the Village of Shorewood

AT THE EDGE OF THE CITY AND THE HEART OF EVERYTHING

Report

Non-Revenue Water Investigation

Village of Shorewood

April 2015

City Water

April 10, 2015

Leeann Butschlick
Director of Public Works
Village of Shorewood
3801 N. Morris Boulevard
Shorewood WI 53211

Re: Non-Revenue Water Project

Dear Leeann:

We are pleased to present you with the Non-Revenue Water Report for the Shorewood Water Utility. Non-revenue water has been over 20% for the past four years prompting investigation by the Public Service Commission of Wisconsin. In 2013, the Utility took an important step in understanding the non-revenue water by rebuilding the Downer Ave meter pit has accounts for approximately 99% of the purchased water from the Milwaukee Water Works. Having accurate master meters is the first step in understanding non-revenue water in a distribution system, and developing realistic strategies to lower system water loss.

This report outlines the findings and recommendations from non-revenue investigations.

Please contact me if you have any questions regarding this report.

Sincerely,

City Water, LLC

Michael P. Rau

Michael Rau, P.E.
President

Thomas Nennig

Thomas Nennig, P.E.
Director of Engineering

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CHAPTER 1

Background & Purpose of Study

BACKGROUND

In June of 2013, the Shorewood Water Utility was investigated by the Public Service Commission of Wisconsin (PSC) for having a high amount of non-revenue water. PSC does this when a utility exceeds 15% non-revenue water. In 2012, Shorewood non-revenue water was approximately 24.4%. In 2011 and 2010, it was 19.8% and 20.9%, respectively.

Non-revenue water (nrw) is an important measure for equitable distribution of costs of a utility plus it may be an indicator of water losses such as leaks and meter inaccuracies. If all of Shorewood's non-revenue water in 2012 were leaks, that would be costing the utility approximately $178,000 per year. While, it is not anticipated that this entire amount is leaks, it is a significant cost.

Until very recently, it was difficult for Shorewood Water Utility to conduct meaningful investigations into this non-revenue water because the utility's master meters, owned by Milwaukee Water, were not thought to be accurate. During 2013, Shorewood upgraded the valves in the meter pits so Milwaukee could install new master meters. Therefore, now is a perfect time to kick off non-revenue water investigations.

Another important component in accounting for water is customer meters. Shorewood's meter stock is thought to be in reasonable condition but a statistical measurement of meter accuracy has not been performed recently. In absence of this statistical measure, Shorewood could be required to replace meters to meet PSC code. Another concern with existing meters is they are constructed of brass which contains lead higher than the amount allowed for in new meters. The current practice for reading customer meters is to walk property to property reading an outside remote register and plugging the reading into a handheld computer. The Village would also like to investigate changing the meter reading system to a more modern automated method to improve billing accuracy, efficiency, and service to customers.

PURPOSE OF THE STUDY

A non-revenue water study was conducted to determine the amount of water lost in the distribution system due to leakage, meter malfunctions, and theft. Additionally, the study estimates the cost associated with non-revenue water by balancing the amount of water produced with the amounts billed.

This study serves as an important step towards improved water conservation and, linked with an implementation plan to reduce non-revenue water, can save the Utility a significant amount of money, and improve efficiency.

Developing a plan to reduce non-revenue water starts with improved water accounting practices to better understand the volume of water used by the Utility for maintenance and operation, leakage, meter inaccuracies, and billing errors. A compressive non-revenue water plan will lead to reduced water losses, financial improvement, increased knowledge of the distribution system, more efficient use of existing supplies, increased safety for public health and property, improved public relations, reduced legal liability, and reduced disruption to customers.

NON-REVENUE WATER

Non-Revenue Water can be categorized into the following four areas:

- **Authorized losses**- Water losses that are approved by the Utility, for water quality purposes such as seasonal hydrant flushing, and water used for new main construction
- **Real losses**- This occurs when water is lost due to a main or lateral leakage
- **Apparent losses-** This is when water is used but not paid for such as meter inaccuracies, billing errors, or unauthorized use.
- **Unaccountable water**- Water that escapes the system, and is not identified where it was lost.

It is important when developing a non-revenue program to look at all areas listed above to help determine where the water is being used, or lost, in order to develop strategies to lower non-revenue water. Accounting for water used in each category is an on-going task through-out the year and reviewing the utility's non-revenue water should be completed on a quarterly basis to help reduce system costs.

