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Department of Watershed Management

TECHNICAL REVIEW OF 3/4” AND 1” WATER METERS

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EXECUTIVE SUMMARY

The purpose of this report is to provide an assessment and technical comparison of various mechanical (positive displacement) and solid state (ultrasonic and magnetic electronic static type) 3/4'' and 1'' residential water meters that are compatible with DeKalb County's existing Sensus FlexNet® Advanced Metering Infrastructure (AMI) system. The results of this comparison will be used to assist the County in the selection of meters that are compatible with the AMI system and that best meet the County's metering and AMI goals.

To begin this analysis, the project team compared the functional characteristics of existing installed meters in DeKalb County and alternate meters that met minimum criteria established by DeKalb County and the project team. In addition to comparing functional characteristics, the team also compared operating characteristics of existing and alternate meters, such as flow range, operating pressure, head loss, and accuracy at different flow rates. The purpose of this comparison was to identify which meters have better operating, warranty, and economic attributes and are compatible with DeKalb County's Sensus FlexNet® AMI system. Meters that met the established technical criteria were bench tested via coordination with Department of Watershed Management (DWM) metering staff and local vendor representatives. The bench tests confirmed the compatibility of selected meters with DeKalb County's AMI infrastructure through connection to a radio endpoint, tested meter accuracy at AWWA specified test ranges, and determined the workability of each selected meter in a simulated field setting. Observations from the bench testing are provided in Appendix B. In addition to the testing activities, a life cycle cost analysis was performed to outline the various costs of each meter at stages throughout its service life. Warranty and life expectancy comparisons were also conducted for the meters in this analysis and were further considered in the life cycle cost analysis for each meter product.

The project team has reviewed technical characteristics of existing 3/4'' and 1'' meters already in place throughout the County. Supplementing the minimum technical requirements established by DeKalb County, the project team selected additional criteria that each meter must meet to be recommended for future consideration. These criteria were then used to determine which existing DeKalb meters and which alternate meter products would be considered for further analysis. The Sensus SR and Neptune T-8 meters (both currently installed in the County's distribution system, although only a small number of T-8 meters exist) were eliminated from consideration because they are no longer produced. Even though the Sensus ICE register is compatible with AMI, a new mechanical Sensus SR meter and its parts are not manufactured anymore and are unavailable for meter replacement and repair. Existing DeKalb County meters that meet the minimum, established technical criteria are the Sensus accuStream™ and Sensus iPERL®. Alternate meters that currently meet the minimum technical criteria include the Badger Recordall® Disc Meters (Bronze and Polymer), Mueller 435 and 452 Bronze PD Meters, Master Meter PD Meter, and Neptune's T-10™ and Mach 10® meters. The Badger E-Series was included in this analysis due to its technical performance however it's compatibility with the Sensus FlexNet® AMI system is limited. The Sensus SR II meter is the same design as the accuStream™, except the meter body is metallic rather than composite. The Sensus Warranty provisions for both SR II and accuStream™ are exactly the same. For this reason, the accuStream™ was selected for evaluation.

Each of these meters has been compared against one another for differentiators with regards to meter life expectancy and warranty information, as well as Sensus FlexNet® compatibility. At the time of this

analysis, only the Sensus iPERL®, and Neptune Mach 10® are FlexNet compatible and have warrantied new meter accuracies for 20 years with no limit on meter accuracy in terms of gallons of throughput. All the meters included in this analysis are compatible with the FlexNet® system per technical literature from Sensus (Sensus Smart Water Network Water Meter and Ancillaries Compatibility List, 2017) and have TouchCoupler connection capability (with the exception of the Badger E-Series®). One concern of DeKalb DWM staff is alarms and the ability to communicate these alarms to Sensus FlexNet® analytics software. Sensus reports that other meter manufacturers have proprietary communication protocols that preclude transfer of non-Sensus meter-based alarms to FlexNet®. Sensus technical staff also report that their FlexNet® radio endpoint monitors and reports alarms, and DeKalb County should not consider the proprietary protocols an absolute exclusionary factor in their meter selection process. Case studies were assembled and summarized by the project team to highlight the experience of other municipalities with comparable meter products utilized within a FlexNet® system.

The water meter life cycle cost analysis section presents an economic evaluation of existing and alternate 3/4" and 1" water meters achieving the technical specifications desired by DeKalb County. The underlying analyses in this evaluation estimate the Net Present Cost of each water meter (by size and manufacturer) using the national warranty information and manufacturer and distributor-provided budgetary costs shown in Appendix A. The results of the economic evaluation indicate the cost for meter ownership over a 20-year time frame based on the assumed life of a given meter considering the costs of purchase, installation, operation, maintenance, and disposal. The Net Present Cost approach allows comparison of today's cost of the sum of cash outflows incurred at different times during the meter's life cycle.

Once bench testing and life cycle cost comparisons were completed, further meter evaluation and scoring was performed to determine the relative importance of key functional and physical characteristics of the alternative meter products included in this analysis.

The comparison and evaluation of water meters was performed in a two-step approach. Initially, individual meters were scored for multiple quantitative and qualitative criteria, then meter scores for each criterion were multiplied by weighting the selected criteria based upon DeKalb County DWM staff input to incorporate utility perspective in the evaluation. Weighting factors were applied in a Microsoft Excel Workbook via cell linking to provide an assessment of relative importance of evaluation criteria. Weighted scores were calculated for each meter and each criterion. Weighted scores for all criteria were summed for each meter, providing a final weighted summary score. The comparisons between meters were performed by evaluating the final weighted total scores. The highest scores represent the best performing meters. A sensitivity analysis was performed by adjusting the evaluation criteria included within a total score to assess changes in meter scores and ranking. The various scoring approaches were as follows:

- Total Overall Score (included all selected criteria)
- No FlexNet Criteria (removed any FlexNet related criteria)
- Quantitative Only – No Costs (removed Qualitative criteria and cost related criteria)
- Quantitative Only – With Costs (removed Qualitative criteria only)

Overall, of the mechanical and solid state meters evaluated, the most consistently highest scoring meters for both ¾" and 1" sizes across the full range of comparison criteria and the various scoring methodologies were:

Mechanical: 1) Sensus accuStream™ and 2) Badger Recordall (bronze nutating disc type).

Solid State: 1) Sensus iPERL and 2) Neptune Mach 10

One additional point to consider alongside these results is that there are advantages to having the same meter manufacturer as the AMI provider. These include consistency and collaboration of asset ownership, same company service provider, warranty under the same company, hardware and software compatibility and easier integration, economy of scale, and accountability for read to bill processes.

1 INTRODUCTION

According to April 2017 meter inventory data provided by DWM staff, DeKalb County currently has approximately 194,200 installed water meters. The vast majority (188,100) are residential water meters which include the 5/8", 3/4", and 1" size classifications. Commercial meters (6,100) within the County range from 1 1/2" to 10" in size. Nearly 61 percent of the existing installed residential meters are Sensus SR models, while nearly 39 percent are Sensus iPERL® models. About 5,000 (2.7%) of DeKalb County residential water meters are Sensus accuStream™ models, and less than 100 (0.05%) are Neptune T-8 models, respectively.

The DeKalb County Department of Watershed Management (DWM) has requested Arcadis to perform a technical review of 3/4'' and 1'' water meters to be used in DeKalb's water meter program moving forward. This program entails equipping all residential and commercial water meters within the County with technology that can relay meter data from smart point stations to regional collectors. These upgrades are being made in part to improve leak detection, increase billing accuracy, and provide quality customer service. The technical approach within this report includes a study of operational and functional capabilities of residential solid state and positive displacement meters as well as asset life cycle analyses to recommend meter products that will support the above-listed objectives of the meter program.

2 APPROACH

Arcadis reviewed existing DeKalb County meters and compared technical characteristics, focusing on meter housing (must be NSF 61 low lead compliant), measuring chamber, electronic register, and several other operating parameters. These technical characteristics are critical to selecting a water meter that will have an extended lifetime and provide accurate measurements. As requested by DeKalb County, Arcadis has only evaluated technical specifications and related information for 3/4" and 1" customer water meters for meter product comparisons.

Once minimum technical requirements were established using the minimum existing criteria set by DeKalb County and additional criteria determined by the project team, metering products were identified based on compatibility with DeKalb County's Sensus FlexNet® AMI System and minimum warranty requirements. Based on compliance with these criteria, Arcadis then contacted local vendors of the compatible water meter products to obtain sample water meter products for bench testing. Bench testing, connection to a FlexNet® radio endpoint (Sensus calls it an "MXU"), and meter testing staff observations on data collection were utilized to confirm whether those meter products that meet the minimum technical characteristics were indeed compatible with FlexNet®. Meter reading data is reviewed in Sensus Analytics software to evaluate data accuracy and endpoint-based alarms. Bench testing included meter accuracy testing at multiple flow rates and also helped determine which products incorporate workability in a simulated field setting. Case studies were researched for similar systems, and warranty information was gathered for each meter product to create further differentiators between meter types. Additionally, life cycle analyses were performed for each meter type and size classification considering initial costs, installation costs, replacement costs, salvage value, and warranty data to compute and compare Net Present Costs. Following bench testing observations and life cycle cost development, a scoring approach

was developed for the purposes of product comparison and ranking within the respective solid state and mechanical meter classes at each residential size.

The technical comparison of the analyzed water meters and the associated scoring methodology and results are described in detail within this report, together with findings, conclusions, and recommendations.

3 ANALYSIS OF EXISTING DEKALB METERS AND ALTERNATE METERS

3.1 Existing DeKalb Residential Meters

According to the DWM meter inventory provided by DeKalb County to Arcadis, there are four residential water meter models (at both 3/4" and 1" sizes) currently installed within DeKalb County: the Sensus iPERL®, the Sensus accuStream™, the Sensus/Rockwell SR and the Neptune T-8 Model SC-ER. The accuStream™ (mechanical positive displacement type similar to the SR II) and iPERL® (solid state type) are both still manufactured by Sensus. The SR is a mechanical positive displacement-type meter previously manufactured by Sensus and its predecessors, Rockwell and Invensys, and the T-8, Model SC-ER is a mechanical positive displacement-type meter previously manufactured by Neptune. The breakdown of these meter products within the existing DeKalb County system as of April 2017 was provided to Arcadis as follows:

188,100 Residential Meters Installed (5/8", 3/4", and 1" size classifications):

- 113,000 Sensus SR – 60.07%
- 70,000 Sensus iPERL® - 37.21% (47,000 pre-2014 and 23,000 post-2014)
- 5,000 Sensus accuStream™ – 2.66%
- Less than 100 Other – 0.05% (includes Neptune T8 Model SC-ER)

Sensus no longer sells the SR meter, and the Neptune T-8 does not connect to the C (production stopped in 1983). They are also both not compliant with the NSF61 low lead requirements, since they were manufactured before the standard became law. Due to these factors, the SR and T-8 are being phased out of DeKalb's inventory and will not be considered in this evaluation. The two remaining meters that are currently manufactured and meet DeKalb County's requirements are discussed in greater detail below.

Sensus accuStream™

Sensus accuStream™ water meters are a mechanical, positive displacement type meter consisting of a maincase, measuring chamber, and sealed register. The register has a hermetically sealed design which helps eliminate dirt and moisture contamination. It is a straight-reading, odometer type display with a center sweep hand that has a low flow leak detector. One of the key features of the accuStream™ is a unique locking system that prevents customers from obtaining free water through physical removal of the register from the meter housing. In terms of operation, water flows through the meter's strainer and then into the measuring chamber where the flow comes into contact with the piston. A magnet conveys the motion of the piston to a sensor within the register. The piston oscillations are then converted into volume totalization units by the sensor to then be displayed on the register face. With the proper utility-provided tool, the register can be taken off without impacting the

water pressure, making the meter secure from vandalism and practically maintenance-free. Components can be interchanged with ease. The accuStream™ meter is a similar design as the Sensus SR II meter with the same warranty but different meter body material (polymer versus bronze).

All Sensus meters are ready to plug and perform via the Sensus TouchCoupler. Once seating has occurred, the unit is unable to be removed unless the holding arms of the unit are physically spread apart. The Sensus TouchCoupler provides a "click connect" capability which provides the installer with assurance that the connection between meter and radio is secure. The data that the meter records and transfers to the radio MXU is extracted using a handheld or laptop computer with a UniPro Communicator. The UniPro connects via a USB cable and pulling the data from the TouchCoupler takes about 1 minute.

Currently, the already installed Sensus accuStream™ products utilize a register called the E Register. However, a new register product is being developed, called the E Register Plus. The E Register Plus will have enhanced alarm functions that the current E Register does not provide. The E Register Plus will have datalogging capabilities of up to 120 days of hourly readings within the register. Data logging within the register is a backup to the Sensus FlexNet® data storage system. Leak detection (continuous flow), backflow alarms (standard 10 gallons), and register tamper / removal alarms are all readily available on the E Register Plus. Leak detection is programmable with the UniPro with the standard set for 24 hours. Without the E Register Plus, only the register tamper alarm is available on the accuStream™. All previously mentioned alarms are passed to the AMI system. AMI alarms featured include leak, backflow, and high consumption. The AMI platform reads the meter hourly and transmits the data to the fixed network. If the meter register or connecting wire is not working or improperly connected it can still report measurements and no measurements. The quality of the connection is paramount for accurate readings. The accuStream™ new and repaired meter accuracy warranty is 5 years and 15 years, respectively.

Sensus iPERL®

Sensus iPERL® meters are solid state, electro-magnetic type meters designed to address water loss and revenue loss concerns. The patented measurement technology of the iPERL® meter allows for nearly 100% accuracy at both low and high flow rates. Improved accuracy meets a conservation compliance goal of the Metro North Georgia Water Planning District, administered by the Environmental Protection Division (EPD). Metering performance is linear over all flow rates, because the traditional mechanical measuring element is replaced with Sensus' patented remanent (remaining) magnetic field technology. Alarms are available with the iPERL® that help detect and resolve field issues such as leaks, reverse flow, and empty pipe. The iPERL® body is made of composite alloy with no metal material. The iPERL® meter has a 20-year accuracy warranty and a 20-year battery life guarantee. Like the accuStream™, the iPERL® is tamper resistant, and one additional unique feature of this meter is that it stores integrated customer data logging information for 35 days. Sensus is preparing to release a new register design called E Register Plus offering more storage.

The iPERL® possesses identical TouchCoupler capabilities, AMI reliability, and AMI alarms previously discussed for the accuStream™. In addition to the alarm features available with the E Register Plus, the iPERL® possesses metrology alarms that give the status of the battery and magnetic field.

Sensus developed and presented the initial iPERL® residential meter design in 2009. The first publicly marketed product was available in 2011. DeKalb recognized the value of the iPERL® design, warranty, and flow range characteristics and purchased many of these meters through competitive bidding for its customers. The initial design included a meter housing that was not completely water proof. The housing was filled with a foam material that had voids subject to water intrusion issues when the meter became submerged for an extended period. The water intrusion issue affected the internal meter electronics and produced erroneous demand readings. This issue is not widespread but specific to certain water immersed conditions and manufactured iPERLs. The problem typically took six months or longer post installation to manifest itself in erroneous meter readings.

After about one year of meter sales, Sensus offered to diagnose the iPERL® meter problem, work with an affected utility to resolve the issues, and redesigned the iPERL® meter. In 2014, Sensus began manufacturing iPERLs with an epoxy material rather than the initial foam. This material exhibits much better water-proofing and void-filling characteristics which protect the internal electronics in water immersion situations. At the same time Sensus changed the iPERL® design and manufacturing process, Sensus modified their internal quality assurance/quality control testing procedures. These new procedures offer better utility and customer assurance that iPERLs achieve the accuracy standards indicated in the nationally published warranty. Approximately two-thirds (47,000) of DeKalb's residential iPERL meters are pre-2014 iPERLs and one-third (23,000) are post-2014 iPERLs.

3.2 Alternate Residential Meters

In addition to the four previously mentioned residential water meter models already installed in the DeKalb County system, the project team was tasked to identify alternate residential water meter products that are compatible with DeKalb County's AMI system. To be considered in this analysis, alternate meters first had to meet the minimum technical criteria set by DeKalb County staff. Components with minimum technical criteria set by DWM included material housing, the measuring chamber, and the electronic register. Minimum warranty criteria were also outlined by DWM staff per AWWA specifications. These criteria are summarized below.

Material Housing

- Meter housing and working pressure must be specified to ensure compatibility with DeKalb's system
- 3/4'' – Must be a full 3/4'' x 9'' lay length to fit required spacing
- 1'' – Must be a full 1'' x 10 3/4'' lay length to fit required spacing

Measuring Chamber

- Measuring element and details on life expectancy must be specified
- Accuracy of the meter at low, medium, and high flows should be evaluated
- Measuring chamber must meet or exceed AWWA C700 accuracy standards for PD meters

Electronic Register

- Must be directly compatible with current Sensus FlexNet™ AMI transmitter
- Connection must be a TouchCoupler interface
- Must output the reading string and register ID in standard ASCII format
- Must be preprogrammed to read 7 dials from left to right in 1-gallon increments
- Must be programmable to other resolutions without removal or replacement
- Standard accuracy warranty minimum of 15 years: 5 years new meter accuracy and 10 years repaired meter accuracy per AWWA specifications.

With the above criteria in mind, the project team reviewed the Water Meter and Ancillaries Compatibility List produced by Sensus. There are several water meter manufacturers compatible with Sensus software and the associated FlexNet system. The query was focused on only those meters that were compatible with TouchCoupler support and whose manufacturers produce 3/4'' and 1'' residential water meters. All other sizes and applications were disregarded. The 2-wire TouchCoupler interface is preferred over the 3-wire connection devices, because no splicing of wires is required for original installation between the radio and the meter, which minimizes future potential connectivity issues. An example of a single port TouchCoupler interface is shown in Figure 1 below.

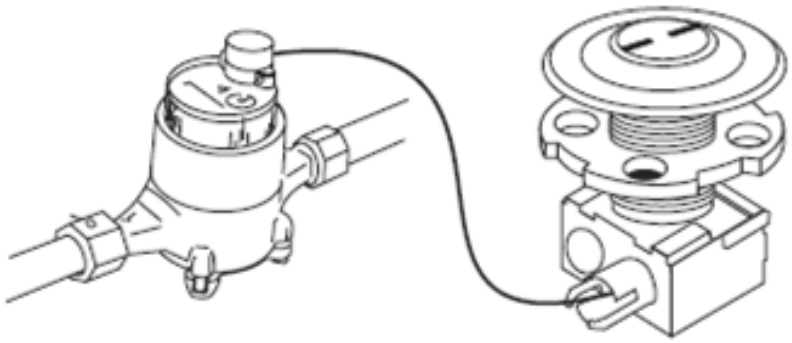


Figure 1: TouchCoupler Interface

After completing the review of the Sensus compatibility list, meters were identified as meeting the minimum technical requirements outlined by DWM and the project team. These meters (categorized by manufacturer) are listed below with some comprehensive attributes and described further in the ensuing sections.

