes a positive rate of return of 20 year net present value of $1,307,271 indicating it would be a viable investment from a financial perspective provided the added benefits associated with reducing non-revenue water are realized.

Aside from the monetary implications presented in the business cases above, the District should include weighing the more qualitative social, economic, and environmental factors when determining the viability of either option. When coupled with the goals of minimizing water losses, improving employee retention, and increasing customer satisfaction, there is a good case for moving forward with an AMI installation. The project viability can be improved to the extent costs are reduced through a combination of possible grant funding, reductions in installation costs from endpoint installation by District crews, and other non-monetary benefits.

APPENDIX A

Triple Bottom Line Evaluation Matrix

Elk Grove Water District
AMI Evaluation Matrix

Triple Bottom Line Evaluation

TBL Category	TBL Consideration	Importance	Feature/Benefit Description	Notes	Mitigation Measures
Social	Customer Service/Solutions (Leak Detection and Budgeting)	4	Two way meter communications, web portals, customer interface and alerting	Alerting Access-email,phone call	
Social	Customer Satisfaction	4	Improved communications and billing practices for improved relations	Reduce visit time to houses	
Social	Employee Satisfaction	4	Eliminating touch-read can improve employee satisfaction and reduce injury	Frees 2 people full time meter reading Improves Safety-Backyard Reading-Dogs	
Social	Employee Changes	3	Re-allocation of staff and training on new technology will be needed	Leak Detection Meter Maintenance	
Environmental	GHG/CO2 Reductions	1	Greenhouse gas reductions available by reducing driving and water losses	On foot or bicycle	
Env./Econ	Water Use Efficiency (Leak Detection)	1	Leak detection can be deployed with AMI for monitoring and tracking Real Losses in the system	Stand alone leak detection may be more viable	
Env./Econ	Water Use Efficiency (Conservation Programs)	3	AMI can be used to monitor target allocations during drought conditions	Public perception of being monitored	
Soc./Econ	Planning and Engineering	3	DMAs and usage profiles provide valuable data for infrastructure assessment	Cost to put in additional sub-metering	
Soc./Econ	Rate Case Analysis	2	Detailed usage information can be used to set optimal rate policies	Future potential but not current	

Importance Ranking Criteria:		
	1	Marginally Important
	2	Should be Considered
	3	High priority
	4	Considered a Top Priority

Elk Grove Water District
AMI Evaluation Matrix

Operations Risk Review

Operational Risks	Importance	Utility Implications	Notes	Mitigation Measures
Staff Re-allocation	1	Reduction in meter reading time and customer call center activities	Fear of job displacement	Meter Readers are cross-trained Potential benefits
Loss of Meter Equipment Diversity	2	AMI/AMR requires on-going commitment to a specific vendor	For established vendors/lower risk	
Lack of Customer Buy-in	2	Threat of customer fears (i.e. PG&E history with issues on radio reading)	Risk tempered by drought	
IT/Data Reconciliation Workload	4	Increased data management and IT workload can be expected	Currently Contracted	Potentially transfer to full time position
Radio Transmission Errors	2	Not all radios will be read due to transmission errors	Technology dependent	Appropriate propagation study Radio communication strategy
Poor Vendor Performance	3	Extensive vendor support required (planning, implementation and operations)	Dependent upon other parties for support	Good contract language Good vendor history of customer service
Loss of "Boots on the Ground"	3	Staff will no longer be visiting each meter which reduces field awareness	Currently feedback is provided on problematic accounts	Analytics of AMI can offset
AMI Vendor Company Viability	2	Company solvency and major long-term consideration with a 20 year min. term	Vendor dependent	Contract with stable company

Importance Ranking Criteria:		
	1	Marginally Important
	2	Should be Considered
	3	High priority
	4	Considered a Top Priority

Elk Grove Water District
AMI Evaluation Matrix

Implementation Considerations

Implementation Considerations	Importance	Utility Implications	Notes	Mitigation Measures
Implementation Strategy/Schedule	2	Time to implement and contractor vs. staff installation	In house crews to implement	Appropriate training/freeing up staff
Meter Compatibility	1	Register compatibility, boxes, lids, etc.	Largely AMI compatible	
Performance Requirements	2	Vendor qualifications, propagation study, reading accuracy, etc.	Flat terrain conducive to good radio propagation	
Software Requirements	3	Billing, utility solutions, customer solutions, third party software	Leverage available customer solutions	Interview variety of software providers Investigate Truepoint compatibility with reading
RFP and Bid Requirements	2	Sole source vs. competitive bidding, agency vs. contractor responsibilities	Minimized by staff labor and existing legacy systems	add or equal language to contracts
Procurement Process and Financing	3	Funding by performance model, bonds, existing CIP, etc. affect ROI	no debt to be issued	Grant funding potential Prioritized against other projects in the CIP
Process and Performance Review	2	Quality control and integration requirements	minimized by utilizing in-house staff	
Installation Schedule and Controls	1	Project duration and integration period affects ROI and impacts operations	High-performance in-house crews to do install	Financial concerns dominate timing
Network Design	1	Hosted vs. non-hosted, new computers and servers, etc. must be determined	Recommend hosted service	Verify firewall and security and consider hosted costs.
Meter Data Management Strategy	3	Third party software support, customer solutions, GIS needs, etc.	Implement appropriate	
Construction/Installation	1	Contractor requirements and support	self-install	
Contract Management	1	Outside CM needs, staff commitment, etc.	in house ta	