Authorized losses are typically unmetered uses that should be carefully estimated, as these losses can represent a significant source of lost revenue. The Utility should improve estimating procedures for determining the amount of water used for system flushing. These procedures should be checked every year to verify they are appropriate. Working with North Shore Fire Department to obtain records of water used during training procedures and fighting fires will help correctly identify the authorized losses in the system.

Real water loss most commonly occurs due to leakage caused by a variety of factors, including:

- Corrosion
- Excess pressure
- Temperature variations
- Lack of regular maintenance
- Excessive traffic loading
- Poor design/installation
- Inappropriate backfill
- Pressure transients/fluctuations

Real losses typically the make up the largest amount of non-revenue water in a distribution system. A large amount of water can be lost from a main break, as well as a service leak that can go undetected for months. The key is for utilities to take a proactive approach and monitor system flows to help identify when there is a leak and how to locate it. Repairing the leak in a timely matter will also help reduce real losses.

Apparent Losses can take some time to identify and estimate. A good meter testing program can help identify and estimate water losses due to inaccurate meters, and develop a meter change out program that will help reduce non-revenue water.

CHAPTER 2

Scope of Study

The non-revenue water study included the following scope as part of in Phase 1:

- Via a questionnaire and interview, we surveyed existing Shorewood practices regarding water accounting.
- We calculated purchased water and sold water. This calculation determines the non-revenue water and provides a baseline for interpolating a yearly non-revenue water volume.
- We reviewed main break and service leak repairs for the previous 2 – 3 years.
- We worked with Utility staff to conduct a statistical analysis of customer meters to determine meter accuracy.
- We review and determined how apparent losses in the distribution system are recorded. Apparent losses include system flushing, main breaks, fire lines, and unmetered but authorized uses.
- We reviewed existing metering, meter reading, and billing practices.
- We identified areas in the distribution system that should be investigated further for leakage and methods for investigation.
- We surveyed approximately 1/3 of the distribution system by acoustic methods and identified leak locations for repair.
- We prepared this report and presentation to the Village Board.

CHAPTER 3

Existing Water Accounting Practices

It is important to understand the major water accounting pieces so best estimates can be made for non-revenue water. The major components include the master meters, the customer meters, meter reading, billing, and reporting.

MASTER METERS

Master meters are those meters that register the water that enters a water system. In Shorewood, the master meters are owned by Milwaukee Water Works.

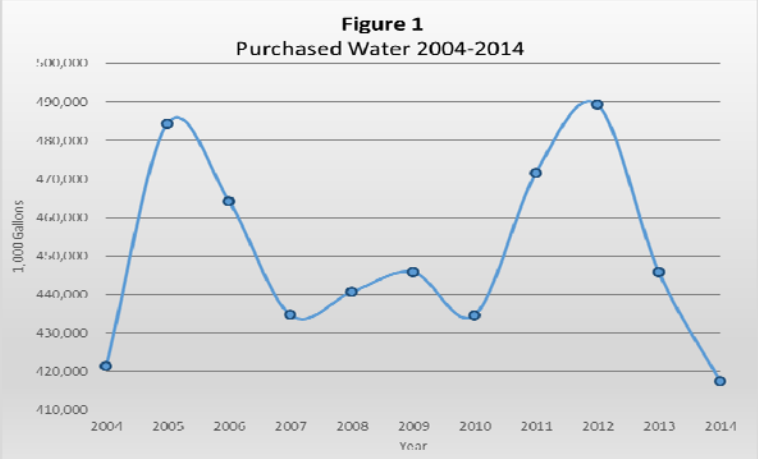
The Village purchases water from Milwaukee Water Works at two points, the Downer Avenue meter pit and the Oakland Avenue meter pit. In 2013, the Downer pit was partially rebuilt so Milwaukee could install two 12 inch magmeters. The new equipment was significant because 99 percent of the water purchased by Shorewood is measured through the Downer Ave. meters. The old turbo meters could not be tested properly because of inadequate isolation valves so there was no way to verify the accuracy of the meters. The Village approved temporary modifications to the meter pit including the installation of new isolation valves so Milwaukee Water could install the new master meters. The Downer Ave. meter pit still needs to be replaced as it does not meet code requirements and the meters still cannot be removed for testing without shutting off the main feed from the City of Milwaukee. Replacement of the Downer Ave. meter pit is in the Utility's 5-year Capital Improvement plan.