Badger Meter

Badger Meter manufactures both mechanical, positive displacement type meters (Recordall) and solid state ultrasonic type meters (E Series). Badger meters utilize a plug and perform connector. Nicor cables are used for corresponding AMR / AMI transmitters, and Badger produces their own connectors for meters with encoders attached to their own Orion radio endpoints. Badger Meter encoders do not have the ability to store data. The meter sends all interval data to the transmitter where it is kept for data logging purposes. There are several alarms that pass directly to the Badger Meter Beacon AMI platform when connected to the Orion endpoints. Alarms include: meter functioning correctly, temperature limit exceedance, tamper or encoder removal, reverse flow, suspected leak, 30-day no usage, and end of battery life. Badger Meter systems have a published failure rate of less than 0.5%. However, these alarms will not pass through a Sensus transmitter and then to the FlexNet® platform. FlexNet® will only see a non-descriptive transmitter alarm. While Badger's Recordall offerings have a short-coil element that is TouchCoupler compatible, this same offering is not available for the E-Series. The five meters evaluated include:

- E-Series® Ultrasonic meter (solid state)
- Recordall® Disc (nutating) PD meter (Model 35 – 3/4'' bronze) (mechanical)
- Recordall® Disc (nutating) PD meter (Model 55 – 1'' bronze) (mechanical)
- Recordall® Disc (nutating) PD meter (Model 25, 3/4" polymer) (mechanical)
- Recordall® Disc (nutating) PD meter (Model 40, 1" polymer) (mechanical)

Mueller Systems

Mueller Systems offer mechanical encoders that possess touch read capabilities. The encoders can be linked to Sensus FlexNet® units. Mechanical encoders utilize the Nicor connector for connection to 3rd party devices. Mueller devices utilize the AMR / AMI radio endpoints for data logging features. AMI reliability for Mueller systems are a minimum of 98.5% but are often greater than 99%. The two meters evaluated include:

- 435 Series Bronze nutating disc PD meter
- 452 Series Bronze nutating disc PD meter

Master Meter

Master Meter systems have the ability to be plug and perform. The meters will be provided with Sensus TRPL (Touch Pads) that are compatible with the Sensus FlexNet TouchCoupler interface. These meters do not possess internal data logging capabilities. The residential oscillating piston PD Meter does not contain any alarm features. The single meter evaluated includes:

- Master Meter oscillating piston PD meter

Neptune

Neptune TouchCoupler compatible connectors are available for Sensus applications. Sensus SmartPoint would indicate if the coupling has been installed correctly. Datalogging is handled through the Sensus SmartPoint Transmitter. The meter does not perform this function - it only passes hourly readings to the SmartPoint. The Sensus Radio system should store meter data and generate alarms. The E-Coder register display possesses a flow indicator, a leak indicator, rate of flow, and a nine-digit LCD display. The Mach 10 register display shows the same features as the E-Coder but also indicates if there is a leaking pipe or low battery present. Neptune registers use the Sensus register protocol and are compatible with Sensus SmartPoints, The two meter types evaluated include:

- T-10™ nutating disc-type PD meter
- Mach 10® solid state-type ultrasonic meter

Badger E-Series® Ultrasonic Meter

The solid state E-Series® meter produced by Badger Meter utilizes a metering insert that holds stainless steel ultrasonic reflectors in the middle of the flow area. This allows for turbulence-free water flow through the tube and around the ultrasonic signal reflectors. The electronic components reside in an engineered polymer enclosure which is attached to the meter housing. As water flows into the measuring tube, ultrasonic signals are sent forwards and backwards in the direction of flow. Velocity is calculated by measuring the difference in time between the measurement in the forward and backward directions. The volumetric flow rate is then calculated from the velocity and the known pipe diameter. The meter and electronic register are composed of one piece that render the meter practically maintenance free. The meter and register are waterproof sealed, non-removable, and tamper-free. One significant downside to this meter is that it is not compatible with the TouchCoupler interface.

Badger Recordall® Disc Meters (Bronze and Polymer)

The mechanical type Recordall® disc meters measure flow with a nutating disc design. Water flows through the meter's strainer and into the measuring chamber. The entering water collects in a known volume on one side of a movable disc within the measuring chamber. The disc then nutates, forcing the known volume of water out of the previously unfilled section of the disc. A drive magnet conveys the motion of the disc to a follower magnet housed within the register. The follower magnet is connected to a register gear train which converts the disc nutations into volume flow rate units displayed on the register face. The meter is produced in a bronze alloy and engineered polymer respectively. For both types of meters, a corrosion resistant engineered polymer comprises the measuring chamber. The meter is tamper proof and maintenance is simplified by not having to remove the housing from the installation. Also, change gears are not required for accuracy calibration.

Mueller Systems 435 (3/4") and 452 (1") Series

Both meters fall into the mechanical nutating disc and positive displacement style. The maincase is made of bronze for extended life duration. The measuring chamber, strainer, roller, and nutating disc are all comprised of thermoplastic material that will not corrode. The sealed register has a glass lens that is heat treated to eliminate dirt and moisture infiltration. Water enters the meter's strainer where debris is rejected

entry. The entering water collects in a known volume of one side of a movable disc within the measuring chamber. The disc then nutates, forcing the known volume of water out of the previously unfilled section of the disc. The process repeats as the sections fill with water and then empty. The movement of the disc is sensed by the register which is then converted into volumetric flow units. For ease of maintenance, all components can be accessed without taking the meter away from the service line.

Master Meter PD Meter

Master Meter's mechanical type Positive Displacement (PD) meter employs an oscillating piston technology that delivers flow rates with minimum head loss. The PD Meter operates by dividing incoming flow into crescent-shaped volumes because of the inlet ports. This hydraulically caused movement forces the center of the oscillating piston to make circular movements. A drive spindle then moves a drive magnet which in turn moves a follower magnet in the register assembly. The register assembly is connected to a gear system which converts the oscillating movements into a corresponding volume. The main case is comprised of bronze with optional copper amounts. The magnetic drive eliminates intermediate gearing and ensures no gearing is exposed to water. A unique feature of the PD meter is that, not only is it tamper proof, but it provides indication of tampering attempts.

Neptune T-10™

The T-10 mechanical type water meter is comprised of three major components: a register, a high-copper bronze maincase, and a nutating disc measuring chamber. The maincase can withstand the most rugged field conditions including internal water pressure, interior piping stress, and rough handling. The design of the nutating disc measuring chamber protects the chamber from damaging frost conditions. The extended low flow accuracy of the meter is made possible by the chamber seal which connects the chamber outlet port to the maincase outlet port. A thrust roller and corrosion resistant materials are applied to increase the lifetime of the meter. The meter employs a tamperproof seal pin that decreases apparent water losses and improves the accuracy of billing statements for utilities. As a result, of a bayonet-style register mount, in-line serviceability is made possible.

Neptune Mach 10®

The Mach 10 is a solid state ultrasonic meter that possesses a 20-year battery life. The extended low flow accuracy is a key differentiator between this meter and its competitors. There are no internal parts that wear out over time, eliminating the likelihood of any accuracy loss. This level of meter performance results in improved revenue tracking and a unit that is maintenance free for its lifetime. The Mach 10® is designed with easy of operations in mind; solid state metrology is offered with the combination of a bronze maincase. The bronze maincase makes the Mach 10 look like a traditional water meter alleviating any customer concerns pertaining to adapting to modern technology. Additionally, the bronze maincase can withstand the most challenging field conditions, but could be subject to theft due to metallic value. The Mach 10 can be installed in a completely submerged environment. The Mach 10 has many other features including: proactive leak notification, onsite troubleshooting capabilities, data logging, and low battery detection and notification. These features need to be tested to determine AMI pass-through functionality.

Within the mechanical-type meter class, there have been some research projects which have attempted to differentiate nutating disc-type from oscillating piston type positive displacement meters in terms of accuracy performance at a wide range of flows. Early reports favored nutating disc type meters, but more recent data indicate that accuracy of oscillating piston type meters is comparable, although accuracy warranty is better for nutating disc type meters. There exists little comparative data for differentiating solid state type meters. The new meter accuracy warranty is typically the same for solid state ultrasonic and electromagnetic meters types.

3.3 Materials and Housing (Body) Composition

All the meters currently being installed and the above identified meter alternates have either NSF61-compliant bronze or engineered polymer as their housing (body) material. The material body and the material measuring device for all currently installed residential water meters in DeKalb County and alternate meters identified as meeting the minimum technical requirements, are shown in Table 1.

Table 1: Meter Materials and Body Composition

Meter Name	Meter Body	Measuring Device	Additional Materials
Existing DeKalb County Meters			
Sensus accuStream™	Composite Polymer	Rocksyn®	Register box and strainer - synthetic polymer
Sensus iPERL	Composite Alloy	Composite alloy flow tube	Inside flow tube-silver electrodes; battery
Sensus SR	Brass (Non NSF61)	Rocksyn®	Strainer - thermoplastic; trim - stainless steel
Neptune T-8, Model SC-ER	Brass (Non NSF61)	Unavailable	Unavailable
Alternate Meters			
Badger E-Series® Ultrasonic	316 Stainless Steel	Engineered polymer	Transducers - Piezo-ceramic device; battery
Badger Recordall Disc® (Bronze)	Lead-free Bronze alloy	Engineered polymer	Strainer - engineered polymer
Badger Recordall Disc® (Polymer)	Engineered polymer	Engineered polymer	Magnet - ceramic
Mueller 435 Bronze PD Meter	No lead Bronze	Thermoplastic	Strainer - thermoplastic
Mueller 452 Bronze PD Meter	No lead Bronze	Thermoplastic	Nutating disc - thermoplastic
Master Meter PD Meter	Bronze case – 81% copper	Engineered polymer	Strainer - polymer
Neptune T-10™	Bronze (high copper)	Proprietary polymer	Register - polycarbonate
Neptune Mach 10®	Bronze	Polymer	Battery

3.4 Accuracy for Various Flows

3.4.1 Accuracy Charts/Curves

Accuracy charts were utilized to determine the accuracy for low and high flows for the meters included in this analysis. These charts are often provided with meter data sheets and are plotted by running a known volume of water through a meter to obtain a multitude of data points. The initial low, medium, and high flow accuracy for the meter models discussed in Section 3.1, Section 3.2, and Section 3.3 are shown in Table 2 and Table 3. Table 2 pertains to 3/4'' meters, and Table 3 pertains to 1'' meters. After interpreting the data sheets, the medium flow signifies accuracy at the lower end of the typical operating range, and the high flow signifies accuracy at the maximum continuous flow. All low flow and high flow accuracy data was derived from the accuracy curves on each respective meter data sheet. Medium flow accuracies were standardized at 3 GPM for 3/4'' meters and 4 GPM for 1'' meters, per AWWA M6, because meter manufacturers define this flow differently.

Table 2: Meter Accuracy for Various Flows – 3/4"

Name	Initial Low Flow Accuracy	Medium Flow Accuracy	High Flow Accuracy
M[1] Sensus accuStream™PD Meter	0.50 GPM - 100%	3 GPM – 100.6%	30 GPM - 99.5%
SS[2] Sensus iPERL® Mag Meter	0.03 GPM - 100%	3 GPM - 100%	35 GPM - 100%
SS[2] Badger E-Series® Ultrasonic	0.05 GPM – 101.1%	3 GPM – 99.8%	32 GPM - 100%
M[1] Badger Recordall Disc® PD Meter (Model 35, Bronze)	0.375 GPM – 99.5%	3 GPM - 101%	25 GPM - 100%
M[1] Badger Recordall Disc® PD Meter (Model 25, Polymer)	0.25 GPM - 98.50%	3 GPM - 100%	15 GPM - 99%
M[1] Mueller 435 Bronze PD Meter	0.25 GPM - 100%	3 GPM – 100.3%	25 GPM - 99.75%
M[1] Master Meter PD Meter	0.50 GPM – 100%	3 GPM – 100.5%	15 GPM – 99.5%
M[1] Neptune T-10™ PD Meter	0.25 GPM – 96%	3 GPM – 100.8%	30 GPM – 99%
SS[2] Neptune Mach 10® Ultrasonic Meter	0.05 GPM – 100%	3 GPM – 100%	35 GPM – 100%

1 Mechanical

2 Solid State

A key differentiator exists in the range of flows for which the solid state meters and mechanical positive displacement meters remains accurate. Solid state meters (i.e. the Sensus iPERL, Neptune Mach-10, and Badger E-Series) exhibit a much lower initial measuring flow than positive displacement meters as well as a higher maximum flow rate. Solid state meters have excellent accuracy at ultra-low flows, which will recover more revenue than positive displacement meters having lower accuracy at low flow rates. The

degree to which ultra-low flow measurement is important to DeKalb County depends on the customer water use characteristics, which must be determined using short measurement interval time-of-day recorders.

Table 3: Meter Accuracy for Various Flows – 1”

Name	Initial Low Flow Accuracy	Medium Flow Accuracy	High Flow Accuracy
Sensus accuStream™ PD Meter	0.75 GPM - 100%	4 GPM – 100.4%	50 GPM - 99.5%
Sensus iPERL® Mag Meter	0.11 GPM - 100%	4 GPM - 100%	55 GPM - 100%
Badger E-Series® Ultrasonic	0.25 GPM – 99.5%	4 GPM – 100.3%	55 GPM – 100.2%
Badger Recordall Disc® PD Meter (Model 55, Bronze)	0.50 GPM – 97.5%	4 GPM – 100.2%	40 GPM - 99%
Badger Recordall Disc® PD Meter (Model 40, Polymer)	0.375 GPM - 98.0%	4 GPM – 100%	20 GPM - 100%
Mueller 452 Bronze PD Meter	0.75 GPM - 100%	4 GPM - 100.8%	35 GPM - 99.25%
Master Meter PD Meter	0.75 GPM – 100%	4 GPM – 100.3%	25 GPM – 99.5%
Neptune T-10™ PD Meter	0.375 GPM – 96%	4 GPM – 100.8%	50 GPM – 99.2%
Neptune Mach 10® Ultrasonic Meter	0.15 GPM – 100%	4 GPM – 100%	55 GPM – 100%

Figure 2 below represents an example accuracy curve for a 3/4’’ iPERL® meter provided by Sensus. It is important to note that the Sensus iPERL® and Neptune Mach 10® are the only meters analyzed that have a 100% accuracy rating across low, medium, and high flows for both size classifications.

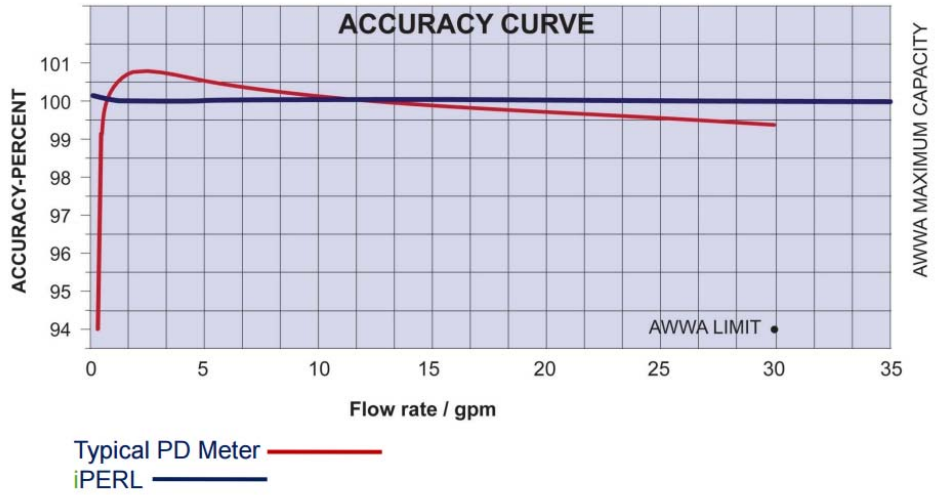


Figure 2: Accuracy curve for iPERL

3.4.2 New Research in Single Family Residential Low Flow Water Demand

Recent utility and customer interest in water loss control have prompted multiple studies in determining typical single family residential water demand patterns in different U.S. geographies. Many states experiencing long-term drought conditions are concerned that existing AWWA low flow specifications specific to certain meter sizes are too high and do not provide for recording of all water passing through a positive displacement meter. Positive displacement meters do not begin registering flow until a specific flow rate (the "initiating flow") is reached. All flow lower than the initiating flow is unregistered and unbilled.

New ultrasonic and electromagnetic metering designs in the Sensus iPERL®, Neptune Mach 10®, and Badger E-Meter series meters allow measurement of lower flows heretofore unavailable in positive displacement designs. The Water Research Foundation recently published its 2016 study of residential end uses which used meters having the improved low flow metering technology to evaluate the entire flow range for single family residences in eight U.S cities. Data from this study was made available to Arcadis and was presented at AWWA ACE in Philadelphia in June 2017. **The data indicates significant low flow usage below the typical minimum reading capability of a positive displacement meter.** The design and application of lower flow residential plumbing fixtures, such as shower heads and toilets, have increased the volume and percentage of ultra-low flow within the total use profile of a single family residential customer. In addition, the East Bay Municipal Water District (EBMUD) in California presented a paper in late 2016 on its Unmeasured Flow Study. This study used Sensus iPERL® meters and one-minute read interval endpoints to evaluate single family residential use within its study area. A major study finding was that unmeasured flow below the reading range of a typical positive displacement meter varied from 4 to 7 percent of the total single family residential use. For utilities using PD meters, this could result in a significant revenue loss from single family customers, based upon the utility's specific rate structure. For this reason, our evaluation of DeKalb County life cycle costs for alternative water meters includes an unmeasured water use component of 5 percent for single family residential positive displacement meters. Measurement of ultra-low flow for single family customers is important for reducing

apparent losses calculated in the Georgia-required M36 water audit, a condition of the DeKalb County water use permit.

3.5 Pressure Zone Overview

During the technical comparison, Arcadis was tasked to look at the available pressure zone data for the DeKalb County water distribution system. This general analysis was performed to gain a better understanding of what pressure rating may be required for water meters installed within the distribution system.

To perform this review, DWM staff provided Arcadis with approximate target hydraulic grade line (HGL) data for the following zones that comprise the DeKalb County water distribution system:

- DeKalb (General System): +/- 1170 ft.
- Dunwoody: +/- 1255 ft.
- Tucker: +/- 1250 ft.
- Arabia Mountain: +/- 1070 ft.

The Arcadis team then utilized GIS software to compare these overall HGL values against surface contour elevations across the County to obtain an estimation of the operating pressure range that could be anticipated in the various zones. Outlier surface contour values at Stone Mountain and just outside the County boundaries were filtered out for the purposes of the analysis. Surface contours were used in place of actual water line depths for two reasons: (1) not all water line depths are available for the system, and (2) water line depths are typically shallow enough such that the variation in results due to difference in elevation from the surface contours would only result in a change of a few psi. Though this exercise was a general approximation, it did demonstrate that maximum operating pressures of 185 to 205 psi could be present within certain areas of the distribution system (especially in the southern parts of the County in the Arabia Mountain and General System zones). These results are consistent with preliminary DWM staff input that pressures of approximately 200 psi are potentially present in the system. This exercise was performed to provide perspective for the desired pressure rating selected by the County for meter products moving forward. It highlights the importance of the pressure rating criteria included in the scoring analysis detailed later within this report. Meters with higher pressure ratings are needed for locations within the service area experiencing peak pressures at this level. Additionally, customers requiring separate residential-sized irrigation meters should also consider these meters to handle anticipated surge pressures due to irrigation system on/off valve actuation.