Importance Ranking Criteria:		
	1	Marginally Important
	2	Should be Considered
	3	High priority
	4	Considered a Top Priority

APPENDIX B

Cost Benefit Analysis

APPENDIX B-1

AMR Cost Benefit Analysis

EGWD Preiminary Cost Estimate AMR System					
Bid Item	**Res/ Com**	**Quantity (EA.)**	**Unit Price**		**Cost**
			Material/Installation		
City-Wide					
VGB (Hardware, Software, GPS Mapping)	Res/Com	1	$45,000		$45,000
Annual Support	Res/Com	LS	$1,900		$1,900
AMR Training	Res/Com	LS	$1,100		$1,100
Service Area 1 and 2					
Transceiver	Res/Com	12,296	$135	$25	$1,967,360
			Sub-Total Cost		**$2,015,360**
Materials Tax[1](8.00%)					$136,397.00
Engineering/Project Management (7.5%)					$151,152.00
Contingency (5%)					$100,768.00
			Total Cost		**$2,403,677**

[1]Based on City of EGWD 2014 Sales Tax. Cost only factored on Materials

EGWD AMR Cost Benefit Analysis - Alternative 1

Project Start Date:	2015		
Total Project Cost:	$2,403,677 (see note 5)	Discount Rate:	1.00%
City Annual Capital Contribution:	$0	Estimated Annual Rate Increase:	3%
Customer Funded Meter Contribution:	$1,000,000	Estimated Operational Cost Increases:	3%
Total Cost to Finance:	$1,403,677		
		20 year Net Present Value:	-$300,238
Rate of Financing:	4.00%	20 year Internal Rate of Return:	-2.88%
Term of Financing:	20	Simple Payback (years):	30.2

Year	Capital (1)	Water Revenue Increase (2)	Operational Savings (3)	Leak Detection Savings (4)	Total Annual Benefits	Annual Debt Service	Ongoing Server and Maintenance Fees(6)	Total Annual Cost	Net Present Cash Flow	Cummulative Cash Flow	Year
1	$0	$0	$79,472	$0	$79,472	$103,285	$20,000	$123,285	-$43,813	-$43,813	2015
2	$0	$0	$81,856	$0	$81,856	$103,285	$20,000	$123,285	-$41,429	-$85,242	2016
3	$0	$0	$84,312	$0	$84,312	$103,285	$20,000	$123,285	-$38,973	-$124,215	2017
4	$0	$0	$86,841	$0	$86,841	$103,285	$20,000	$123,285	-$36,444	-$160,659	2018
5	$0	$0	$89,446	$0	$89,446	$103,285	$20,000	$123,285	-$33,839	-$194,498	2019
6	$0	$0	$92,130	$0	$92,130	$103,285	$20,000	$123,285	-$31,155	-$225,653	2020
7	$0	$0	$94,894	$0	$94,894	$103,285	$20,000	$123,285	-$28,391	-$254,044	2021
8	$0	$0	$97,741	$0	$97,741	$103,285	$20,000	$123,285	-$25,545	-$279,589	2022
9	$0	$0	$100,673	$0	$100,673	$103,285	$20,000	$123,285	-$22,612	-$302,201	2023
10	$0	$0	$103,693	$0	$103,693	$103,285	$20,000	$123,285	-$19,592	-$321,793	2024
11	$0	$0	$106,804	$0	$106,804	$103,285	$20,000	$123,285	-$16,481	-$338,274	2025
12	$0	$0	$110,008	$0	$110,008	$103,285	$20,000	$123,285	**-$13,277**	-$351,552	2026
13	$0	$0	$113,308	$0	$113,308	$103,285	$20,000	$123,285	**-$9,977**	-$361,529	2027
14	$0	$0	$116,707	$0	$116,707	$103,285	$20,000	$123,285	**-$6,578**	-$368,106	2028
15	$0	$0	$120,209	$0	$120,209	$103,285	$20,000	$123,285	**-$3,077**	-$371,183	2029
16	$0	$0	$123,815	$0	$123,815	$103,285	$20,000	$123,285	**$530**	-$370,653	2030
17	$0	$0	$127,529	$0	$127,529	$103,285	$20,000	$123,285	**$4,244**	-$366,409	2031
18	$0	$0	$131,355	$0	$131,355	$103,285	$20,000	$123,285	**$8,070**	-$358,339	2032
19	$0	$0	$135,296	$0	$135,296	$103,285	$20,000	$123,285	**$12,011**	-$346,328	2033
20	$0	$0	$139,355	$0	$139,355	$103,285	$20,000	$123,285	**$16,070**	-$330,258	2034
21	$0	$0	$143,535	$0	$143,535	$103,285	$20,000	$123,285	**$20,250**	-$310,008	2035