The new magmeters were tested at the Badger Meter factory and installed in the rebuilt pits. Milwaukee's protocol is to test these meters at low flow rates at least every two years. It is generally felt the new meters are accurate at this time.

The Oakland Avenue meter pit still uses an older 8-inch turbo meter. Valves in the meter pit need to be replaced so this meter can also be replaced. It is estimated that only 1 percent of the Shorewood Water Utility water is purchased through this meter.

Figure 1 shows the annual water purchased by the Shorewood Water Utility. The years prior to 2014 are considered questionable for data validity.

Figure 1
Purchased Water 2004-2014



Reading of master meters is generally done by Milwaukee because they send the bills to Shorewood. Shorewood can read the meters but it requires manual reading in a confined space atmosphere. Better water accounting would be possible with an on-line system or SCADA (Supervisory Control and Data Acquisition) type reading system. This type of system would allow the village to see water flows immediately, monitor night time flow rates, and see pressure fluctuations to better respond to emergencies.

CUSTOMER METERS

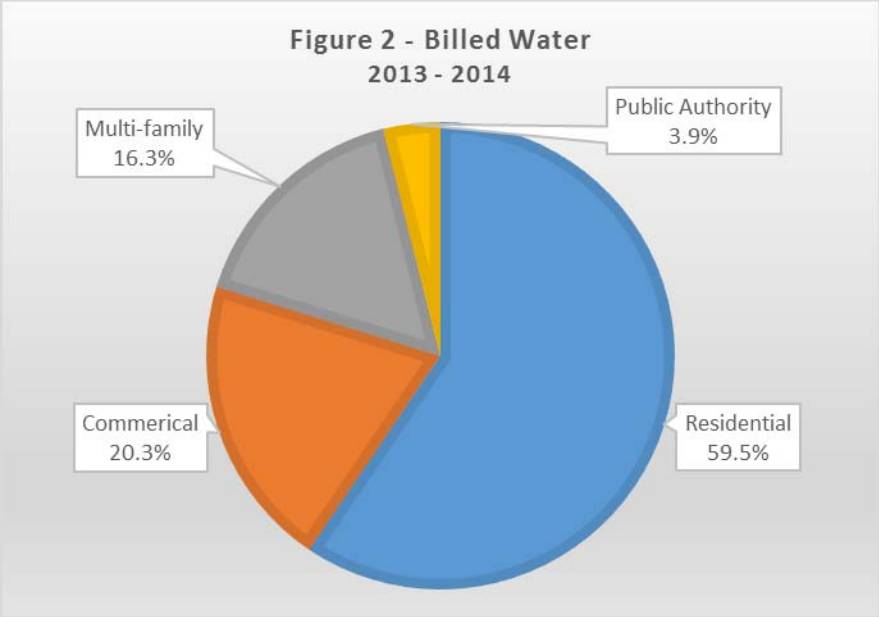
There are approximately 3,528 customer meters in the Shorewood system. Table 1 shows the meter population by size and age. These meters which are the Sensus brand and average over 10 years old. The age of the meters is not a concern except for the meters larger than 1-inch.

Table 1 - Meter Size and Age

Size / Year	5/8	3/4	1	1 1/2	2	3	4	Total
1992			1					1
1995	16	166	5		1			188
1996	32	314	5		1			352
1997	26	300	6	1	1			334
1998	7	320	30	2	2			361
1999	9	334	18	5				366
2000	13	346	16	16	4			395
2001	99	286	4	4	1			394
2002	25	249	76	6	1			357
2003	16	283	40	9				348
2004	15	192	48	16	1	2		274
2005		4	46	6				56
2006	1	2	1	22	1			27
2007		3	3		1	6		13
2008		4				1	7	12
2009		2			1		1	4
2010			6		1			7
2011		4		5	4			13
2012		7			1			8
2013		7	2	1		1		11
2014		7						7
Total	259	2,830	307	93	21	10	8	3,528

Have not been tested since installed

Figure 2 shows the amount of water measured by customer class in 2013 and 2014 (prior to 2013 multi-family was classified as residential or commercial accounts). Approximately 75 percent of the water used in Shorewood is for single family residential or multi-family residential. Many of the larger meters in the system are used to measure water for multi-family buildings. The flow rate of the larger meters are not sensitive enough to pick up low flow. An interior plumbing leak, such as a typical toilet leak may be missed by the larger meter, in addition, the accuracy level of the low flow range for the meter will decrease over time.