3.6 Summary Comparison of Technical Characteristics

After identifying, reviewing, and comparing the technical characteristics between various meter types, key operating parameters, such as flow range, accuracy, head loss, and pressure, were identified as differentiators and compared to the criteria set by the County and by the project team. Special attention was given to the accuracy of flows within these products as well as their material composition. Again, key minimum requirement comparison criterion included:

- A measuring chamber meeting AWWA C700 accuracy standards (for mechanical meters only, since there is no existing standard for solid state meters)

- 9'' lay length for 3/4'' meters; 10 3/4'' lay length for 1'' meters
- A register compatible with the current Sensus AMI transmitter and FlexNet system
- Compatibility with TouchCoupler support (per Sensus provided literature)
- No additional programming required to communicate in Sensus FlexNet protocol
- A minimum warranty criterion for standard repaired meter accuracy of 15 years
- Alarm capabilities and associated features
- Compliance with Metro North Georgia Water Planning District conservation requirements

Important observations from this analysis include the following:

- The Sensus iPERL® is the only meter with a rated operating pressure of 200 psi (3/4'' size only); all other meters have rated operating pressures of either 175 psi (Badger E-Series and Neptune Mach 10®) or 150 psi (all others). The 200 psi is required for service within certain areas of the County's water distribution system (particularly in the southern region of the County), where surface elevations are relatively low and system pressures are high as well as in irrigation meter applications due to surges related to varied valve actuation times.
- The Sensus iPERL® and Neptune Mach 10® have 100 percent accuracy across low, medium, and high flow rates for both the 3/4" and 1" size classifications.
- The Sensus iPERL®, Badger E-Series, and Neptune Mach 10® meters have initial low flow measurement from 0.03 to 0.05 gpm for 3/4-inch meters- much lower than PD meters.
- All meters meet the minimum requirement for the warranty of the register.
- Meter accuracy warranty varies significantly for the solid state meter type (20 years) than for the mechanical meter type (maximum 5 years new meter accuracy, conditional on volumetric throughput).
- Sensus SR and Neptune T-8 have been eliminated from consideration because they are no longer manufactured and are not compatible with the current Sensus AMI platform.
- Meters manufactured by Elster, Amco, and Schlumberger have been eliminated from consideration because these meters only accept the 3-wire connection models and are not considered to be TouchCoupler compatible.
- Apart from the Badger E-Series, all meters included for consideration in this report (this excludes SR and the T-8) are compatible with the TouchCoupler "plug and play" features.
- Alarm functions tend to be manufacturer-specific and proprietary within register communication protocols, but can be passed through the Flexnet MXU.

Based on review of the June 2017 Water Resource Management Plan prepared for the Metropolitan North Georgia Water Planning District, the capabilities and financial and non-financial benefits of the meters and AMI technology described in this evaluation are substantially consistent with the desired features described in Action Item WSWC-5 - AMI Benefit and Feasibility Studies. Please reference Tables 4 and 5 below as the master summary of the technical comparison for the meter product identified and discussed in Section 3. Key comparative factors are bolded in the tables.

3.6.1 Comparison of Solid State and Mechanical Water Meters

Tables 4 and 5 serve as the basis for comparing differentiating characteristics of newer design (solid state or electronic) water meters and historically available (mechanical) meters. This section highlights many of the advantages of solid state meters over positive displacement mechanical meters. The primary advantages of solid state water meters are as follows:

- A solid state, all-electronic meter provides long-term sustained accuracy (within +/-1%). Manufacturers typically provide a full 20-year new meter accuracy warranty. A repaired meter accuracy warranty is not needed.
- Electromagnetic and ultrasonic (solid state) meter designs have no moving parts. This virtually eliminates mechanical wear in the measuring chamber that might shorten meter life.
- Internal corrosion and clogging by particulates are minimized due to flow-through design. This reduces maintenance requirements and concerns.
- Solid state meters accurately convey a wider flow range compared to a positive displacement meter, including both a lower extended low-flow rate and a higher continuous flow rate.
- Solid state meters come with a built-in register with large number of digits displayed. This feature reduces vandalism and tampering due to removal of the meter register.
- Solid state meters are totally potted and waterproof. The meter, including electronics, battery, and display are enclosed and waterproof. This feature also adds to the no maintenance requirement.

Additional solid state meter features of note are:

- Lower initial low flow registration
- Higher maximum flow rate
- Higher maximum working pressure
- More meter alarms
- Lower head loss at typical operating flow
- No limit of throughput volume over the meter life
- No separate meter register and maincase. The meter is an integrated unit which may be considered more secure and less subject to vandalism
- Considerably lower life cycle cost over 20 years

Some disadvantages of solid state meters include:

- Higher initial cost
- No replaceable parts

- Newer design with embedded electronics
- Built in non-replaceable battery
- Lesser field experience timeframe
- No AWWA adopted meter standard, although a standard document is pending

Advantages of mechanical positive displacement meters include:

- Lower initial cost
- Better meter maincase warranty
- Longer history and experience with water utilities
- Some components may be replaceable/maintainable
- Long-term adopted meter specification exists (AWWA C-700)

Some disadvantages of mechanical meters include:

- Susceptible to particulate clogging
- Mechanical parts wear out
- Susceptible to internal corrosion and scaling
- Multiple components to break
- Lose accuracy over time and throughput
- Removal register subject to vandalism
- Lesser warranty for accuracy in terms of time and throughput
- Less inclusive flow range

Table 4: Residential Meter Technical Comparison Summary Table – 3/4”

Operational Parameters - 3/4''

	Existing DeKalb Meters				Alternate Meters							
Name	**accuStream™ (E Register)**	**iPERL®**	**SR[1]**	**T-8, Model SC-ER[1]**	**accuStream™ (E Register Plus)**	**E-Series® Ultrasonic Meter**	**Recordall® Disc Meters (Model 35, Bronze)**	**Recordall® Disc Meters (Model 25, Polymer)**	**435 Bronze PD Meter**	**Master Meter PD Meter**	**T-10®**	**Mach 10®**
Image												
Manufacturer	Sensus	Sensus	Sensus/Rockwell	Neptune	Sensus	Badger Meter	Badger Meter	Badger Meter	Mueller Systems	Master Meter	Neptune	Neptune
Lay Length	9''	9''	9''	9''	9''	9''	9''	9''	9''	9''	9''	9''
Meter Type	Mechanical	Solid State	Mechanical	Mechanical	Mechanical	Solid State	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical	Solid State
Measurement Type	Oscillating Piston, Positive Displacement	Magnetic Field Flow Measurement	Oscillating Piston, Positive Displacement	Nutating Disc, Positive Displacement	Oscillating Piston, Positive Displacement	Ultrasonic Sensors located in flow tube	Nutating Disc, Positive Displacement	Nutating Disc, Positive Displacement	Nutating Disc, Positive Displacement	Positive Displacement	Magnetic drive, nutating disc/PD	Ultrasonic sensors
Body Composite	Composite Polymer	Composite Alloy	Metallic Alloy	Metallic Alloy	Composite Polymer	316SS	Lead-free Bronze Alloy	Engineered Polymer	Bronze	Bronze	Bronze	Bronze
NSF61	100% No Lead Material	100% No Lead Material	Not Compliant	Not Compliant	100% No Lead Material	100% No Lead Material	100% No Lead Material	100% No Lead Material	100% No Lead Material	100% No Lead Material	100% No Lead Material	100% No Lead Material
Initial Low Flow	**0.50 GPM**	**0.03 GPM**	**0.50 GPM**	**0.50 GPM**	**0.50 GPM**	**0.05 GPM**	**0.375 GPM**	**0.25 GPM**	**0.25 GPM**	**0.5 GPM**	**0.25 GPM**	**0.05 GPM**
Medium Flow	3 GPM	3 GPM	3 GPM	3 GPM	3 GPM	3 GPM	3 GPM	3 GPM	3 GPM	3 GPM	3 GPM	3 GPM
Maximum Flow	**30 GPM**	**35 GPM**	**30 GPM**	**30 GPM**	**30 GPM**	**32 GPM**	**25 GPM**	**15 GPM**	**25 GPM**	**15 GPM**	**30 GPM**	**35 GPM**
Maximum Pressure	**150 psi**	**200 psi**	**150 psi**	**150 psi**	**150 psi**	**175 psi**	**150 psi**	**150 psi**	**150 psi**	**150 psi**	**150 psi**	**175 psi**
Register Type	Digital Smart Electronic Register	Digital Smart Electronic Register	ICE - Mechanical Electronic Register; ECRII Register; Manual Direct Read	Manual Direct Read - Mechanical	Digital Smart Electronic Register	Absolute Digital Encoder® / Sweep-hand registration	Absolute Digital Encoder® / Sweep-hand registration	Absolute Digital Encoder® / Sweep-hand registration	Solid State Register (No touch pad compatibility)	Direct Read / DIALOG®	E-Coder®	E-Coder®
Register Connection	Potted Wire, TouchCoupler	Field Replaceable Wire, TouchCoupler	Potted Wire, TouchCoupler, None	None	Potted Wire, TouchCoupler	TouchCoupler	TouchCoupler	TouchCoupler	TouchCoupler	TouchCoupler	TouchCoupler	TouchCoupler
Meter Reading Type	TouchRead / FlexNet®	TouchRead / FlexNet® / Driveby RadioRead	TouchRead / FlexNet® / Driveby RadioRead / Manual	Manual	TouchRead / FlexNet®	FlexNet® / TouchRead	FlexNet® / TouchRead	FlexNet® / TouchRead	FlexNet® / TouchRead	FlexNet® / TouchRead	FlexNet®/ ProRead™	FlexNet®/ ProRead™
Meter Based Alarms	Low flow leak detector and tamperproof	Constant Flow, Reverse Flow, Tamper Alarm, Magnetic Field, Empty Pipe	None	None	Leak detection, backflow, tamper/removal	Empty pipe, low temperature, maximum flow rate exceedance, reverse flow, leak	Cellular network, reverse flow, suspected leak	Cellular network, reverse flow, suspected leak	Tamper alarm, leak detection, unable to read, low flow, and battery health	Tamper detection and flow leak indicator	Leak, tamper, and reverse flow detection	Leak, tamper, reverse flow detection, and low battery
Initial Low Flow Accuracy	100%	100%	N/A	N/A	100%	101.1%	99.5%	98.5%	100%	100%	96%	100%
Medium Flow Accuracy	100.6%	100%	N/A	N/A	100.6%	99.8%	101%	100%	100.3%	100.5%	100.8%	100%
High Flow Accuracy	99.5%	100%	N/A	N/A	99.5%	100.2%	100%	99%	99.75%	99.5%	99%	100%
Head Loss @ 15 GPM	**3.2 psi**	**1.9 psi**	**N/A**	**N/A**	**3.2 psi**	**2.0 psi**	**1.6 psi**	**2.8 psi**	**2.3 psi**	**3.5 psi**	**2.8 psi**	**1.9 psi**
Warranty Provisions												
New Meter Accuracy (yrs)	**5**	**20**	**N/A**	**N/A**	**5**	**20**	**5**	**5**	**5**	**5**	**5**	**20**
New Meter Accuracy (gal)	750,000	No limit	N/A	N/A	750,000	No limit	750,000	750,000	666,667	750,000	750,000	No limit
Repaired Accuracy (yrs)	**15**	**None**	**N/A**	**N/A**	**15**	**None**	**15**	**15**	**15**	**15**	**10**	**None**
Repaired Accuracy (gal)	2,250,000	None	N/A	N/A	2,250,000	None	2,500,000	2,500,000	2,000,000	2,500,000	2,250,000	None
Extended Low Flow Accuracy	**None**	**None**	**N/A**	**N/A**	**None**	**plus/minus 3% for 20 yrs**	**97% at 0.375 GPM for 5 years or 675,000 gallons**	**98.5% at 0.25 GPM for 5 years or 675,000 gallons**	**None**	**None**	**0.25 GPM at 95% for 5 years or 750,000 gallons**	**None**
Maincase (yrs)	20	None on External Housing	N/A	N/A	20	20	25.5	25.5	25	25	15	20 years prorated after 10
Encoder Register (yrs)	20 years prorated after 10	20 years prorated after 10	N/A	N/A	20 years prorated after 10	20 years prorated after 10	25.5	25.5	20 years prorated after 10	10	10	20 years prorated after 10
Meter Batteries (yrs)	20 years prorated after 10	20 years prorated after 10	N/A	N/A	20 years prorated after 10	20 years prorated after 10	N/A	N/A	N/A	15	None	20
Cost Estimates												
Initial Cost ($)	**100**	**125**	**N/A**	**N/A**	**100**	**188**	**149**	**108**	**155**	**285**	**140**	**199**
Salvage Value ($)	N/A	N/A	N/A	N/A	N/A	1.54	1.73	N/A	1.41	2.52	1.80	0.87

[1] Not considered for recommendation

Table 5: Residential Meter Technical Comparison Summary Table – 1”

Operational Parameters - 1''												
Existing DeKalb Meters					Alternate Meters							
Name	**accuStream™ (E Register)**	**iPERL®**	**SR[1]**	**T-8, Model SC-ER[1]**	**accuStream™ (E Register Plus)**	**E-Series® Ultrasonic Meter**	**Recordall® Disc Meters (Model 55, Bronze)**	**Recordall® Disc Meters (Model 40, Polymer)**	**452 Bronze PD Meter**	**Master Meter PD Meter**	**T-10®**	**Mach 10®**
Image												
Manufacturer	Sensus	Sensus	Sensus/Rockwell	Neptune	Sensus	Badger Meter	Badger Meter	Badger Meter	Mueller Systems	Master Meter	Neptune	Neptune
Lay Length	10.75''	10.75''	10.75''	10.75''	10.75''	10.75''	10.75''	10.75''	10.75''	10.75''	10.75''	10.75''
Meter Type	Mechanical	Solid State	Mechanical	Mechanical	Mechanical	Solid State	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical	Solid State
Measurement Type	Oscillating Piston, Positive Displacement	Magnetic Field Flow Measurement	Oscillating Piston, Positive Displacement	Nutating Disc, Positive Displacement	Oscillating Piston, Positive Displacement	Ultrasonic Sensors located in flow tube	Nutating Disc, Positive Displacement	Nutating Disc, Positive Displacement	Nutating Disc, Positive Displacement	Positive Displacement	Magnetic drive, nutating disc/PD	Ultrasonic sensors
Body	Composite Polymer	Composite Alloy	Metallic Alloy	Metallic Alloy	Composite Polymer	316SS	Lead-free Bronze Alloy	Engineered Polymer	Bronze	Bronze	Bronze	Bronze
NSF61	100% No Lead Material	100% No Lead Material	Not Compliant	Not Compliant	100% No Lead Material	100% No Lead Material	100% No Lead Material	100% No Lead Material	100% No Lead Material	100% No Lead Material	100% No Lead Material	100% No Lead Material
Initial Low Flow	**0.75 GPM**	**0.11 GPM**	**0.5 GPM**	**0.5 GPM**	**0.75 GPM**	**0.25 GPM**	**0.5 GPM**	**0.375 GPM**	**0.75 GPM**	**0.75 GPM**	**0.375 GPM**	**0.15 GPM**
Medium Flow	4 GPM	4 GPM	4 GPM	4 GPM	4 GPM	4 GPM	4 GPM	4 GPM	4 GPM	4 GPM	4 GPM	4 GPM
Maximum Flow	**50 GPM**	**55 GPM**	**30 GPM**	**30 GPM**	**50 GPM**	**55 GPM**	**40 GPM**	**20 GPM**	**35 GPM**	**25 GPM**	**50 GPM**	**55 GPM**
Maximum Pressure	**150 psi**	**175 psi**	**150 psi**	**150 psi**	**150 psi**	**175 psi**	**150 psi**	**150 psi**	**150 psi**	**150 psi**	**150 psi**	**175 psi**
Register Type	Digital Smart Electronic Register	Digital Smart Electronic Register	ICE - Mechanical Electronic Register; ECRII Register; Manual Direct Read	Manual Direct Read - Mechanical	Digital Smart Electronic Register	Absolute Digital Encoder® / Sweep-hand registration	Absolute Digital Encoder® / Sweep-hand registration	Absolute Digital Encoder® / Sweep-hand registration	Solid State Register (No touch pad compatibility)	Direct Read / DIALOG®	E-Coder®	E-Coder®
Register Connection	Potted Wire, TouchCoupler	Field Replaceable Wire, TouchCoupler	Potted Wire, TouchCoupler, None	None	Potted Wire, TouchCoupler	TouchCoupler	TouchCoupler	TouchCoupler	TouchCoupler	TouchCoupler	TouchCoupler	TouchCoupler
Meter Reading Type	TouchRead / FlexNet®	TouchRead / FlexNet® / Driveby RadioRead	TouchRead / FlexNet® / Driveby RadioRead / Manual	Manual	TouchRead / FlexNet®	FlexNet® / TouchRead	FlexNet® / TouchRead	FlexNet® / TouchRead	FlexNet® / TouchRead	FlexNet® / TouchRead	FlexNet®/ ProRead™	FlexNet®/ ProRead™
Meter Based Alarms	Low flow leak detector and tamperproof	Constant Flow, Reverse Flow, Tamper Alarm, Magnetic Field, Empty Pipe	None	None	Leak detection, backflow, tamper/removal	Empty pipe, low temperature, maximum flow rate exceedance, reverse flow, leak	Cellular network, reverse flow, suspected leak	Cellular network, reverse flow, suspected leak	Tamper alarm, leak detection, unable to read, low flow, and battery health	Tamper detection and flow leak indicator	Leak, tamper, and reverse flow detection	Leak, tamper, reverse flow detection, and low battery
Initial Low Flow Accuracy	100%	100%	N/A	N/A	100%	99.5%	97.5%	98.0%	100%	100%	96%	100%
Medium Flow Accuracy	100.4%	100%	N/A	N/A	100.4%	100.3%	100.2%	100%	100.8%	100.3%	100.8%	100%
High Flow Accuracy	99.5%	100%	N/A	N/A	99.5%	100.2%	99%	100%	99.25%	99.5%	99.2%	100%
Head Loss @ 25 GPM	**3.5 psi**	**2.1 psi**	**N/A**	**N/A**	**3.5 psi**	**1.8 psi**	**1.2 psi**	**3.0 psi**	**2.0 psi**	**6.5 psi**	**2.2 psi**	**2.4**
Warranty Provisions												
New Meter Accuracy (yrs)	**5**	**20**	**N/A**	**N/A**	**5**	**20**	**5**	**3**	**5**	**5**	**5**	**20**
New Meter Accuracy (gal)	1,000,000	No limit	N/A	N/A	1,000,000	No limit	1,000,000	1,100,000	1,000,000	1,100,000	1,000,000	No limit
Repaired Accuracy (yrs)	**15**	**None**	**N/A**	**N/A**	**15**	**None**	**15**	**15**	**15**	**15**	**10**	**None**
Repaired Accuracy (gal)	3,000,000	None	N/A	N/A	3,000,000	None	3,000,000	3,250,000	3,000,000	3,250,000	3,000,000	None
Extended Low Flow Accuracy	**None**	**None**	**N/A**	**N/A**	**None**	**Plus/minus 3% for 20 yrs**	**95% at 0.375 GPM for 3 years or 575,000 gallons**	**95% at 0.375 GPM for 3 years or 1,100,000 gallons**	**None**	**None**	**0.375 GPM at 95% for 5 years or 1,000,000 gallons**	**None**
Maincase (yrs)	20	None on External Housing	N/A	N/A	20	20	25.5	25.5	25	25	15	20 years prorated after 10
Encoder Register (yrs)	20 years prorated after 10	20 years prorated after 10	N/A	N/A	20 years prorated after 10	20 years prorated after 10	25.5	25.5	20 years prorated after 10	10	10	20 years prorated after 10
Meter Batteries (yrs)	20 years prorated after 10	20 years prorated after 10	N/A	N/A	20 years prorated after 10	20 years prorated after 10	None	None	None	15	None	20
Cost Estimates												
Initial Cost ($)	**155**	**190**	**N/A**	**N/A**	**155**	**204**	**199**	**163**	**240**	**365**	**171**	**250**
Salvage Value ($)	N/A	N/A	N/A	N/A	N/A	1.98	2.63	N/A	3.30	3.66	2.93	1.08

[1] Not considered for recommendation

4 METER LIFE EXPECTANCY, WARRANTY, AND FLEXNET COMPATIBILITY

Following the technical comparison, the project team reviewed and analyzed the warranty, life expectancy, and FlexNet® compatibility for the selected range of meter products. The summary of this analysis is included in the sections below.