Notes and Preliminary Savings Related Assumptions:

(1) $1,000,000 capital infusion is included.
(2) This analysis assumes no water revenue increases
(3) Operational savings assume $61,333 in field staff savings. Other misc. savings include savings related to reducing re-reads, improved billing related services, and other related savings.
(4) No Leak Detection related savings or revenue increase from improved meter accuracy was assumed in this analysis.
(5) The total project cost is based on installing 12,296 new Transceivers. A VGB is included in the cost along with training, computer software, and hardware.
(6) Costs to be verified subsequent to vendor prices that will need to be verified in response to a future replacement project RFP.

APPENDIX B-2

Base AMI Cost Benefit Analysis

EGWD Preiminary Cost Estimate
Base AMI System

Bid Item	Res/ Com	Quantity (EA.)	Unit Price		Cost
			Materials	Installation	
City-Wide					
AMI Collector (Base Station)	Res/Com	1	$33,000	$25,000	$58,000
AMI Hardware (ECHO)	Res/Com	2	$5,000	$1,800	$13,600
AMI Software	Res/Com	1	$33,750		$33,750
AMI Training	Res/Com	1	$6,900		$6,900
Service Area 1 & 2					
<=1-inch Register Replacement	Res/Com	4,878	$85	$10	$463,410
1.5-inch Register Replacement	Res/Com	39	$85	$10	$3,705
2-inch Register Replacement	Res/Com	88	$85	$10	$8,360
3-inch Register Replacement	Res/Com	2	$85	$10	$190
4-inch Register Replacement	Res/Com	9	$85	$10	$855
6-inch Register Replacement	Res/Com	2	$85	$10	$190
8-inch Register Replacement	Res/Com	1	$85	$10	$95
Transceiver	Res/Com	12,296	$135	$25	$1,967,360
Sub-Total Cost - Service Area 1 and 2					**$2,444,165**
Sub-Total Cost					**$2,556,415**
Materials Tax[1](8.00%)					$170,366.00
Engineering/Project Management (7.5%)					$191,731.13
Contingency (5%)					$127,820.75
Total Cost					**$3,046,333**

[1]Based on City of EGWD 2014 Sales Tax. Cost only factored on Materials

EGWD Base AMI Cost Benefit Analysis - Alternative 2

Project Start Date:	2015			
Total Project Cost:	$3,046,333	(see note 5)	Discount Rate:	1.00%
City Annual Capital Contribution:	$0		Estimated Annual Rate Increase:	3%
Customer Funded Meter Contribution:	$1,000,000		Estimated Operational Cost Increases:	3%
Total Cost to Finance:	$2,046,333			
			20 year Net Present Value:	-$773,200
Rate of Financing:	4.00%		20 year Internal Rate of Return:	-2.96%
Term of Financing:	20		Simple Payback (years):	31.7

Year	Capital (1)	Water Revenue Increase (2)	Operational Savings (3)	Leak Detection Savings (4)	Total Annual Benefits	Annual Debt Service	Ongoing Server and Maintenance Fees(6)	Total Annual Cost	Net Present Cash Flow	Cummulative Cash Flow	Year
1	$0	$0	$95,999	$0	$95,999	$150,573	$20,000	$170,573	-$74,574	-$1,074,574	2015
2	$0	$0	$98,879	$0	$98,879	$150,573	$20,000	$170,573	-$71,694	-$1,146,268	2016
3	$0	$0	$101,845	$0	$101,845	$150,573	$20,000	$170,573	-$68,727	-$1,214,995	2017
4	$0	$0	$104,901	$0	$104,901	$150,573	$20,000	$170,573	-$65,672	-$1,280,667	2018
5	$0	$0	$108,048	$0	$108,048	$150,573	$20,000	$170,573	-$62,525	-$1,343,192	2019
6	$0	$0	$111,289	$0	$111,289	$150,573	$20,000	$170,573	-$59,284	-$1,402,476	2020
7	$0	$0	$114,628	$0	$114,628	$150,573	$20,000	$170,573	-$55,945	-$1,458,421	2021
8	$0	$0	$118,067	$0	$118,067	$150,573	$20,000	$170,573	-$52,506	-$1,510,927	2022
9	$0	$0	$121,609	$0	$121,609	$150,573	$20,000	$170,573	-$48,964	-$1,559,891	2023
10	$0	$0	$125,257	$0	$125,257	$150,573	$20,000	$170,573	-$45,316	-$1,605,207	2024
11	$0	$0	$129,015	$0	$129,015	$150,573	$20,000	$170,573	**-$41,558**	-$1,646,765	2025
12	$0	$0	$132,885	$0	$132,885	$150,573	$20,000	$170,573	**-$37,688**	-$1,684,453	2026
13	$0	$0	$136,872	$0	$136,872	$150,573	$20,000	$170,573	**-$33,701**	-$1,718,154	2027
14	$0	$0	$140,978	$0	$140,978	$150,573	$20,000	$170,573	**-$29,595**	-$1,747,749	2028
15	$0	$0	$145,207	$0	$145,207	$150,573	$20,000	$170,573	**-$25,366**	-$1,773,115	2029
16	$0	$0	$149,563	$0	$149,563	$150,573	$20,000	$170,573	**-$21,009**	-$1,794,124	2030
17	$0	$0	$154,050	$0	$154,050	$150,573	$20,000	$170,573	**-$16,523**	-$1,810,647	2031
18	$0	$0	$158,672	$0	$158,672	$150,573	$20,000	$170,573	**-$11,901**	-$1,822,548	2032
19	$0	$0	$163,432	$0	$163,432	$150,573	$20,000	$170,573	**-$7,141**	-$1,829,689	2033
20	$0	$0	$168,335	$0	$168,335	$150,573	$20,000	$170,573	**-$2,238**	-$1,831,927	2034

Notes and Preliminary Savings Related Assumptions:

(1) $1,000,000 capital infusion is included.

(2) Water related revenue increases were not factored in for this analysis.

(3) Operational savings assume $64,835 in field staff savings. Other misc. savings include savings related to reducing re-reads, improved billing related services, and other related savings.

(4) No Leak Detection related savings or revenue increase from improved meter accuracy was assumed in this analysis.

(5) The total project cost is based on installing 5,019 new AMI compatible registers along with 12,296 new radio transmitters on all meters. One antenna for reading meters and related meter data management software also included.

(6) Costs to be verified subsequent to vendor prices that will need to be verified through a future replacement project RFP.

APPENDIX B-3

Full AMI Cost Benefit Analysis

EGWD Preiminary Cost Estimate AMI System with Targeted Meter Replacement					
Bid Item	**Res/ Com**	**Quantity (EA.)**	**Unit Price**		**Cost**
			Materials	**Installation**	
City-Wide					
AMI Collector (Base Station)	Res/Com	1	$33,000	$25,000	$58,000
AMI Hardware (ECHO)	Res/Com	2	$5,000	$1,800	$13,600
AMI Software	Res/Com	1	$33,750		$33,750
AMI Training	Res/Com	1	$6,900		$6,900
Service Area 1 & 2					
1-inch Meter Replacement	Res/Com	432	$165	$55	$95,040
<=1-inch Register Replacement	Res/Com	4,878	$85	$10	$463,410
1.5-inch Register Replacement	Res/Com	39	$85	$10	$3,705
2-inch Register Replacement	Res/Com	88	$85	$10	$8,360
3-inch Register Replacement	Res/Com	2	$85	$10	$190
4-inch Register Replacement	Res/Com	9	$85	$10	$855
6-inch Register Replacement	Res/Com	2	$85	$10	$190
8-inch Register Replacement	Res/Com	1	$85	$10	$95
Transceiver	Res/Com	12,296	$135	$25	$1,967,360
			Sub-Total Cost - Service Area 1 & 2		**$2,539,205**
			Sub-Total Cost		**$2,651,455**
Materials Tax[1](8.00%)					$176,068.00
Engineering/Project Management (7.5%)					$198,859.13
Contingency (5%)					$132,572.75
			Total Cost		**$3,158,955**

[1]Based on City of EGWD 2014 Sales Tax. Cost only factored on Materials

EGWD Full AMI Project Cost Benefit Analysis - Alternative 3

Project Start Date:	2015			
Total Project Cost:	$3,158,955	(see note 5)	Discount Rate:	1.00%
City Annual Capital Contribution:	$0		Estimated Annual Rate Increase:	3%
Customer Funded Meter Contribution:	$1,000,000		Estimated Operational Cost Increases:	3%
Total Cost to Finance:	$2,158,955			
			20 year Net Present Value:	$1,299,468
Rate of Financing:	4.00%		20 year Internal Rate of Return:	4.53%
Term of Financing:	20		Simple Payback (years):	16.2