4.1 Meter Life Expectancy and Warranty Comparison

Water Meter Warranty

Meter manufacturers offer different warranty terms for varying meter types, sizes, and components. The warranty applies to the purchasing utility and not to individual customers. Typical water meter warranties have different subheadings. These include Products, Materials and Workmanship, Meter Accuracy, Extended Low-Flow Meter Accuracy (if offered), Product Returns, and Limits of Liability. Manufacturers are generally required to submit nationally publicized warranties for meter bids.

Warranty provisions can be used to differentiate meters for a specific size and compute life cycle costs based on meter accuracy provisions. Key warranty provisions are indicated within the master comparison tables (Tables 4 and 5) located in Section 3.6. Differentiating provisions are generally based on new and repaired meter accuracy. Positive displacement meters have warranties for new meter accuracy based on years and gallonage throughput. New solid state electronic meters have 20-year new meter accuracy warranties and no repaired meter provisions, since these meters need to be replaced if broken, and internal electronic batteries cannot be individually replaced due to water proofing.

Water Meter Life

Water meter life is subjective. One criterion used to determine meter life is the end of a warrantied repaired meter accuracy period. This is typically 15 years for residential-sized meters. Based on local utility economics, water quality, and water rates, some utilities define a meter life as when the meter is losing more revenue due to inaccuracy than it costs to replace. In the case of new solid state electronic meters, based on new meter accuracy warranty, one can assume a 20-year meter life. **For the life cycle cost calculations in this report, we have assumed a 20-year economic timeframe for all meters achieving DeKalb County's AMI communication and technical operating requirements.** For all of the residential sized meters, the underperforming meter is assumed to be replaced and a new meter purchased and installed in its place at the end of its repaired meter accuracy warranty for mechanical positive displacement meters and at the end of new meter accuracy warranty for solid state meters. Life cycle analyses must have the same time period for economic comparisons.

There exists a pro-rated battery warranty for new solid state meters which covers 100 percent of replacement costs for a new meter for ten years, not including removal and installation. After ten years, different new meter purchase percentages apply which decline to zero at 20 years. Based on manufacturer research and expected battery life for normal one-hour interval reads with AMI, internal batteries in meters are expected to last more than 20 years. Accelerated aging tests by meter

manufacturers have confirmed this meter life assumption for electronic meters. Since these meters haven't been field-tested for 20 years, actual performance needs to be monitored and reported.

4.2 Meter Compatibility with DWM's Sensus FlexNet® System

As described in Sensus product literature, FlexNet® is a robust communications software platform for smart metering applications. FlexNet® allows water utilities to improve meter reading accuracy and reduce overhead costs. Simple communications and reliable data delivery are critical to any metering system. FlexNet® approaches these two industry challenges with a direct meter-to-receiver architecture and by operating on unique frequency licenses. Utilities who use FlexNet® products can avoid conflicting interference in shared bands by using specially distributed frequencies within National Radio Spectrum protection laws.

Key FlexNet® Features for Water Utilities include:

- 2 Watts, 400-MHz licensed power
- Daily, hourly, and minute data intervals
- Time-of-use, critical peak billing
- Tamper and energy theft alarms
- Power fail and restoration notification

FlexNet's® smart grid solution uses long-range radio to provide a secure communications network. This technology allows water utilities to manage assets and conserve resources. Water utilities are concerned with the cost of electricity and, thus, invest in reducing their operating costs. FlexNet's® smart water meters permit time-of-day tariffs to support off-peak and night-time uses of water when the cost of energy and evaporative losses have decreased. This system includes SCADA (Supervisory Control and Data Acquisition) devices which have lighting controls and distribution leak detection.

DeKalb County has 10 fixed base stations that can currently read about 95% of the DeKalb water service geographic area. Meters having readable MXU radio units are about 20 percent of the total meter population at this time. The readings occur on an hourly basis, and the system is expected to provide 100 percent coverage to DeKalb County when required repeaters are installed. Data is passed from the base stations to the Regional Network Interface (RNI), which is a cloud-based server. All data measurements from the meter are stored in the RNI and are accessible via Sensus Analytics. In the future, if desired and affordable, residents can view their water consumption interval data and manage individual use as they see fit. The existing DeKalb billing system provides both monthly and bi-monthly bills to customers. Once FlexNet® is fully operational, DeKalb intends to bill monthly.

The meters identified in Tables 4 and 5 (except for the existing Sensus SR and the Neptune T-8) are compatible with DeKalb County's FlexNet® System, except for meter-based alarms. Sensus technical staff reports an industry-wide problem with communication language and protocols of competing meter manufacturers which sometimes provides challenges with the transfer of meter-based alarms to the FlexNet® data analytics system. Alarm communication functionality differs between the Sensus iPERL® and Sensus accuStream™ meter types within the FlexNet® analytics system.

Per direct communication with Sensus technical staff, Sensus does not offer a specific hand-held device (HHD) for programming various capabilities into the meter registers, and devices manufactured by others

will be suitable for this purpose. However, neither the HHD nor Sensus FlexNet® endpoints, nor software, will communicate specific alarms generated by third-party meter registers.

Sensus does have software to load in the HHD which is called “Field Logic Tools”. The functions of Field Logic Tools are to program and trouble shoot registers and the MXU radio end points, data log the water meters, program the meter electronic registers, and generally read all Sensus registers (iPERL, accuStream™, etc.).

There are two types of alarms: meter-based register and MXU (radio endpoint). The iPERL alarms consist of both alarm types. The meter register can be programmed in a specific Smart Point mode to let the radio endpoint monitor the alarms.

An important key performance indicator (KPI) of any AMI/AMR system is “read success rate”. This factor needs to be very high (99.9%+) but varies among utilities and AMI systems. The typical AMI system currently reads all meters on an hourly basis (read interval equals one hour). Some hourly reads are missed due to transmission errors caused by physical issues, electronic issues, environmental issues, and other factors affecting radio signal propagation in water service areas. It is important to note that a high read success rate does not mean a high read accuracy rate. **A high read accuracy rate (the AMI data collection system reflects the actual meter register) does not reflect the accuracy of the meter to record and report actual customer consumption through the meter. It is important to note the differences in these KPIs.**

4.3 Case Study Comparisons

4.3.1 Case Study No. 1

Nashville Metro Water Services

Nashville Metro Water Services (MWS) serves more than 191,000 customers in Nashville, Tennessee and surrounding areas. As this number continues to grow, quality service and operational efficiency is critical to their success. Manual meter reading posed challenges to achieving these goals. Manual meter reading was subject to error and re-reading meters was costly. In addition, technicians at MWS often faced poison ivy and bug bites, walked through overgrown fields and drove through hazardous road conditions making reading meters difficult and time-consuming. Also, MWS collected meter readings once a month so the utility relied on customers to report unusually high water bills before investigating the source of a leak or billing inaccuracy.

MWS turned to Sensus for a smart water network to improve its operations. The utility deployed SR II® mechanical, positive displacement type water meters and the FlexNet® communication network. MWS now collects real-time data from the field to improve leak detection and proactively alert customers of potential leaks. They have reduced the cost per meter reading by 95 cents, saving $181,000 per month. At the same time, MWS has improved working conditions for technicians, who no longer have to face the insects and other routine discomforts of manually reading meters in the field.

The Sensus meters and FlexNet® communication network allowed MWS to:

- Increase employee safety
- Improve meter reads

- Save $181,000 per month

4.3.2 Case Study No. 2

Etowah Water and Sewer Authority

Etowah Water and Sewer Authority (the Authority) serves 5,400 consumers and runs 1.5 million gallons of water per day through 175 miles of pipe. Faced with aging meters from multiple manufacturers, the Authority looked to implement a complete replacement program including an advanced metering infrastructure (AMI) solution from one vendor that would offer improved accuracy, greater longevity and forward-looking capabilities. Two-way communication between the meters and base stations was a primary driver as were overall cost and a clear path to achieving return on investment (ROI).

The Authority turned to Sensus for its FlexNet® communication system and iPERL® meters, which offered low flow accuracy with high flow durability with a 20-year warranty. The AMI connectivity gave the authority the ability to read meters every hour, and with the mountainous terrain surrounding the authority, the powerful radio capabilities were necessary to ensure reliable communication.

The Authority measured results against three key metrics: customer service, conservation, and cash flow. They developed a program which allows customers to see their consumption over a 24-hour period, making billing and water usage more transparent. Also, alerts triggered by unusual or continuous usage patterns warn customers of possible leaks before there is extensive use or damage. In addition, the Sensus Flexnet® system provides the Authority the ability to accurately read the lowest usage flows, computing a more accurate bill for the customer. The improved accuracy has given the Authority a five percent increase in revenue without a corresponding rate increase. This meter conversion will provide a complete ROI in five to seven years.

The Sensus meters and FlexNet® communication network allowed the Authority to:

- Provide the customer greater transparency of their water usage
- Measure the lowest usage flow to compute a more accurate bill for the customer
- Increase revenue by five percent without a corresponding rate increase

4.3.3 Case Study No. 3

Eastern Municipal Water District

Located in Perris, California, Eastern Municipal Water District (EMWD) provides services to seven cities in Riverside County and is California's sixth-largest water agency. With 795,000 individuals served, EMWD is quickly installing meters to keep up with its expanding customer base – in the past four years, the utility has installed more than 7,000 new residential and commercial meters. Manually reading 148,000 meters across a 555-square mile service area was a daunting task. With a growing number of customers, California's ongoing drought creating new regulatory challenges, and the need for accurate data, the organization needed to conserve time and water.

EMWD deployed the Sensus FlexNet® communication network with third-party multijet meters to improve operations and meet the needs of a growing population. FlexNet® was used to collect accurate data in a timely manner, generate reports for customers, analyze usage, conserve water and improve operational efficiency. This application of FlexNet indicated its ability to successfully communicate with a third-party

meter provider. Without FlexNet®, EMWD leaders estimate it would take as many as eight additional staff members to manually read the meters of the utility's growing population. Now employees can focus their time on analyzing data and using insights to better serve customers. For example, continuous usage reports identify customers with high consumption levels and EMWD staff are able to inform customers of elevated usage. As a flexible and scalable technology, FlexNet® enables accurate and reliable meter readings no matter how many people and businesses move to the Riverside County area.

The FlexNet® communication network allowed EMWD to:

- Avoid allocating eight additional staff members to manually read meters for EMWD's growing population
- Empower customers to conserve water in drought by informing them of recorded, elevated water use

5 SAMPLE METER BENCH TESTING

5.1 Bench Testing

5.1.1 Background and Test Protocol

Once meters were prequalified based on the technical analysis and compatibilities outlined in previous sections, the project team coordinated with local vendors and with DWM staff to have sample meters of each of the identified products made available for accuracy and AMI compatibility bench testing by DWM. The existing DWM meter accuracy testing protocol utilized for this evaluation is outlined below.

Bench testing by DWM staff was performed by using the existing calibrated MARS test bench located at DWM's Roadhaven facility. At this facility, meters are tested to AWWA M6 new meter accuracy standards, and results are recorded. Table 6 shows new meter accuracy performance, as reported by meter manufacturer technical documents. Per AWWA M6 mechanical meters, new meter accuracy for low flow should be at least 95%, and medium and high flow accuracy should be 98.5% to 101.5%. Repaired meter accuracy for low flow should be at least 90%, and accuracy for medium and high flows should be 98.5% to 101.5%. There is no existing AWWA new meter accuracy standard for solid state meters.

Table 6: New Meter Accuracy Specifications per Manufacturer References

Type	Size	Low Flow (GPM)	Medium Flow (GPM)	High Flow (GPM)
Magnetic/Ultrasonic	3/4"	0.11	0.18	35
Magnetic/Ultrasonic	1"	0.30	0.40	55
Positive Displacement	3/4"	0.50	3.0	25
Positive Displacement	1"	0.75	4.0	40

The bench testing procedure for accuracy testing as provided by DWM involved the following steps:

1.) Empty the test tanks and confirm bench is fully operational.
2.) Place each test meter in the test bench using the gaskets present. Confirm meters are not leaking.
3.) Record the start read and serial number on each meter being tested.
4.) Begin low flow test to above flow range in Table 6 and flow quantity. Record post low flow test reading.
5.) Begin the medium flow test. Record post medium flow test readings.
6.) Begin the high flow test. Record high flow test readings.
7.) Continue flow through meter and repeat test after set time intervals.
8.) Record all results and remove all meters from test bench.

In addition to accuracy testing, meters were connected to Sensus FlexNet® radio endpoints to test connector capability, data transfer compatibility, and other functional characteristics.

5.2 Summary of DWM Staff Meter Testing Observations

In conjunction with the meter accuracy testing described above, DWM staff made and recorded observations about other elements important to meter performance and functionality. Other functionality includes such factors as security, register readability, effectiveness of register connector with MXU, transferability of meter readings to Sensus Analytics, consistent serial numbering with electronic meter ID, and water proofing. These test protocols and performance requirements were coordinated and observed by DeKalb DWM staff. These observations are summarized with the testing results presented in Appendix B.

6

6 CONCLUSIONS

6.1 FlexNet Functionality and Compatibility

The meters identified in Tables 4 and 5 (except for the existing Sensus SR, existing Neptune T-8, and the alternate Badger E-Series) are compatible with DeKalb County's FlexNet® System, except for passing meter-based alarms. Sensus reports an industry-wide problem with communication language and protocols of competing meter manufacturers which preclude transfer of meter-based alarms to the FlexNet® data analytics system. Alarm communication functionality differs between the Sensus iPERL® and Sensus accuStream™ meter types within the FlexNet® analytics system. Transmitter-based alarms (via the Sensus MXU) will still be reported.

Per Sensus technical staff, Sensus does not offer a specific hand-held device (HHD) for programming various capabilities into the meter registers, but devices manufactured by others will be suitable for this purpose. However, neither the HHD nor Sensus FlexNet® endpoints, nor software, will communicate specific meter-based alarms generated by third-party meter registers.

6.2 Summary of Life Cycle Cost Analysis

The basis for the life cycle cost analysis performed for this assessment incorporates the evolving body of knowledge gained from recent and ongoing investigations of meter performance at low and ultra-low flows. Interest in these performance capabilities has increased recently with the increasing use of more efficient low-flow fixtures, particularly in single family residential dwellings, as further described below.

Water Meter Life Cycle Cost Analysis

This section presents an economic evaluation of existing and alternative 3/4"and 1" water meters achieving the technical specifications selected by DeKalb staff and the project team. The underlying analyses in this evaluation estimate the Net Present Cost of each water meter (by size and manufacturer) using the national warranty information and manufacturer and distributor-provided budgetary costs shown in the Life Cycle Cost Excel Workbook in Appendix A. Specific assumptions for the analyses are discussed below.

Acquiring the meter includes the initial bid price for the meter, the encoder register, and the FlexNet™ TouchCoupler, plus installation costs. The initial cost of the meter is the price the purchaser will pay today for one meter at the specified size. The installation costs were assumed to be $50 each for all meters based on recent experience and observed regional costs.

Maintenance and operation costs include estimates of lost revenue for DeKalb County's water and sewer services due to inaccuracy of metered flow measurements. The estimated lost revenue would occur in those years in which the meter is covered by the repaired meter accuracy warranty (only applies to mechanical meters, since solid state meters have no repaired meter accuracy warranty).

The accuracy of the meter during the repaired meter warranty period was assumed at 93.6 percent, based on the residential usage distribution (15-70-15% for low-medium-high flow), as stated in AWWA Manual M6, and on recent research on short-interval demand indicating that unmeasured flow for typical positive displacement water meters is 5 percent or more. During the repaired meter accuracy period, initial low flow is warrantied at 90 percent accuracy. Medium (normal) and high flow are warrantied at a band of 1.5 percent above or below 100 percent and, thus, are assumed to be 100 percent. Incorporating

the 5 percent unmeasured flow for mechanical positive displacement meters results in the following distribution of flow for SFR customers:

- Unmeasured Flow = 5%,
- Initial Low Flow = 14%,
- Normal Flow = 67%, and
- High Flow = 14%.

Based on this flow distribution, 81 percent of the flow (67 normal plus 14 high) is measured at 100 percent accuracy, 14 percent of the flow is measured at 90 percent accuracy, and 5 percent is measured at 0 percent accuracy. Applying these factors yields a repaired meter accuracy of 93.6 percent. Using the SFR flow distribution described above and the meters' accuracy for initial low flow, medium flow and high flow presented in Tables 2 and 3 in Section 3.4, the accuracy of the meter during the new meter warranty period was determined.

Each water meter evaluated has a 20-year timeline for economic comparison. All meters are initially purchased new at the purchase price shown in Appendix A. A new meter accuracy period is shown for all

meters per national warranty. A repaired meter accuracy is also shown for positive displacement meters based on warranty years. The DeKalb average SFR usage per dwelling is insufficient to reach the warrantied cumulative volume (in gallons) before the end of the warranty period, so no reduction in warranty period is assumed.

In this evaluation, meter replacement would occur at the end of the repaired meter accuracy warranty period. At the time of meter replacement, a new meter is purchased, and the utility expends labor and equipment costs to replace the old meter with the new. Meter replacement costs are assumed to be the new meter purchase price at the time of replacement (adjusted for inflation) and installation costs at $50 plus inflation for all meters.

The economic evaluation includes the salvage or scrap value of the meter at the time of meter replacement, which also has been inflated to the year of replacement. This is primarily the value of the meter's main case if it is of metallic construction.

Table 7 indicates all the assumptions which provide the basis for the meter Net Present Cost economic evaluation. Sources for each assumption are indicated in the reference column in the table on the right. A Microsoft Excel spreadsheet approach was used for calculating Net Present Cost for each meter size and type. Once the costs for acquiring, maintaining, and disposing of each meter were determined for each year within the 20-year cost period, the Net Present Cost (NPC) of the cash flows was computed. The Net Present Cost allows comparison of the sum of cash flows incurred at different times during the meter's life cycle. To make these cash flows time-equivalent, they are converted to present day cost by discounting them to the present time using a discount rate that approximates the County's average cost of capital. The range for cost of capital utilized in the analysis was based on DeKalb County's recent debt issue rates (i.e. 2.0 percent - 5.5 percent). A sensitivity analysis was performed comparing the NPC of each meter using this range of capital rate costs. The comparative summary in Table 7 uses the assumed cost of capital of 5.5 percent for DeKalb County.