Year	Capital (1)	Water Increase (2)	Operational Savings (3)	Leak Detection Savings (4)	Total Annual Benefits	Annual Debt Service	Ongoing Server and Maintenance Fees(6)	Total Annual Cost	Net Present Cash Flow	Cummulative Cash Flow	Year
1	$0	$73,916	$95,999	$24,800	$194,715	$158,860	$20,000	$178,860	**$15,855**	$15,855	2015
2	$0	$76,133	$98,879	$24,800	$199,812	$158,860	$20,000	$178,860	**$20,953**	$36,808	2016
3	$0	$78,417	$101,845	$24,800	$205,063	$158,860	$20,000	$178,860	**$26,203**	$63,011	2017
4	$0	$80,770	$104,901	$24,800	$210,471	$158,860	$20,000	$178,860	**$31,611**	$94,622	2018
5	$0	$83,193	$108,048	$24,800	$216,041	$158,860	$20,000	$178,860	**$37,181**	$131,803	2019
6	$0	$85,689	$111,289	$24,800	$221,778	$158,860	$20,000	$178,860	**$42,918**	$174,722	2020
7	$0	$88,260	$114,628	$24,800	$227,687	$158,860	$20,000	$178,860	**$48,828**	$223,549	2021
8	$0	$90,907	$118,067	$24,800	$233,774	$158,860	$20,000	$178,860	**$54,914**	$278,464	2022
9	$0	$93,635	$121,609	$24,800	$240,043	$158,860	$20,000	$178,860	**$61,184**	$339,647	2023
10	$0	$96,444	$125,257	$24,800	$246,501	$158,860	$20,000	$178,860	**$67,641**	$407,288	2024
11	$0	$99,337	$129,015	$24,800	$253,152	$158,860	$20,000	$178,860	**$74,292**	$481,580	2025
12	$0	$102,317	$132,885	$24,800	$260,002	$158,860	$20,000	$178,860	**$81,142**	$562,722	2026
13	$0	$105,387	$136,872	$24,800	$267,058	$158,860	$20,000	$178,860	**$88,198**	$650,920	2027
14	$0	$108,548	$140,978	$24,800	$274,326	$158,860	$20,000	$178,860	**$95,466**	$746,387	2028
15	$0	$111,805	$145,207	$24,800	$281,812	$158,860	$20,000	$178,860	**$102,952**	$849,339	2029
16	$0	$115,159	$149,563	$24,800	$289,522	$158,860	$20,000	$178,860	**$110,662**	$960,001	2030
17	$0	$118,613	$154,050	$24,800	$297,464	$158,860	$20,000	$178,860	**$118,604**	$1,078,605	2031
18	$0	$122,172	$158,672	$24,800	$305,644	$158,860	$20,000	$178,860	**$126,784**	$1,205,389	2032
19	$0	$125,837	$163,432	$24,800	$314,069	$158,860	$20,000	$178,860	**$135,209**	$1,340,598	2033
20	$0	$129,612	$168,335	$24,800	$322,747	$158,860	$20,000	$178,860	**$143,887**	$1,484,485	2034
21	$0	$133,501	$173,385	$24,800	$331,685	$158,860	$20,000	$178,860	**$152,826**	$1,637,311	2035

Notes and Preliminary Savings Related Assumptions:

(1) $1,000,000 capital infusion is included.
(2) Water related revenue increases assumes meter accuracy improvements (50% of Apparent Losses from AWWA Water Audit).
(3) Operational savings assume $64,835 in field staff savings. Other misc. savings include savings related to reducing re-reads, improved billing related services, and other related savings.
(4) Leak detection related annual savings assumes 25% of the real losses identified in the AWWA water audit are identified and repaired.
(5) The total project cost is based on installing 5,019 new AMI compatible registers along with 12,296 new radio transmitters on all meters. One antenna for reading meters and related meter data management software also included.
(6) Costs to be verified subsequent to vendor prices that will need to be verified through a future replacement project RFP.

Appendix C Sensus Limited Warranty

I. General Product Coverage

Sensus USA Inc. ("Sensus") warrants its products and parts to be free from defects in material and workmanship for one (1) year from the date of Sensus shipment and as set forth below. All products are sold to customer ("Customer") pursuant to Sensus' Terms of Sale, available at: sensus.com/TC ("Terms of Sale").

II. SR II® and accuSTREAM ™5/8", 3/4" & 1" Meters…

are warranted to perform to AWWA New Meter Accuracy Standards for five (5) years from the date of Sensus shipment or until the registration shown below, whichever occurs first. Sensus further warrants that the SR II meter will perform to at least AWWA Repaired Meter Accuracy Standards for fifteen (15) years from the date of Sensus shipment or until the registration shown below, whichever occurs first:

	New Meter Accuracy	Repair Meter Accuracy
5/8" SR II Meter and accuSTREAM Meter	500,000 gallons	1,500,000 gallons
3/4" SR II Meter and accuSTREAM Meter	750,000 gallons	2,250,000 gallons
1" SR II Meter and accuSTREAM Meter	1,000,000 gallons	3,000,000 gallons

III. SR® 5/8", 3/4" & 1" Meters…

are warranted to perform to AWWA New Meter Accuracy Standards for one (1) year from the date of Sensus shipment. Sensus further warrants that the 5/8", 3/4" and 1" SR meter will perform to at least AWWA Repaired Meter Accuracy Standards for fifteen (15) years from the date of Sensus shipment or until the registration shown below, whichever occurs first:

	Repair Meter Accuracy
5/8" SR Meter	1,500,000 gallons
3/4" SR Meter	2,250,000 gallons
1" SR Meter	3,000,000 gallons

IV. SR 1-1/2" & 2"…

are warranted to perform to AWWA New Meter Accuracy Standards for one (1) year from the date of Sensus shipment. Sensus further warrants that the 1-1/2" and 2" SR meter will perform to at least AWWA Repaired Meter Accuracy Standards for ten (10) years from the date of Sensus shipment or until the registration shown below, whichever occurs first:

	Repair Meter Accuracy
1-1/2" SR	5,000,000 gallons
2" SR	8,000,000 gallons

V. PMM® 5/8", 3/4", 1" Meters…

are warranted to perform to AWWA New Meter Accuracy Standards for one (1) year from the date of Sensus shipment. Sensus further warrants that the 5/8", 3/4", and 1" PMM meter will perform to at least AWWA Repaired Meter Accuracy Standards for fifteen (15) years from the date of Sensus shipment or until the registration shown below, whichever occurs first:

	Repair Meter Accuracy
5/8" PMM	1,500,000 gallons
3/4" PMM	2,000,000 gallons
1" PMM	3,000,000 gallons

VI. PMM 1-1/2", 2" Meters…

are warranted to perform to AWWA New Meter Accuracy Standards for one (1) year from the date of Sensus shipment. Sensus further warrants that the 1-1/2", and 2" PMM meter will perform to at least AWWA Repaired Meter Accuracy Standards for ten (10) years from the date of Sensus shipment or until the registration shown below, whichever occurs first:

	Repair Meter Accuracy
1-1/2" PMM	5,000,000 gallons
2" PMM	8,000,000 gallons

VII. iPERL™ Water Management Systems...

that register water flow are warranted to perform to the accuracy levels set forth in the iPERL Water Management System Data Sheet available at sensus.com/iperl/datasheet or by request from 1-800-METER-IT, for twenty (20) years from the date of Sensus shipment. The iPERL System warranty does not include the external housing.

VIII. Maincase…

of the SR, SR II and PMM in both standard and low lead alloy meters are warranted to be free from defects in material and workmanship for twenty-five (25) years from the date of Sensus shipment. Composite and E-coated maincases will be free from defects in material and workmanship for fifteen (15) years from the date of Sensus shipment.

IX. Sensus "W" Series Turbo Meters, OMNI™ Meters and Propeller Meters…

are warranted to perform to AWWA New Meter Accuracy Standards for one (1) year from the date of Sensus shipment.

X. Sensus accuMAG™ Meters...

are warranted to be free from defects in material and workmanship, under normal use and service, for 18 months from the date of Sensus shipment or 12 months from startup, whichever occurs first.

XI. Sensus Registers…

are warranted to be free from defects in material and workmanship from the date of Sensus shipment for the periods stated below or until the applicable registration for AWWA Repaired Meter Accuracy Standards, as set forth above, are surpassed, whichever occurs first:

5/8" thru 2" SR, SR II, PMM, accuSTREAM Standard Registers	25 years
5/8" thru 2" SR, SR II, PMM, accuSTREAM Encoder Registers	10 years
Electronic Communication Index (ECI)	10 years
All HSPU, IMP Contactor, R.E.R. Elec. ROFI	1 year
Standard and Encoder Registers for:"W" Turbo and Propeller Meters	1 year
OMNI Register with Battery	10 years

XII. Sensus Electric Meters…

are warranted to be free from defects in material and workmanship for one (1) year from the date of Sensus shipment. Spare parts and components are warranted to be free from defects in material and workmanship for one (1) year from the date of Sensus shipment.

Repaired or refurbished equipment repaired by Sensus is warranted to be free from defects in material and workmanship for ninety (90) days from the date of Sensus shipment or for the time remaining on the original warranty period, whichever is longer.