Table 7: Assumptions for Net Present Cost Economic Analysis

Parameter	Assumed Value or Basis		Reference
Cost of Capital	5.5%		DeKalb DWM
New Meter Accuracy	100%		Meter Manufacturer
Repaired Meter Accuracy	93.6%		Arcadis Research
Single Family Residential (SFR) Use Distribution	5-14-67-14 % for Unmeasured-L-M-H flow		AWWA M6 plus Arcadis Research
Positive Displacement Meter Unmeasured Flow	5.0%		EBMUD Unmeasured Flow Study[1], JCI Research[2], USU Tests[3]
Water Meter Replacement Date	End of Repaired Meter Accuracy Warranty		Arcadis Assumption
DeKalb Average SFR Water Use	100	gallons per person per day	USEPA
DeKalb SFR Persons per Dwelling	2.5	people/dwelling	USEPA
Days in a Year	365	Days	Calculation

DeKalb SFR Annual Water Use	91,250	gallons	Calculation
DeKalb SFR Monthly Water Use	7,604	gallons	Calculation
DeKalb Irrigation Usage	20%		DeKalb DWM
DeKalb SFR Monthly Sewer Discharge	6,083	gallons	DeKalb DWM
Bi-Monthly Water Consumption (0-4,000) 3/4" Meter	$ 2.16	per 1,000 gallons	DeKalb DWM
Bi-Monthly Water Consumption (4,001-20,000) 3/4" Meter	$ 3.08	per 1,000 gallons	DeKalb DWM
Bi-Monthly Water Consumption 1" meter	$ 3.08	per 1,000 gallons	DeKalb DWM
Bi-Monthly Irrigation Consumption	$ 8.08	per 1,000 gallons	DeKalb DWM
Bi-Monthly Sewer Consumption	$ 11.34	per 1,000 gallons	DeKalb DWM
Annual Average Water/Sewer Rate Increase	4%		DeKalb DWM
Annual Average Inflation Rate for Meter Costs	2%		Meter Manufacturers
Average Annual Cost of Water/Sewer (3/4" Meter)	$ 1,035.00		DeKalb DWM
Year 1 Annual Lost Revenue (3/4" Meter)	$ 66.24		Calculation
Average Annual Cost of Water/Sewer (1" Meter)	$ 1,052.66		DeKalb DWM
Year 1 Annual Lost Revenue (1" Meter)	$ 67.37		Calculation
Register Battery Life (Non-Replaceable)	20	years	Manufacturer Warranty
Replacement/Installation Costs (Labor-All Meters)	$ 50		DeKalb DWM
2010 Recovery Zone Bond	$ 28,400,000	Coupon Rate (%): 5.440	DeKalb DWM
Series 2011A Serial Bonds	$ 214,280,000	Coupon Rate (%): 5.106	DeKalb DWM
Series 2011A 2036 Serial Bonds	$ 54,845,000	Coupon Rate (%): 5.250	DeKalb DWM
Series 2011A 2041 Serial Bonds	$ 112,375,000	Coupon Rate (%): 5.250	DeKalb DWM
2010 Revenue Refunding Bond	$ 70,490,000	Coupon Rate (%): 4.469	DeKalb DWM

1 David Wallenstein "Unmeasured Flow Study" (EBMUD 2016)

2 "Residential End Uses of Water, Flow Rate Analysis of the Logging Data" Craig Hannah, Johnson Controls, AWWA ACE Philadelphia, PA June, 2017

3 Utah State University (USU) Water Research Laboratory research project entitled "Accuracy of In-Service Water Meters at Low and High Flow Rates". This project was funded by the Water Research Foundation and the United States Environmental Protection Agency (US EPA) and published in 2011.

The results of the economic evaluation presented in an Excel Workbook in Appendix A indicate the total cost for meter ownership over a 20-year time frame based on the assumed life of a given meter considering the costs of acquiring and disposing of the meters. A summary of Net Present Cost for all

meters evaluated is provided in Table 8. Lower Net Present Cost amounts are indicative of greater benefit and value to the County.

Table 8: Summary of Net Present Cost Calculations for ¾" and 1" Meters

iPERL 3/4"	$ 175.00
accuSTREAM 3/4"	$ 1,279.80
HM 435 Series Bronze 3/4"	$ 1,363.93
Master Meter 3/4"	$ 1,574.81
Badger E-Series 3/4"	$ 262.29
Badger Recordall® (Model 35, Bronze Disc) 3/4"	$ 1,357.30
Badger Recordall® (Model 25, Polymer Disc) 3/4"	$ 1,318.07
Neptune T-10 3/4"	$ 1,398.91
Neptune Mach 10 3/4"	$ 248.50
iPERL 1"	$ 240.00
accuSTREAM 1"	$ 1,385.70
HM 452 Series Bronze 1"	$ 1,523.19
Master Meter 1"	$ 1,720.09
Badger E-Series 1"	$ 266.91
Badger Recordall® (Model 55, Bronze Disc) 1"	$ 1,493.46
Badger Recordall® (Model 40, Polymer Disc) 1"	$ 1,458.45
Neptune T-10 1"	$ 1,464.62
Neptune Mach 10 1"	$ 299.50

6.3 Meter Evaluation and Scoring

The comparison and evaluation of water meters was performed in a two-step approach. Initially, individual meters were scored for multiple quantitative and qualitative criteria. Subsequently, meter scores for each criterion were multiplied by weighting factors derived by DeKalb County DWM staff to incorporate utility input in the evaluation. Weighted scores for all criteria were summed for each meter providing a final weighted summary score. The comparisons between meters were performed by evaluating the final weighted total scores. The highest scores represented the best performing meters. A sensitivity analysis was performed by applying different weighting factors to the evaluation criteria to assess changes in meter scores and ranking.

Quantitative evaluations were performed on criteria where numeric data was available from manufacturer specifications and input to make comparisons. Qualitative evaluations were performed for criteria that do not have numeric data and require subjective assessment of the features for specific meters through DeKalb and other utility operational experience and bench testing.

Fifteen evaluation criteria were applied, grouped into four categories as shown in Table 9 below:

Table 9: Evaluation Categories and Associated Criteria

Category	Criteria
Point-of-use Performance	1. Initial Low Flow reported by the manufacturer 2. Maximum Flow reported by the manufacturer 3. Head Loss through the meter at a standard flow rate (differs by meter size)
Utility-related	4. Maximum Pressure 5. Initial Cost 6. Life Cycle Cost 7. AMI Compatibility Cost
Warranty-related	8. New Meter Accuracy 9. Repaired Meter Accuracy 10. Low Flow Accuracy
Qualitative	11. Readability 12. Water/Weatherproofing 13. Security 14. Communication of Alarms 15. TouchCoupler Connectivity

All fifteen criteria above were applied to each meter type in the individual 3/4- and 1-inch meter sizes to assign a score, depending on the scoring brackets for each criterion. Weighting factors were applied to each criterion to determine a total score. Meters in each size were numerically ranked based on highest to lowest score. Various scoring approaches and combinations of criteria were also developed. These scoring approaches were as follows:

- Total Overall Score (included all 15 selected criteria)
- No FlexNet Criteria (removed any FlexNet related criteria)
  - Removed Criteria 7, 14, and 15
- Quantitative Only – No Costs (removed Qualitative criteria and cost related criteria)
  - Removed Criteria 5, 6, 7 and Criteria 11 through 15
- Quantitative Only – With Costs (removed Qualitative criteria only)
  - Removed Criteria 11 through 15

Tables 10 through 13 below show the two highest scoring meters at each size category for each of these approaches within the respective mechanical (positive displacement) and solid state meter product classes.

Table 10: Total Overall Scoring Approach – Results

0.75”		1”	
Solid State	**Mechanical**	**Solid State**	**Mechanical**
1. Sensus iPERL	**1. Sensus AccuSTREAM**	**1. Sensus iPERL**	**1. Sensus AccuSTREAM**
2. Neptune Mach 10	**2. Badger Recordall 35**	**2. Neptune Mach 10**	**2. Badger Recordall 55**

Table 11: No FlexNet Criteria Scoring Approach – Results

0.75”		1”	
Solid State	**Mechanical**	**Solid State**	**Mechanical**
1. Sensus iPERL	**1. Sensus AccuSTREAM**	**1. Sensus iPERL**	**T1. Sensus AccuSTREAM**
2. Neptune Mach 10	**T2. Badger Recordall 35** **T2. Mueller 435**	**T2. Neptune Mach 10** **T2. Badger E-Series SS**	**T1. Badger Recordall 55**

Table 12: Quantitative Only (No Costs) Scoring Approach - Results

0.75”		1”	
Solid State	**Mechanical**	**Solid State**	**Mechanical**
1. Sensus iPERL	**T1. Badger Recordall 35**	**T1. Sensus iPERL**	**T1. Badger Recordall 55**
2. Neptune Mach 10	**T1. Mueller 435**	**T1. Neptune Mach 10**	**T2. Sensus AccuSTREAM** **T2. Mueller 452**

Table 13: Quantitative Only (With Costs) Scoring Approach - Results

0.75”		1”	
Solid State	**Mechanical**	**Solid State**	**Mechanical**
1. Sensus iPERL	**1. Sensus AccuSTREAM**	**1. Sensus iPERL**	**1. Sensus AccuSTREAM**
2. Neptune Mach 10	**T2. Mueller 435** **T2. Badger Recordall 35**	**2. Neptune Mach 10**	**2. Badger Recordall 55**

Overall, of the mechanical and solid state meters evaluated, the highest scoring meters for both ¾” and 1” sizes across the full range of comparison criteria and the various scoring methodologies are:

Mechanical: 1) Sensus accuStream™ and 2) Badger Recordall (bronze nutating disc type).

Solid State: 1) Sensus iPERL and 2) Neptune Mach 10

APPENDIX A

Life Cycle Cost Analysis

DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis Assumptions

Element	Assumed Value or Basis	
Cost of Capital	5.5%	
New Meter Accuracy	See New Meter Warranty Accuracies Table	
Repaired Meter Accuracy	93.6%	
Single Family Residential (SFR) Use Distribution	5-14-67-14 Percent for Unmeasured-L-M-H flow	
Positive Displacement Meter Unmeasured Flow	5.0%	
Water Meter Replacement Date	End of Repaired Meter Accuracy Warranty	
DeKalb Average SFR Water Use	100	gallons per person per day
DeKalb SFR Persons per Dwelling	2.5	people/dwelling
Days in a Year	365	Days
DeKalb SFR Annual Water Use	91,250	gallons
DeKalb SFR Monthly Water Use	7,604	gallons
DeKalb Irrigation Usage	20%	
DeKalb SFR Monthly Sewer Discharge	6,083	gallons
Bi-Monthly Water Consumption (0-4,000) 3/4" meter	$ 2.16	per 1,000 gallons
Bi-Monthly Water Consumption (4,001-20,000) 3/4" meter	$ 3.08	per 1,000 gallons
Bi-Monthly Water Consumption 1" meter	$ 3.08	per 1,000 gallons
Bi-Monthly Irrigation Consumption	$ 8.08	per 1,000 gallons
Bi-Monthly Sewer Consumption	$ 11.34	per 1,000 gallons
Annual Average Water/Sewer Rate Increase	4%	
Annual Average Inflation Rate for Meter Costs	2%	
Average Annual Cost of Water/Sewer (3/4" Meter)	$ 1,035.00	
Year 1 Annual Lost Revenue (3/4" Meter)	$ 66.24	
Average Annual Cost of Water/Sewer (1" Meter)	$ 1,052.66	
Year 1 Annual Lost Revenue (1" Meter)	$ 67.37	
Sensus iPERL Accuracy and Duration	100%, 20 years	
Register Battery Life (Non-Replaceable)	20	years
Replacement/Installation Costs (All Meters)	$ 50.00	
2010 Recovery Zone Bond	$ 28,400,000	Coupon Rate (%): 5.440
Series 2011A Serial Bonds	$ 214,280,000.00	Coupon Rate (%): 5.106
Series 2011A 2036 Serial Bonds	$ 54,845,000.00	Coupon Rate (%): 5.250
Series 2011A 2041 Serial Bonds	$ 112,375,000.00	Coupon Rate (%): 5.250
2010 Revenue Refunding Bond	$ 70,490,000.00	Coupon Rate (%): 4.496

DeKalb County Department of Watershed Management
Water Meter New Meter Warranty Accuracies

SFR Use Distribution	
Unmeasured Flow	5%
Low Flow	14%
Medium Flow	67%
High Flow	14%

3/4" New Meter Accuracy Warranties

	Low Flow Accuracy (0.5 gpm)	Medium Flow Accuracy (3 gpm)	High Flow Accuracy (25 gpm)	New Meter Warranty Accuracy
accuStream™	100%	100%	99.50%	**94.93%**
iPERL®	100%	100%	100%	**100.00%**
E-Series® Ultrasonic	100%	99.8%	100%	**99.87%**
Recordall Disc® (Model 35, Bronze)	99.5%	100%	100%	**94.93%**
Recordall Disc® (Model 25, Polymer)	98.5%	100%	99%	**94.65%**
435 Bronze PD Meter	100%	100%	99.75%	**94.97%**
Master Meter PD Meter	100%	100%	99.5%	**94.93%**
Neptune T-10	96%	100%	99.0%	**94.30%**
Neptune Mach-10	100%	100%	100%	**100%**

1" New Meter Accuracy Warranties

	Low Flow Accuracy (0.75 gpm)	Medium Flow Accuracy (4 gpm)	High Flow Accuracy (40 gpm)	New Meter Warranty Accuracy
accuStream™	100%	100%	99.50%	**94.93%**
iPERL®	100%	100%	100%	**100.00%**
E-Series® Ultrasonic	99.5%	100%	100%	**99.93%**
Recordall Disc® (Model 55, Bronze)	97.5%	100%	99%	**94.51%**
Recordall Disc® (Model 40, Polymer)	98%	100%	100%	**94.72%**
452 Bronze PD Meter	100%	100%	99.25%	**94.90%**
Master Meter PD Meter	100%	100%	99.5%	**94.93%**
Neptune T-10	96%	100%	99.2%	**94.33%**
Neptune Mach-10	100%	100%	100%	**100.00%**

DeKalb County Department of Watershed Management
Water Meter Life Cycle Sensitivity Analysis

Net Present Cost with Varying Cost of Capital Rates

	Cost of Capital						
	2.5%	**3.0%**	**3.5%**	**4.0%**	**4.5%**	**5.0%**	**5.5%**
iPERL 3/4"	$175.00	$175.00	$ 175.00	$ 175.00	$ 175.00	$ 175.00	$ 175.00
accuSTREAM 3/4"	$1,656.59	$1,582.69	$ 1,513.69	$ 1,449.24	$ 1,388.98	$ 1,332.59	$ 1,279.80
HM 435 Series Bronze 3/4"	$1,757.21	$1,680.00	$ 1,607.95	$ 1,540.66	$ 1,477.78	$ 1,418.97	$ 1,363.93
Master Meter 3/4"	$2,011.17	$1,925.32	$ 1,845.29	$ 1,770.61	$ 1,700.88	$ 1,635.73	$ 1,574.81
Badger E-Series 3/4"	$269.95	$268.45	$ 267.05	$ 265.74	$ 264.51	$ 263.37	$ 262.29
Recordall Disc® (Model 35, Bronze) 3/4"	$1,749.52	$1,672.52	$ 1,600.67	$ 1,533.56	$ 1,470.85	$ 1,412.19	$ 1,357.30
Recordall Disc® (Model 25, Polymer) 3/4"	$1,705.50	$1,629.45	$ 1,558.48	$ 1,492.20	$ 1,430.25	$ 1,372.30	$ 1,318.07
Neptune T-10 3/4"	$1,805.88	$1,725.90	$ 1,651.30	$ 1,581.66	$ 1,516.61	$ 1,455.80	$ 1,398.91
Neptune Mach-10 3/4"	$248.50	$248.50	$ 248.50	$ 248.50	$ 248.50	$ 248.50	$ 248.50
iPERL 1"	$240.00	$240.00	$ 240.00	$ 240.00	$ 240.00	$ 240.00	$ 240.00
accuSTREAM 1"	$1,786.04	$1,707.44	$ 1,634.09	$ 1,565.60	$ 1,501.59	$ 1,441.72	$ 1,385.70
HM 452 Series Bronze 1"	$1,951.21	$1,867.07	$ 1,788.59	$ 1,715.34	$ 1,646.93	$ 1,582.99	$ 1,523.19
Master Meter 1"	$2,187.78	$2,095.69	$ 2,009.85	$ 1,929.80	$ 1,855.09	$ 1,785.31	$ 1,720.09
Badger E-Series 1"	$270.98	$270.18	$ 269.43	$ 268.74	$ 268.09	$ 267.48	$ 266.91
Recordall Disc® (Model 55, Bronze) 1"	$1,919.55	$1,835.77	$ 1,757.64	$ 1,684.73	$ 1,616.63	$ 1,552.98	$ 1,493.46
Recordall Disc® (Model 40, Polymer) 1"	$1,882.67	$1,799.23	$ 1,721.44	$ 1,648.84	$ 1,581.05	$ 1,517.70	$ 1,458.45
Neptune T-10 1"	$1,886.46	$1,803.52	$ 1,726.18	$ 1,654.00	$ 1,586.58	$ 1,523.56	$ 1,464.62
Neptune Mach-10 1"	$299.50	$299.50	$ 299.50	$ 299.50	$ 299.50	$ 299.50	$ 299.50

The range of cost of capital utilized in the analysis was based on DeKalb County's recent debt issue rates (2.5% - 5.5%). Project costs that occur at different points in the life of a meter cannot be compared or summed directly due to the varying time value of money. These costs (i.e. operation and maintenance costs, end of life costs) must be discounted back to their present value through the net present cost equation. Costs must be discounted to the present value, because dollars in the present are worth more than dollars in the future – a dollar today can be invested to earn interest to yield more than a dollar in the future. The present value can be thought of as the amount of money that would need to be invested today, at an interest rate equal to the cost of capital, in order to have the money available to meet the future cost at the time when it is predicted to occur. Therefore, the cost of capital is what is used to determine the extent the future costs are discounted to the present.

DeKalb County Department of Watershed Management
Water Meter Life Cycle Cash Flows

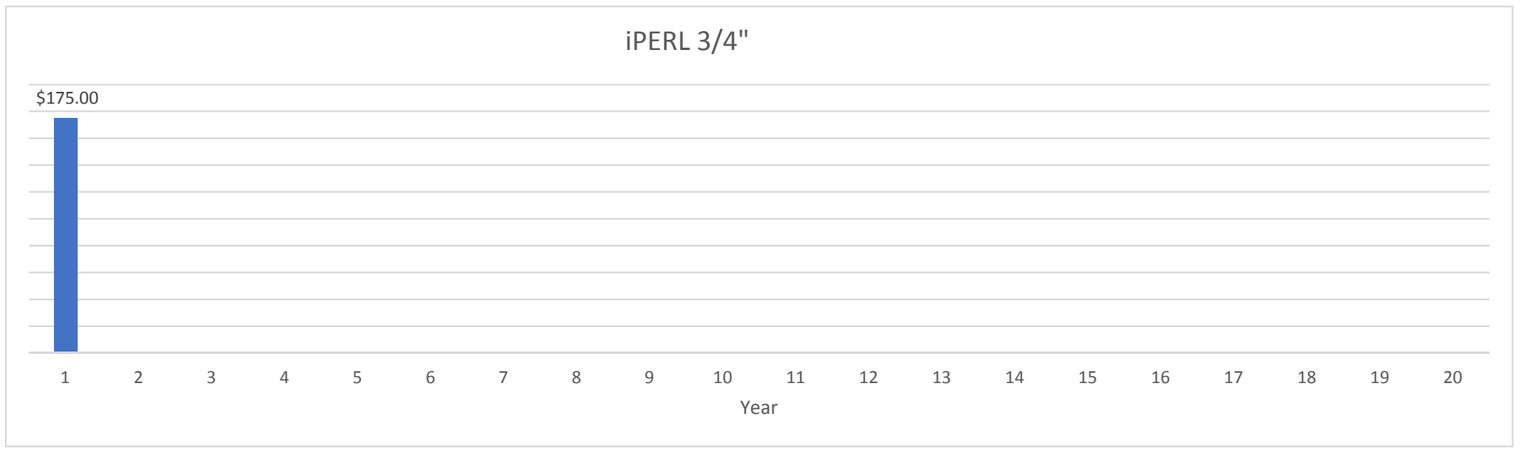
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
iPERL 3/4"	$ 175.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
accuSTREAM 3/4"	$ 202.47	$ 54.57	$ 56.76	$ 59.03	$ 61.39	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 296.38	$ 98.28	$ 102.21	$ 106.30	$ 110.56
HM 435 Series Bronze 3/4"	$ 257.11	$ 54.20	$ 56.36	$ 58.62	$ 60.96	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 367.86	$ 97.60	$ 101.51	$ 105.57	$ 109.79
Master Meter 3/4"	$ 387.47	$ 54.57	$ 56.76	$ 59.03	$ 61.39	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 541.98	$ 98.28	$ 102.21	$ 106.30	$ 110.56
Badger E-Series 3/4"	$ 239.39	$ 1.44	$ 1.50	$ 1.56	$ 1.62	$ 1.69	$ 1.75	$ 1.83	$ 1.90	$ 1.97	$ 2.05	$ 2.14	$ 2.22	$ 2.31	$ 2.40	$ 2.50	$ 2.60	$ 2.70	$ 2.81	$ 2.92
Recordall Disc® (Model 35, Bronze) 3/4"	$ 251.47	$ 54.57	$ 56.76	$ 59.03	$ 61.39	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 360.00	$ 98.28	$ 102.21	$ 106.30	$ 110.56
Recordall Disc® (Model 25, Polymer) 3/4"	$ 213.37	$ 57.59	$ 59.89	$ 62.29	$ 64.78	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 312.37	$ 103.71	$ 107.86	$ 112.17	$ 116.66
Neptune T-10 3/4"	$ 248.49	$ 61.35	$ 63.81	$ 66.36	$ 69.02	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 358.05	$ 110.50	$ 114.92	$ 119.51	$ 124.29
Neptune Mach-10 3/4"	$ 248.50	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
iPERL 1"	$ 240.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
accuSTREAM 1"	$ 258.37	$ 55.50	$ 57.72	$ 60.03	$ 62.44	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 372.02	$ 99.96	$ 103.96	$ 108.12	$ 112.44
HM 452 Series Bronze 1"	$ 343.74	$ 55.89	$ 58.12	$ 60.45	$ 62.87	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 482.64	$ 100.65	$ 104.68	$ 108.86	$ 113.22
Mastrer Meter 1"	$ 468.37	$ 55.50	$ 57.72	$ 60.03	$ 62.44	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 649.73	$ 99.96	$ 103.96	$ 108.12	$ 112.44
Badger E-Series 1"	$ 254.74	$ 0.77	$ 0.80	$ 0.83	$ 0.86	$ 0.90	$ 0.93	$ 0.97	$ 1.01	$ 1.05	$ 1.09	$ 1.13	$ 1.18	$ 1.23	$ 1.28	$ 1.33	$ 1.38	$ 1.44	$ 1.49	$ 1.55
Recordall Disc® (Model 55, Bronze) 1"	$ 306.79	$ 60.10	$ 62.51	$ 65.01	$ 67.61	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 435.66	$ 108.24	$ 112.57	$ 117.07	$ 121.76
Recordall Disc® (Model 40, Polymer) 1"	$ 268.58	$ 57.80	$ 60.12	$ 75.78	$ 78.81	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 386.77	$ 104.10	$ 108.27	$ 136.48	$ 141.94
Neptune T-10 1"	$ 280.71	$ 62.10	$ 64.58	$ 67.16	$ 69.85	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 399.69	$ 111.83	$ 116.30	$ 120.96	$ 125.79
Neptune Mach-10 1"	$ 299.50	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: iPERL 3/4"
New Meter Warranty: 20 years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 125.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Labor for Meter Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value																				
Net Cash Flow	$ 175.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

Net Present Cost $ 175.00

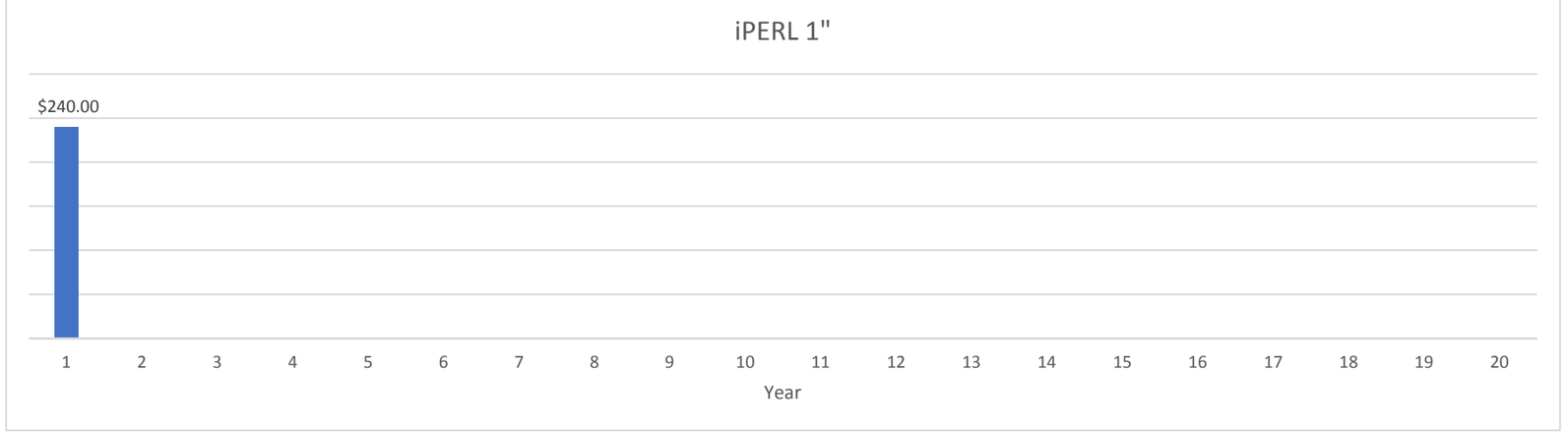


DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: iPERL 1"
New Meter Warranty: 20 years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 190.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Labor for Meter Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value																				
Net Cash Flow	$ 240.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

Net Present Cost $ 240.00

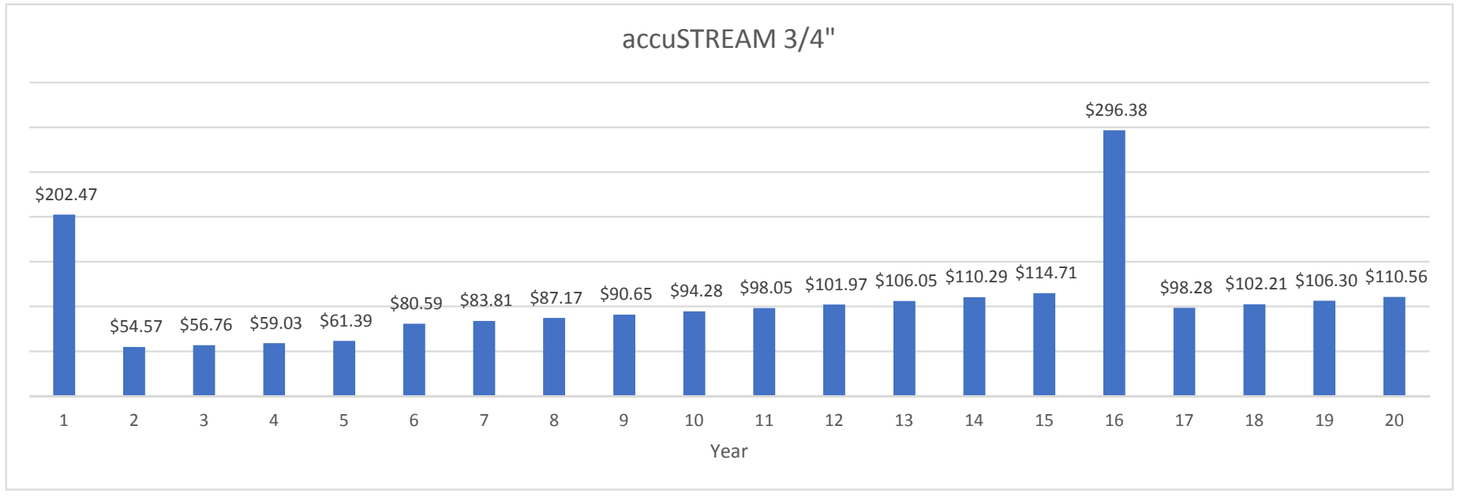


DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: accuSTREAM 3/4"
Lifetime: 15 years
New Meter Accuracy: 5 years
Repaired Meter Accuracy: 15 years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 100.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ 52.47	$ 54.57	$ 56.76	$ 59.03	$ 61.39	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 94.50	$ 98.28	$ 102.21	$ 106.30	$ 110.56
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 134.59	$ -	$ -	$ -	$ -
Labor for Meter Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 67.29	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value - Housing																$ -				
Net Cash Flow	$ 202.47	$ 54.57	$ 56.76	$ 59.03	$ 61.39	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 296.38	$ 98.28	$ 102.21	$ 106.30	$ 110.56

Net Present Cost $ 1,279.80

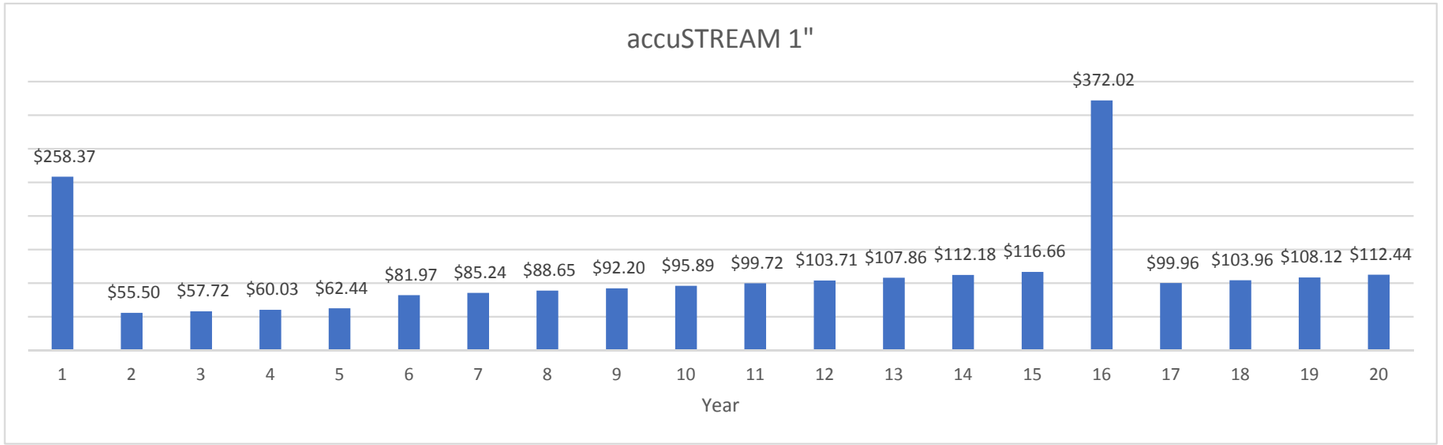


DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: accuSTREAM 1"
New Meter Accuracy: 5 years
Repaired Meter Accuracy: 15 years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 155.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ 53.37	$ 55.50	$ 57.72	$ 60.03	$ 62.44	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 96.12	$ 99.96	$ 103.96	$ 108.12	$ 112.44
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 208.61	$ -	$ -	$ -	$ -
Labor for Meter Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 67.29	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value - Housing																$ -				
Net Cash Flow	$ 258.37	$ 55.50	$ 57.72	$ 60.03	$ 62.44	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 372.02	$ 99.96	$ 103.96	$ 108.12	$ 112.44

Net Present Cost $ 1,385.70

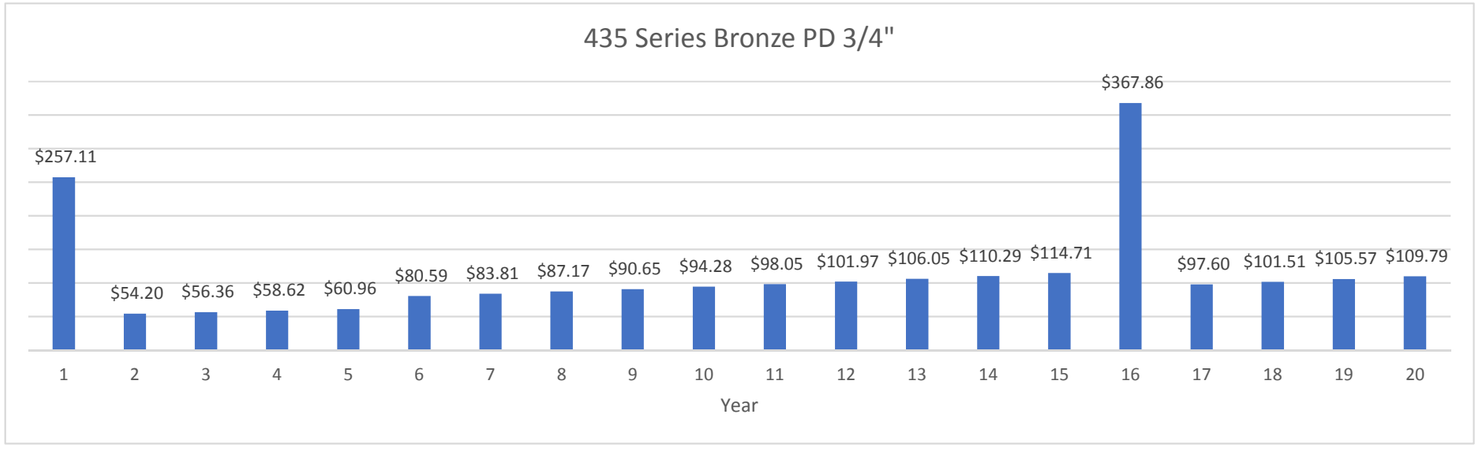


DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: Mueller 435 Series Bronze 3/4"
New Meter Accuracy: 5 years
Repaired Meter Accuracy: 15 years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 155.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ 52.11	$ 54.20	$ 56.36	$ 58.62	$ 60.96	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 93.85	$ 97.60	$ 101.51	$ 105.57	$ 109.79
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 208.61	$ -	$ -	$ -	$ -
Labor for Meter Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 67.29	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value - Housing																$ (1.90)				
Net Cash Flow	$ 257.11	$ 54.20	$ 56.36	$ 58.62	$ 60.96	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 367.86	$ 97.60	$ 101.51	$ 105.57	$ 109.79

Net Present Cost $ 1,363.93

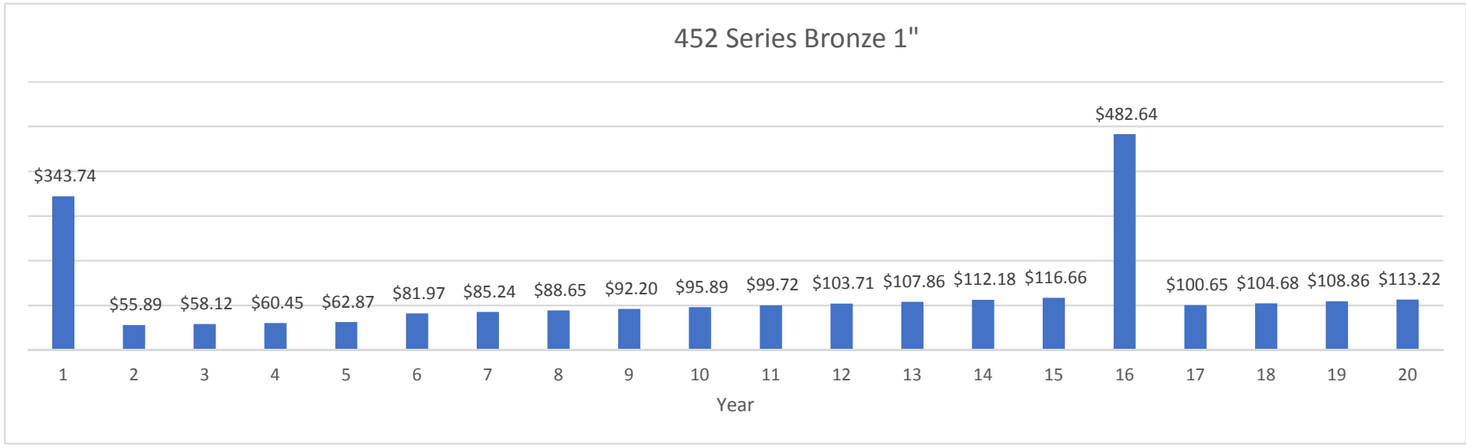


DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: Mueller 452 Series, Bronze 1"
New Meter Accuracy: 5 years
Repaired Meter Accuracy: 15 years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 240.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ 53.74	$ 55.89	$ 58.12	$ 60.45	$ 62.87	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 96.78	$ 100.65	$ 104.68	$ 108.86	$ 113.22
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 323.01	$ -	$ -	$ -	$ -
Labor for Meter Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 67.29	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value - Housing																$ (4.44)				
Net Cash Flow	$ 343.74	$ 55.89	$ 58.12	$ 60.45	$ 62.87	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 482.64	$ 100.65	$ 104.68	$ 108.86	$ 113.22

Net Present Cost $ 1,523.19

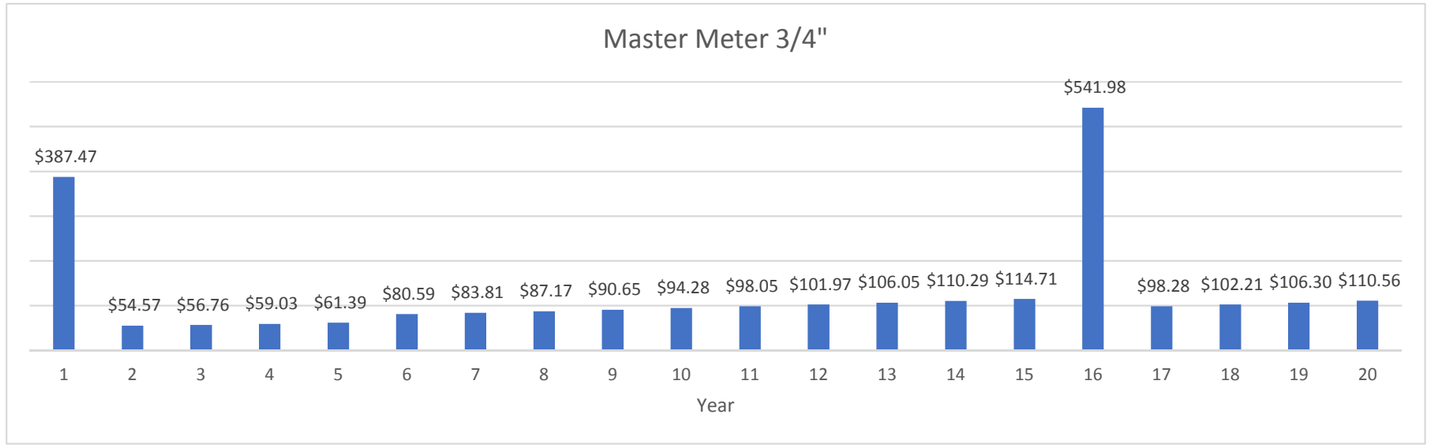


DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: Master Meter 3/4"
New Meter Warranty: 5 years
Repaired Meter Warranty: 15 years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 285.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ 52.47	$ 54.57	$ 56.76	$ 59.03	$ 61.39	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 94.50	$ 98.28	$ 102.21	$ 106.30	$ 110.56
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 383.57	$ -	$ -	$ -	$ -
Labor for Meter Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 67.29	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value - Housing																$ (3.39)				
Net Cash Flow	$ 387.47	$ 54.57	$ 56.76	$ 59.03	$ 61.39	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 541.98	$ 98.28	$ 102.21	$ 106.30	$ 110.56