XIII. Batteries, iPERL System Components, AMR and FlexNet™ System AMI Interface Devices…

are warranted to be free from defects in material and workmanship from the date of Sensus shipment for the period stated below:

Electronic TouchPad	10 years
RadioRead® MXU (Model 505C, 510R or 520R) and Batteries	20 years*
Act-Pak® Instrumentation	1 year
TouchRead® Coupler and AMR Equipment	1 year
FlexNet Water or Gas SmartPoint™ Modules and Batteries	20 years*
Hand Held Device	1 year
Vehicle Gateway Base Station	1 year
FlexNet Base Station (including the Metro and M400 base stations)	1 year
Echo Transceiver	1 year
Remote Transceiver	1 year
iConA and FlexNet Electricity SmartPoint Module	1 year
iPERL System Battery and iPERL System Components	20 years*
Residential Electronic Register	20 years*

* Sensus will repair or replace non-performing:

- RadioRead® MXU (Model 505C, 510R and 520R) and Batteries,
- FlexNet Water or Gas SmartPoint Modules (configured to the factory setting of six transmissions per day under normal system operation of up to one demand read to each SmartPoint Module per month and up to two firmware downloads during the life of the product) and batteries,
- Residential Electronic Register with hourly reads, and
- iPERL System Batteries, and/or the iPERL System flowtube, the flow sensing and data processing assemblies, and the register ("iPERL System Components") with hourly reads

at no cost for the first ten (10) years from the date of Sensus shipment, and for the remaining ten (10) years, at a prorated percentage, applied towards the published list prices in effect for the year product is accepted by Sensus under warranty conditions according to the following schedule:

Years	Replacement Price	Years	Replacement Price
1 – 10	0%	16	55%
11	30%	17	60%
12	35%	18	65%
13	40%	19	70%
14	45%	20	75%
15	50%	>20	100%

Note: Software supplied and licensed by Sensus is warranted according to the terms of the applicable software license agreement. Sensus warrants that network and monitoring services shall be performed in a professional and workmanlike manner.

XIV. Return…

Sensus' obligation, and Customer's exclusive remedy, under this Sensus Limited Warranty is, at Sensus' option, to either (i) repair or replace the product, provided the Customer (a) returns the product to the location designated by Sensus within the warranty period; and (b) prepays the freight costs both to and from such location; or (ii) deliver replacement components to the Customer, provided the Customer installs, at its cost, such components in or on the product (as instructed by Sensus), provided, that if Sensus requests, the Customer (a) returns the product to the location designated by Sensus within the warranty period; and (b) prepays the freight costs both to and from such location. In all cases, if Customer does not return the product within the time period designated by Sensus, Sensus will invoice, and Customer will pay within thirty days of the invoice date, for the cost of the replacement product and/or components.

The return of products for warranty claims must follow Sensus' Returned Materials Authorization (RMA) procedures. Water meter returns must include documentation of the

Customer's test results. Test results must be obtained according to AWWA standards and must specify the meter serial number. The test results will not be valid if the meter is found to contain foreign materials. If Customer chooses not to test a Sensus water meter prior to returning it to Sensus, Sensus will repair or replace the meter, at Sensus' option, after the meter has been tested by Sensus. The Customer will be charged Sensus' then current testing fee. Sensus SmartPoints modules and MXU's returned must be affixed with a completed return evaluation label. For all returns, Sensus reserves the right to request meter reading records by serial number to validate warranty claims.

For products that have become discontinued or obsolete ("Obsolete Product"), Sensus may, at its discretion, replace such Obsolete Product with a different product model ("New Product"), provided that the New Product has substantially similar features as the Obsolete Product. The New Product shall be warranted as set forth in this Sensus Limited Warranty.

THIS SECTION XIV SETS FORTH CUSTOMER'S SOLE REMEDY FOR THE FAILURE OF THE PRODUCTS, SERVICES OR LICENSED SOFTWARE TO CONFORM TO THEIR RESPECTIVE WARRANTIES.

XV. Warranty Exceptions and No Implied Warranties…

This Sensus Limited Warranty does not include costs for removal or installation of products, or costs for replacement labor or materials, which are the responsibility of the Customer. The warranties in this Sensus Limited Warranty do not apply to goods that have been: installed improperly or in non-recommended installations; installed to a socket that is not functional, or is not in safe operating condition, or is damaged, or is in need of repair; tampered with; modified or repaired with parts or assemblies not certified in writing by Sensus, including without limitation, communication parts and assemblies; improperly modified or repaired (including as a result of modifications required by Sensus); converted; altered; damaged; read by equipment not approved by Sensus; for water meters, used with substances other than water, used with non-potable water, or used with water that contains dirt, debris, deposits, or other impurities; subjected to misuse, improper storage, improper care, improper maintenance, or improper periodic testing (collectively, "Exceptions."). If Sensus identifies any Exceptions during examination, troubleshooting or performing any type of support on behalf of Customer, then Customer shall pay for and/or reimburse Sensus for all expenses incurred by Sensus in examining, troubleshooting, performing support activities, repairing or replacing any Equipment that satisfies any of the Exceptions defined above. The above warranties do not apply in the event of Force Majeure, as defined in the Terms of Sale.

THE WARRANTIES SET FORTH IN THIS SENSUS LIMITED WARRANTY ARE THE ONLY WARRANTIES GIVEN WITH RESPECT TO THE GOODS, SOFTWARE LICENSES AND SERVICES SOLD OR OTHERWISE PROVIDED BY SENSUS. SENSUS EXPRESSLY DISCLAIMS ANY AND ALL OTHER REPRESENTATIONS, WARRANTIES, CONDITIONS, EXPRESSED, IMPLIED, STATUTORY OR OTHERWISE, REGARDING ANY MATTER IN CONNECTION WITH THIS SENSUS LIMITED WARRANTY OR WITH THE TERMS OF SALE, INCLUDING WITHOUT LIMITATION, WARRANTIES AS TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, NON-INFRINGEMENT AND TITLE.

SENSUS ASSUMES NO LIABILITY FOR COSTS OR EXPENSES ASSOCIATED WITH LOST REVENUE OR WITH THE REMOVAL OR INSTALLATION OF EQUIPMENT. THE FOREGOING REMEDIES ARE CUSTOMER'S SOLE AND EXCLUSIVE REMEDIES FOR THE FAILURE OF EQUIPMENT, LICENSED SOFTWARE OR SERVICES TO CONFORM TO THEIR RESPECTIVE WARRANTIES.

XVI. Limitation of Liability...

SENSUS' AGGREGATE LIABILITY IN ANY AND ALL CAUSES OF ACTION ARISING UNDER, OUT OF OR IN RELATION TO THIS AGREEMENT, ITS NEGOTIATION, PERFORMANCE, BREACH OR TERMINATION (COLLECTIVELY "CAUSES OF ACTION") SHALL NOT EXCEED THE TOTAL AMOUNT PAID BY CUSTOMER TO SENSUS UNDER THIS AGREEMENT. THIS IS SO WHETHER THE CAUSES OF ACTION ARE IN TORT, INCLUDING, WITHOUT LIMITATION, NEGLIGENCE OR STRICT LIABILITY, IN CONTRACT, UNDER STATUTE OR OTHERWISE.

AS A SEPARATE AND INDEPENDENT LIMITATION ON LIABILITY, SENSUS' LIABILITY SHALL BE LIMITED TO DIRECT DAMAGES. SENSUS SHALL NOT BE LIABLE FOR: (I) ANY INDIRECT, INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES; NOR (II) ANY REVENUE OR PROFITS LOST BY CUSTOMER OR ITS AFFILIATES FROM ANY END USER(S), IRRESPECTIVE OF WHETHER SUCH LOST REVENUE OR PROFITS IS CATEGORIZED AS DIRECT DAMAGES OR OTHERWISE; NOR (III) ANY IN/OUT COSTS; NOR (IV) MANUAL METER READ COSTS AND EXPENSES; NOR (V) DAMAGES ARISING FROM MAINCASE OR BOTTOM PLATE BREAKAGE CAUSED BY FREEZING TERMPERATURES, WATER HAMMER CONDITIONS, OR EXCESSIVE WATER PRESSURE. "IN/OUT COSTS" MEANS ANY COSTS AND EXPENSES INCURRED BY CUSTOMER IN TRANSPORTING GOODS BETWEEN ITS WAREHOUSE AND ITS END USER'S PREMISES AND ANY COSTS AND EXPENSES INCURRED BY CUSTOMER IN INSTALLING, UNINSTALLING AND REMOVING GOODS. "END USER" MEANS ANY END USER OF ELECTRICITY/WATER/GAS THAT PAYS CUSTOMER FOR THE CONSUMPTION OF ELECTRICITY/WATER/GAS, AS APPLICABLE.

The limitations on liability set forth in this Agreement are fundamental inducements to Sensus entering into this Agreement. They apply unconditionally and in all respects. They are to be interpreted broadly so as to give Sensus the maximum protection permitted under law.

To the maximum extent permitted by law, no Cause of Action may be instituted by Customer against Sensus more than TWELVE (12) MONTHS after the Cause of Action first arose. In the calculation of any damages in any Cause of Action, no damages incurred more than TWELVE (12) MONTHS prior to the filing of the Cause of Action shall be recoverable.