Net Present Cost $ 1,574.81



DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: Master Meter 1"
New Meter Warranty: 5 years
Repaired Meter Warranty: 15 years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 365.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ 53.37	$ 55.50	$ 57.72	$ 60.03	$ 62.44	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 96.12	$ 99.96	$ 103.96	$ 108.12	$ 112.44
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 491.24	$ -	$ -	$ -	$ -
Labor for Meter Replaceme	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 67.29	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value - Housing																$ (4.93)				
Net Cash Flow	$ 468.37	$ 55.50	$ 57.72	$ 60.03	$ 62.44	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 649.73	$ 99.96	$ 103.96	$ 108.12	$ 112.44

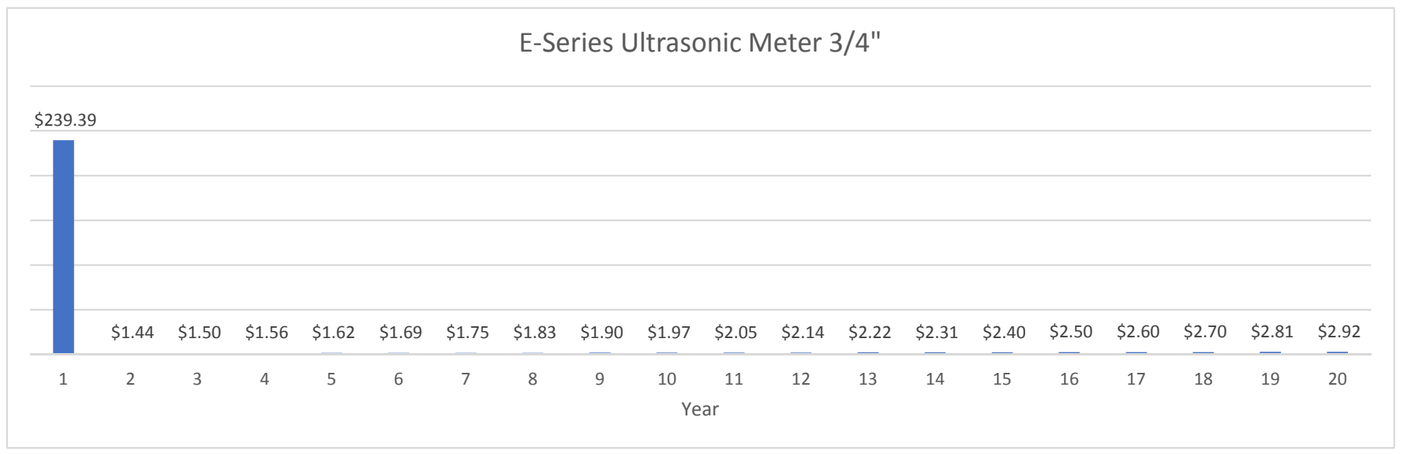
Net Present Cost $ 1,720.09

DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: Badger E-Series Ultrasonic Meters 3/4"
New Meter Warranty: 20 years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 188.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ 1.39	$ 1.44	$ 1.50	$ 1.56	$ 1.62	$ 1.69	$ 1.75	$ 1.83	$ 1.90	$ 1.97	$ 2.05	$ 2.14	$ 2.22	$ 2.31	$ 2.40	$ 2.50	$ 2.60	$ 2.70	$ 2.81	$ 2.92
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Labor for Meter Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value - Housing																				
Net Cash Flow	$ 239.39	$ 1.44	$ 1.50	$ 1.56	$ 1.62	$ 1.69	$ 1.75	$ 1.83	$ 1.90	$ 1.97	$ 2.05	$ 2.14	$ 2.22	$ 2.31	$ 2.40	$ 2.50	$ 2.60	$ 2.70	$ 2.81	$ 2.92

Net Present Cost $ 262.29

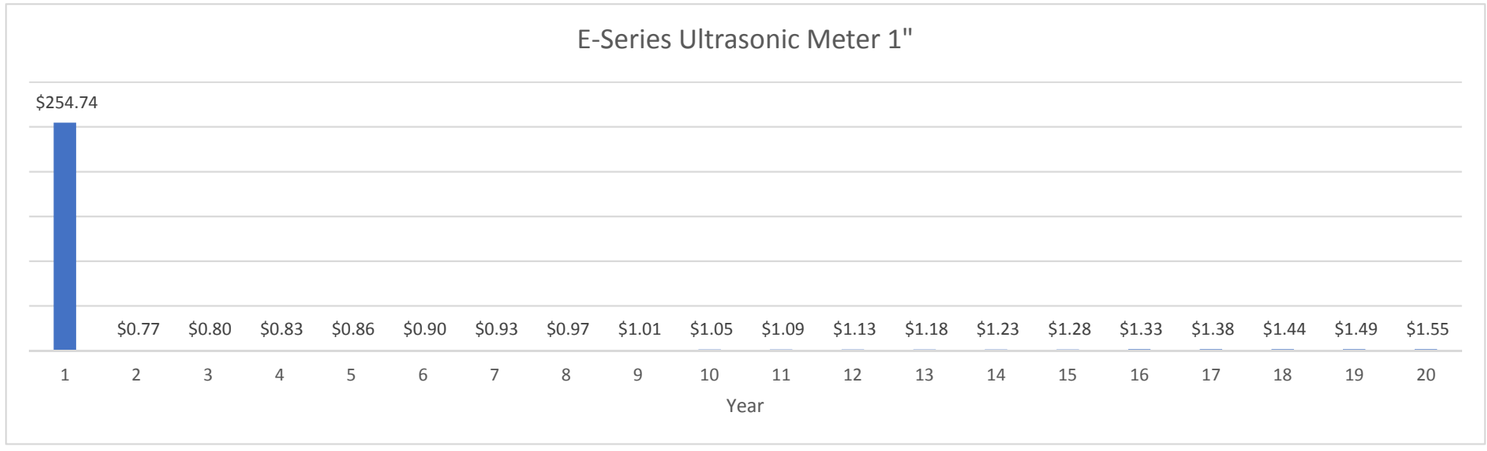


DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: Badger E-Series Ultrasonic Meters 1"
New Meter Warranty: 20 years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 204.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ 0.74	$ 0.77	$ 0.80	$ 0.83	$ 0.86	$ 0.90	$ 0.93	$ 0.97	$ 1.01	$ 1.05	$ 1.09	$ 1.13	$ 1.18	$ 1.23	$ 1.28	$ 1.33	$ 1.38	$ 1.44	$ 1.49	$ 1.55
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Labor for Meter Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value - Housing																				
Net Cash Flow	$ 254.74	$ 0.77	$ 0.80	$ 0.83	$ 0.86	$ 0.90	$ 0.93	$ 0.97	$ 1.01	$ 1.05	$ 1.09	$ 1.13	$ 1.18	$ 1.23	$ 1.28	$ 1.33	$ 1.38	$ 1.44	$ 1.49	$ 1.55

Net Present Cost $ 266.91

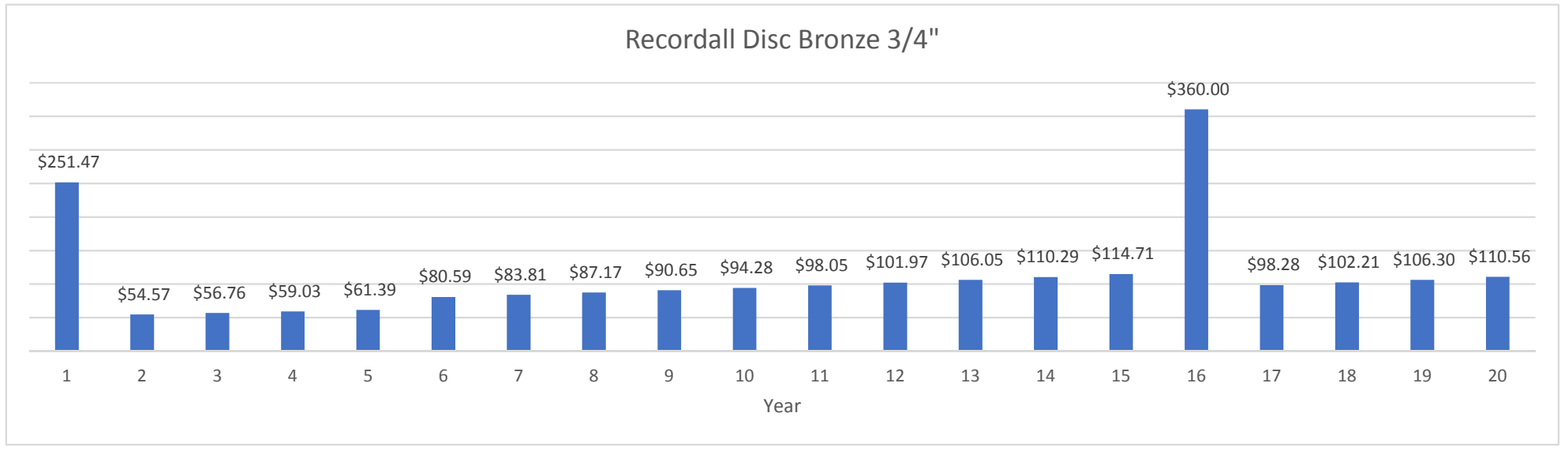


DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: Recordall® Disc (Model 35, Bronze) 3/4"
New Meter Warranty: 5 years
Repaired Meter Warranty: 15 years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 149.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ 52.47	$ 54.57	$ 56.76	$ 59.03	$ 61.39	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 94.50	$ 98.28	$ 102.21	$ 106.30	$ 110.56
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 200.53	$ -	$ -	$ -	$ -
Labor for Meter Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 67.29	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value - Housing																$ (2.33)				
Net Cash Flow	$ 251.47	$ 54.57	$ 56.76	$ 59.03	$ 61.39	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 360.00	$ 98.28	$ 102.21	$ 106.30	$ 110.56

Net Present Cost $ 1,357.30

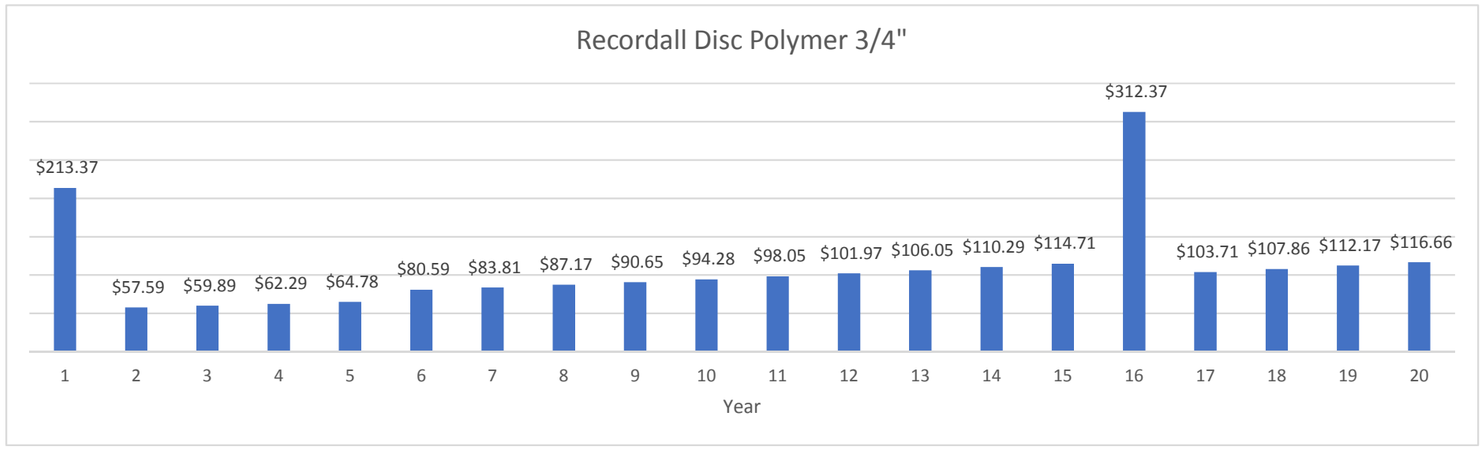


DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: Recordall® Disc (Model 25, Polymer) 3/4"
New Meter Warranty: 5 years
Repaired Meter Warranty: 15 years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 108.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ 55.37	$ 57.59	$ 59.89	$ 62.29	$ 64.78	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 99.72	$ 103.71	$ 107.86	$ 112.17	$ 116.66
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 145.35	$ -	$ -	$ -	$ -
Labor for Meter Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 67.29	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value - Housing																$ -				
Net Cash Flow	$ 213.37	$ 57.59	$ 59.89	$ 62.29	$ 64.78	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 312.37	$ 103.71	$ 107.86	$ 112.17	$ 116.66

Net Present Cost $ 1,318.07

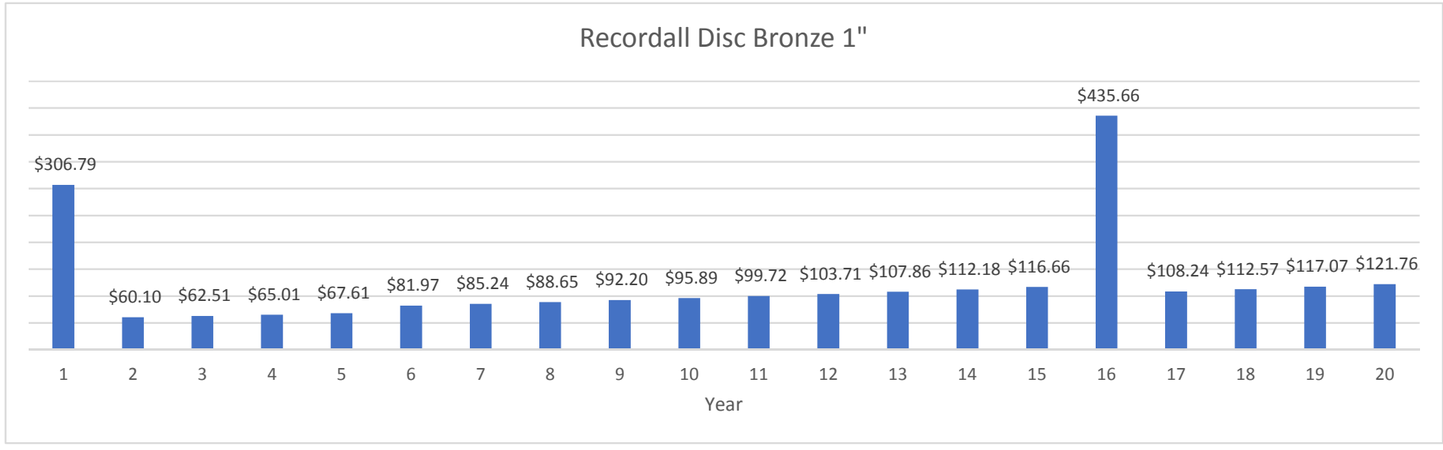


DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: Recordall® Disc (Model 55, Bronze) 1"
New Meter Warranty: 5 years
Repaired Meter Warranty: 15 years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 199.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ 57.79	$ 60.10	$ 62.51	$ 65.01	$ 67.61	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 104.08	$ 108.24	$ 112.57	$ 117.07	$ 121.76
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 267.83	$ -	$ -	$ -	$ -
Labor for Meter Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 67.29	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value - Housing																$ (3.54)				
Net Cash Flow	$ 306.79	$ 60.10	$ 62.51	$ 65.01	$ 67.61	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 435.66	$ 108.24	$ 112.57	$ 117.07	$ 121.76

Net Present Cost $ 1,493.46

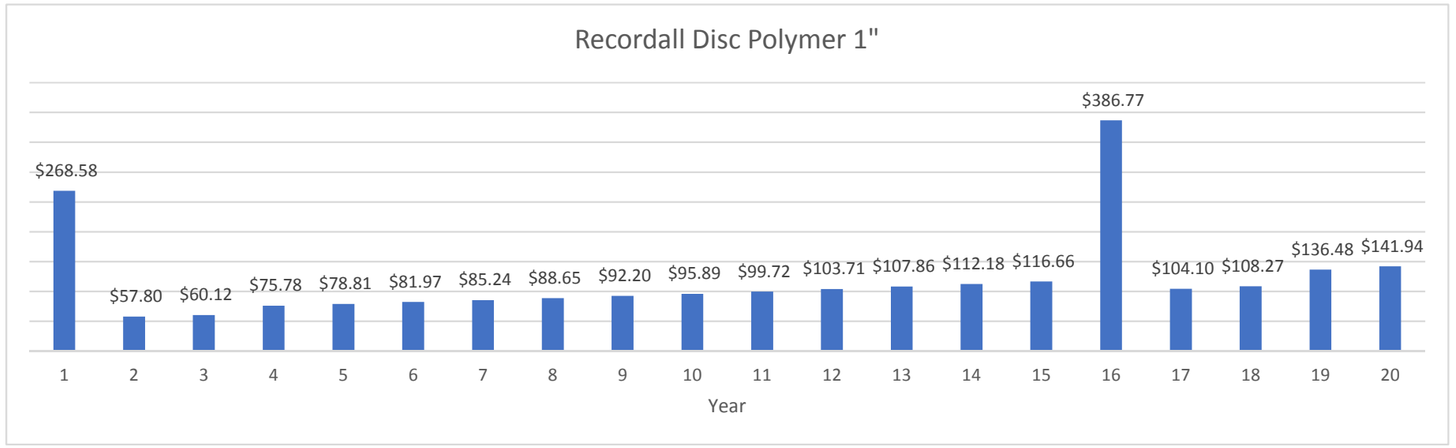


DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: Recordall® Disc (Model 40, Polymer) 1"
New Meter Warranty: 3 years
Repaired Meter Warranty: 15 years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 163.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ 55.58	$ 57.80	$ 60.12	$ 75.78	$ 78.81	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 100.10	$ 104.10	$ 108.27	$ 136.48	$ 141.94
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 219.38	$ -	$ -	$ -	$ -
Labor for Meter Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 67.29	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value - Housing																$ -				
Net Cash Flow	$ 268.58	$ 57.80	$ 60.12	$ 75.78	$ 78.81	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 386.77	$ 104.10	$ 108.27	$ 136.48	$ 141.94

Net Present Cost $ 1,458.45

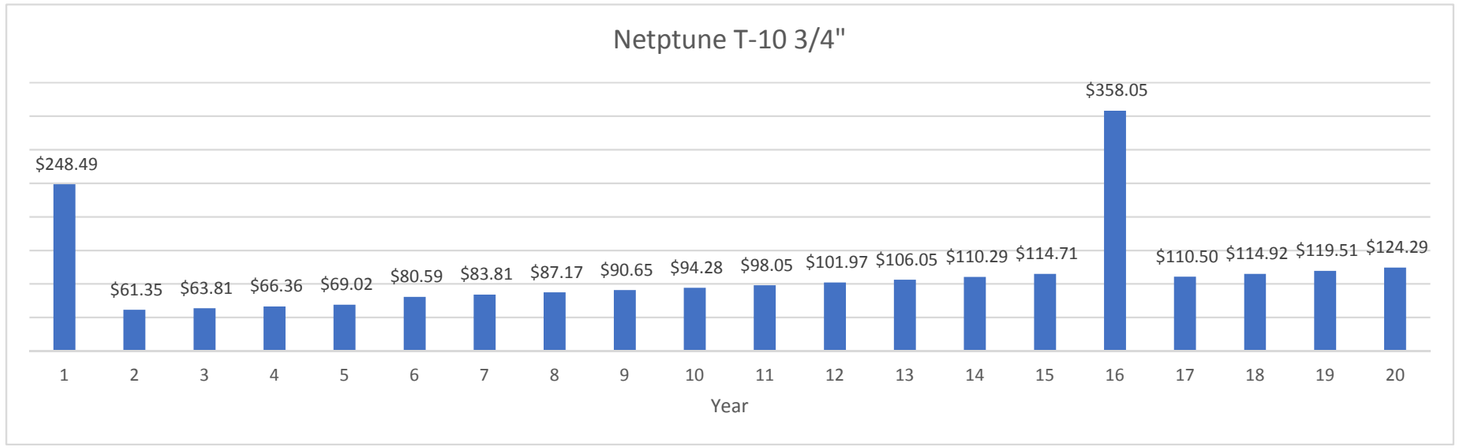


DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: Neptune T-10 3/4"
New Meter Warranty: 5 years
Repaired Meter Warranty: 15 years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 139.50	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ 58.99	$ 61.35	$ 63.81	$ 66.36	$ 69.02	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 106.25	$ 110.50	$ 114.92	$ 119.51	$ 124.29
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 187.75	$ -	$ -	$ -	$ -
Labor for Meter Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 67.29	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value - Housing																$ (3.24)				
Net Cash Flow	$ 248.49	$ 61.35	$ 63.81	$ 66.36	$ 69.02	$ 80.59	$ 83.81	$ 87.17	$ 90.65	$ 94.28	$ 98.05	$ 101.97	$ 106.05	$ 110.29	$ 114.71	$ 358.05	$ 110.50	$ 114.92	$ 119.51	$ 124.29

Net Present Cost $ 1,398.91

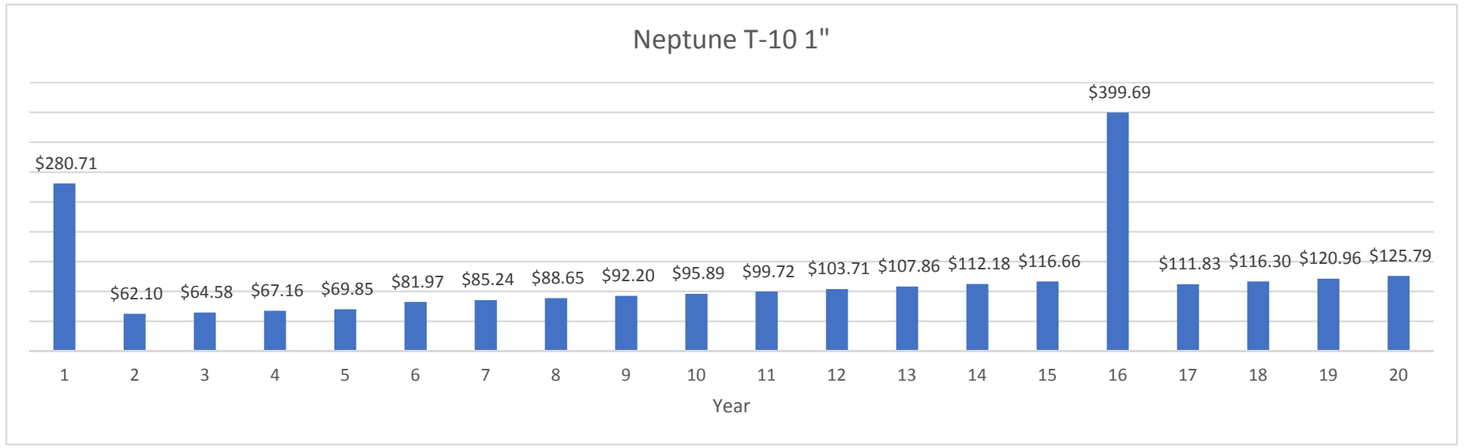


DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: Neptune T-10 1"
New Meter Warranty: 5 years
Repaired Meter Warranty: 15 years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 171.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ 59.71	$ 62.10	$ 64.58	$ 67.16	$ 69.85	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 107.53	$ 111.83	$ 116.30	$ 120.96	$ 125.79
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 230.14	$ -	$ -	$ -	$ -
Labor for Meter Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 67.29	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value - Housing																$ (5.28)				
Net Cash Flow	$ 280.71	$ 62.10	$ 64.58	$ 67.16	$ 69.85	$ 81.97	$ 85.24	$ 88.65	$ 92.20	$ 95.89	$ 99.72	$ 103.71	$ 107.86	$ 112.18	$ 116.66	$ 399.69	$ 111.83	$ 116.30	$ 120.96	$ 125.79

Net Present Cost $ 1,464.62

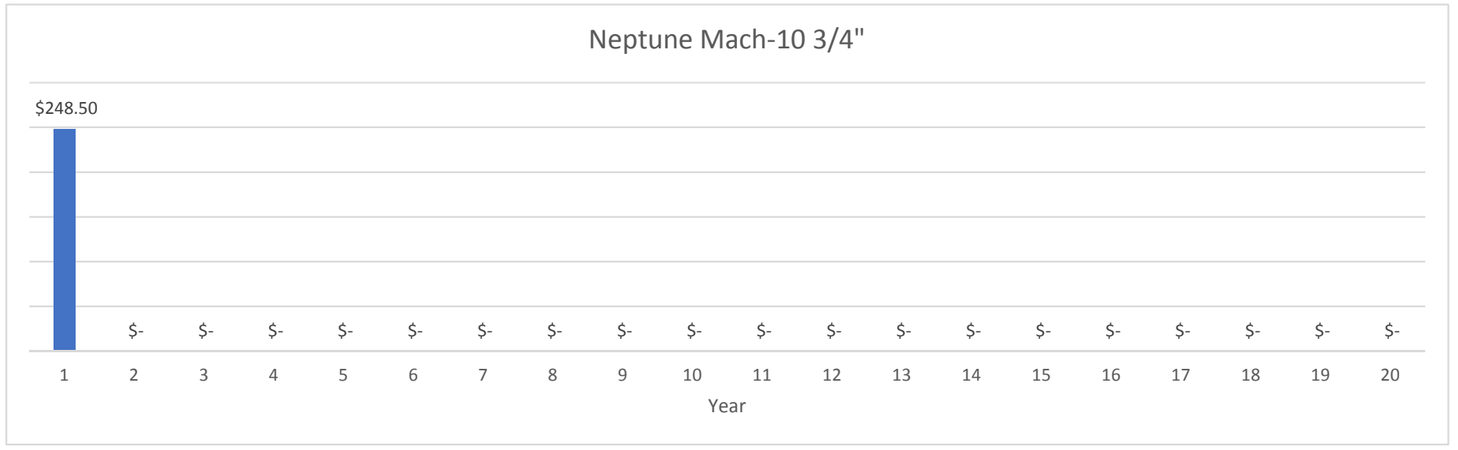


DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: Neptune Mach-10 3/4"
New Meter Warranty: 20 years

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 198.50	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Labor for Meter Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value - Housing																				
Net Cash Flow	$ 248.50	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

Net Present Cost $ 248.50

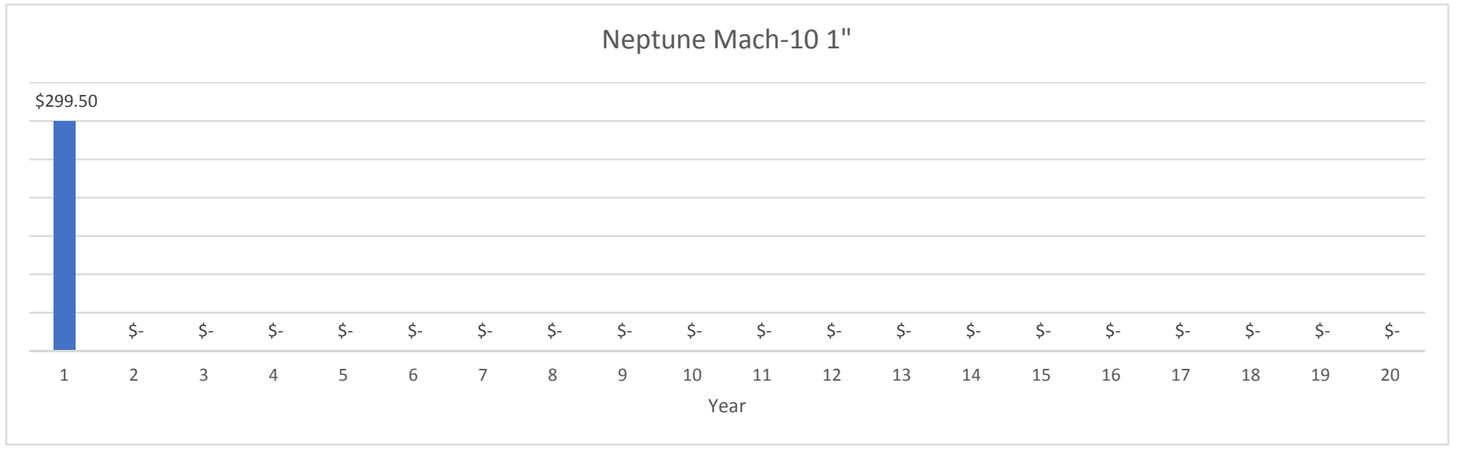


DeKalb County Department of Watershed Management
Water Meter Life Cycle Analysis

Water Meter: Neptune Mach-10 1"
New Meter Warranty: 20 years

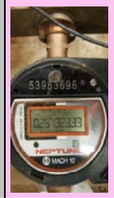
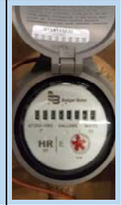
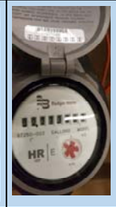
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Initial Costs																				
Meter Acquisition Price with Housing	$ 249.50	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Installation	$ 50.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operation and Maintenance Costs																				
Gallons lost due to meter inaccuracy	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Repaired Meter Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Labor for Meter Replacement	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
End of Life																				
Salvage Value - Housing																				
Net Cash Flow	$ 299.50	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

Net Present Cost $ 299.50



APPENDIX B

Bench Test Results

Manufacturer	Neptune	Neptune	Master Meter	Hersey - Mueller	Badger	Badger	Badger	Sensus	Sensus	Sensus	Master Meter	Badger	Badger	Neptune	Neptune	Hersey-Mueller	Badger	Sensus	Sensus
Meter Type	Solid State	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical	Solid State	Mechanical	Solid State	Solid State	Mechanical	Mechanical	Mechanical	Solid State	Mechanical	Mechanical	Solid State	Mechanical	Solid State
Model	Mach 10	E-Coder T-10	PD07	435	Recordall 35L	Recordall 25	E Series	accuSTREAM	iPERL (Pre-14)	iPERL (Post-14)[1]	PD1	Recordall 55	Recordall 40	Mach 10	E-Coder T-10	452 [2]	E Series[3]	accuSTREAM	iPERL (Pre-14)
Measuring Chamber Type	Ultrasonic	Positive Displacement Nutating Disc	Positive Displacement Oscillating Piston	Positive Displacement Nutating Disc	Positive Displacement Nutating Disc	Positive Displacement Nutating Disc	Ultrasonic	Positive Displacement Oscillating Piston	Magnetic	Magnetic	Positive Displacement Oscillating Piston	Positive Displacement Nutating Disc	Positive Displacement Nutating Disc	Ultrasonic	Positive Displacement Nutating Disc	Positive Displacement Nutating Disc	Ultrasonic	Positive Displacement Oscillating Piston	Magnetic
Size	3/4"	3/4"	3/4"	3/4"	3/4"	3/4"	3/4"	3/4"	3/4"	3/4"	1"	1"	1"	1"	1"	1"	1"	1"	1"
Lay Length	9"	9"	9"	7.5" [4]	9"	9"	9"	9"	9"	9"	10.75"	10.75"	10.75"	10.75"	10.75"	10.75"	10.75"	10.75"	10.75"
Meter Body	Metallic Alloy	Metallic Alloy	Metallic Alloy	Plastic [4]	Metallic Alloy	Polymer	Stainless Steel	Composite material	Composite Alloy	Composite Alloy	Metallic Alloy	Metallic Alloy	Polymer	Metallic Alloy	Metallic Alloy	N/A	N/A	Composite material	Composite Alloy
Bottom Plate	N/A	Metallic Alloy	Metallic Alloy	Plastic [4]	Metallic Alloy	Polymer	N/A	Composite material	Composite Alloy	Composite Alloy	Metallic Alloy	Metallic Alloy	Polymer	N/A	Metallic Alloy	N/A	N/A	Composite material	Composite Alloy
MXU Number	85824826	85432692	85828764	N/A	85824682	85831836	N/A	85831026	85827476	85828148	85830722	85825550	85714500	N/A	85831660	N/A	N/A	85827500	85828136
Serial Number	53963696	53968056	9007599	N/A	17717404	12066900	16016787	83084997	75689593	80618844	8239181	16512830	16937837	17717407	20150059	N/A	N/A	82768850	77412629
Electronic ID	53963696	53968056	51028311	N/A	17717404	17717405	N/A	83084997	75689593	80618844	51028386	17717406	17717407	17717407	20150059	N/A	N/A	82768850	77412629
Register Picture														Photo Not Available	Photo Not Available	Photo Not Available	Photo Not Available	Photo Not Available	Photo Not Available
Register Display Type	Digital LCD	Digital LCD	Digital LCD	Mechanical	Digital LCD [6]	Mechanical	Digital LCD	Digital LCD	Digital LCD	Digital LCD	Digital LCD	Mechanical	Mechanical	Digital LCD	Digital LCD	N/A	N/A	Digital LCD	Digital LCD
Display Observation Comment	Electronic Read Dials are not visibly displayed	Display does not come on unless a high powered flashlight is shown onto solar panels. Turns off quickly after displayed reading.	Electronic Read Dials noted by bar under digits, GPM on main screen	Electronic Read Dials are not visibly displayed, highest resolution is only 10 gallons	Electronic Read Dials are not visibly displayed	Electronic Read Dials noted by bar under digits	Electronic Read Dials noted by bar under digits	Electronic Read Dials noted by bar above digits, Comma is present for easier reading, Rate of flow is available on 2nd screen	Electronic Read Dials noted by bar above digits	Electronic Read Dials noted by bar above digits	Electronic Read Dials noted by bar under digits, GPM on main screen	Electronic Read Dials are not visibly displayed	Electronic Read Dials are not visibly displayed	Electronic Read Dials are not visibly displayed	Display does not come on unless a high powered flashlight is shown onto solar panels. Turns off quickly after displayed reading.	N/A	N/A	Electronic Read Dials noted by bar above digits, Comma is present for easier reading, Rate of flow is available on 2nd screen	Electronic Read Dials noted by bar above digits
Rate of Flow Display on Register	Yes	Yes	Yes	No	No	N/A	N/A	Yes	No	No	Yes	No	No	Yes	Yes	N/A	N/A	Yes	No
Electronic Read Resolution	1 Gallon	1 Gallon	1 Gallon	10 Gallon	1 Gallon	1000 Gallon on meter provided	1000 Gallon on meter provided	1 Gallon	100 Gallon	1 Gallon	1 Gallon	.1 Gallons, programmed wrong	.1 Gallons, programmed wrong	1 Gallon	1 Gallon	N/A	N/A	1 Gallon	1 Gallon
Register Removable	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	No	Yes	N/A	N/A	Yes	No
Register Security Type	N/A	Plastic Pin	Plastic Pin	Plastic Pin	Flat head screw w/ seal wire.	Star Type Security Socket	N/A	Special Security Socket provided by manufacturer, ovaled Stainless Steel screw	Not Removeable	Not Removeable	Plastic Pin	Flat head screw w/ seal wire.	Flat head screw w/ seal wire.	Not Removeable	Plastic Pin	N/A	N/A	Special Security Socket provided by manufacturer, ovaled Stainless Steel screw	Not Removeable
Register Removal Observation	N/A	Easily removable by customer	Easily removable by customer	Easily removable by customer	Easily removable by customer	Difficult to remove by customer, but tool is over the counter available and difficult for field personnel if dirt has entered fitting	N/A	Very Difficult to remove, need special tool	Not Removeable	Not Removeable	Easily removable by customer	Easily removable by customer	Easily removable by customer	Not Removeable	Easily removable by customer	N/A	N/A	Very Difficult to remove, need special tool	Not Removeable
AMI Connection Type	Neptune Made Connector	Neptune Made Connector	TouchCoupler	Can't connect to FlexNet, Adapter not compatible [5]	Badger Made Connector	Badger Made Connector	Can't connect to FlexNet, Adapter not compatible	TouchCoupler	TouchCoupler	TouchCoupler	TouchCoupler	Badger Made Connector	Badger Made Connector	Neptune Made Connector	Neptune Made Connector	N/A	N/A	TouchCoupler	TouchCoupler
AMI Compatible	Yes	Yes	Yes	No [5]	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A	Yes	Yes
Observation on Physical Connection to AMI	Connection is tapered and does not securely fit into adapter, difficult to remove	Connection is tapered and does not securely fit into adapter, difficult to remove	Connection is correct	Cannot Connect to AMI [5]	Connection is tapered and does not securely fit into adapter, difficult to remove	Connection is tapered and does not securely fit into adapter, difficult to remove	Cannot Connect to AMI	Connection is correct	Connection is correct	Connection is correct	Connection is correct	Connection is tapered and does not securely fit into adapter, difficult to remove	Connection is tapered and does not securely fit into adapter, difficult to remove	Connection is tapered and does not securely fit into adapter, difficult to remove	Connection is tapered and does not securely fit into adapter, difficult to remove	N/A	N/A	Connection is correct	Connection is correct
AMI Meter Communication Observation	Meter Communication Failure 5 times	Meter Communication Failure 5 times	Communicates well through the AMI system	N/A	Meter communication Failure 1 Time	Communicates well through the AMI system	N/A	Communicates well through the AMI system	Communicates well through the AMI system	Communicates well through the AMI system	Communicates well through the AMI system	Communicates well through the AMI system	Communicates well through the AMI system	N/A	Meter Communication Failure 5 times	N/A	N/A	Communicates well through the AMI system	Communicates well through the AMI system

[1] Post 2014 iPERL testing at the 3/4" size only. No testing done for post 2014 iPERL at the 1" size.

[2] Hersey-Mueller Model 452 (1") not tested.

[3] Badger E Series not tested at the 1" size.

[4] Hersey-Mueller provided plastic/composite meter at 3/4" size due to sample availability at time of analysis. Meter in report is metallic. While sample is 7.5" lay length, 9" lay length is available at this size.

[5] While this sample was not able to be connected, this meter does have compatibility per manufacturer and Sensus literature.

[6] HRE LCD encoder is not yet AMI Compatible with Sensus FlexNet, however, this meter is AMI compatible with the HRE encoder and is, therefore, marked as such in these observations.

Notes:

1) Information included within this appendix is based on upon records and observations of testing staff.

2) Master Meter PD07 (3/4") sample stopped advancing during testing due to break in piston.

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