In Chapter 6 we will discuss testing completed on customer meters.

METER READING

The Village uses the Sensus touch pad system to read the vast majority of meters today. In this system, the meter reading is transferred electronically to the reading device (interrogator). The interrogator provides the power to bounce off the encoded odometer wheels of the meter register. The meter reader just needs to mate the interrogator device with the touchpad on the outside of the building. The interrogator then stores the reading until it can be downloaded later to the billing system.

Currently, the village reads meters quarterly. The labor to read the meter is currently two Utility works for approximately 40 – 50 hours each per quarter.

The meter reading system works but does not provide read frequency or enough data to implement a modern water conservation program. Since meter reads are once per quarter, it is often difficult to determine the reason a customer's water use changed in between this 90 day period. For example, a toilet leak of ½ gallon per minute could happen 2 weeks after the meter was read and the customer could end up with a bill of $150 - $200 at the end of the quarter.

Severe weather can also impact meter reading since it requires a person to walk down the street and to the building. Three times in the last 5 years, the village did not complete the quarterly reading due to severe weather.

Since meter reading occurs over a week long period, there are some timing issues related to water accounting.

BILLING

The Village administrative/finance staff performs the billing operation quarterly. BSA software is used for this data managing operation. BSA software coordinates with the Sensus interrogator software to manage historical reads and apply appropriate rates for customer bills.

The billing system performs satisfactorily. Only three times in the last 5 years the village has had to estimate bills. However, this was due to the severe weather impacting meter reading.

Quarterly meter reading/billing is still the most common frequency for Wisconsin municipal water utilities but monthly frequency is considered best practices. Customers prefer monthly bills plus customers can manage their water use better with more frequent information.

REPORTING

The Village has formally reviewed water loss reports on an annual basis as part of the PSC reporting process, however identifying and estimating non-revenue water sources has not been a common practice. Appendix A shows the water accounting practices reported to the PSC for the past 10 years.

We have developed a non-revenue water report that should be updated quarterly to coincide with the village meter reading and billing statements. The report is a water accounting spreadsheet that will help identify the non-revenue water volume in the utility. The non-revenue water report for 2014 can be found in Table 2. More frequent reporting and review would allow the village to better manage water losses, and react to issues/concerns before they become a significant cost issue for the utility rate payers.

In 2014 the non-revenue water decreases from 32.3% in quarter one to 11.2% in quarter four. This is mainly due to the repair of main breaks in quarter one and two, and the service leaks repaired in quarter three. The estimated leakage amount for the service leaks was based on when the leak was discovered to when it was repaired. The actual leakage amount is higher but it is not known when the service leaks first began.

As you can see from the amount of money it costs the Utility, lowering the amount of un-accounted for water will have a significant savings. While it is impossible to account for all of the water used in a distribution system, 5% of un-accounted-for water goal is a realistic goal for any water utility.

Table 2- NRW Report
Shorewood Water Utility

Category / Billing Period	2014 Q1	Q2	Q3	Q4	Total
Purchased Water	Jan-Mar *	Apr-Jun	Jul-Sep	Oct-Dec	
Kgal	128,055	96,696	101,418	91,250	417,419
Billed Water (kgal)					
Residential	49,880	44,136	50,515	46,951	191,483
Commercial	6,665	7,010	6,702	6,478	26,855
Multi-family	25,760	24,202	23,015	23,822	96,799
Public Authority	2,795	3,480	3,438	3,373	13,085
Hydrant Meters					
Total	85,100	78,827	83,671	80,623	328,221
Non-Revenue Water	Q1	Q2	Q3	Q4	Total
Volume (kgal)	42,955	17,869	17,747	10,627	89,198
% NRW	33.5%	18.5%	17.5%	11.6%	21.4%
NRW Categories	Q1	Q2	Q3	Q4	Total
Unbilled / Authorized					
Treatment Process					-
Unidirectional Flushing					-
Hydrant Flushing					-
Fire Protection	147	147	147	147	588
Prevent Freezing					-
Sub-total	147	147	147	147	588
Real Losses					
# of breaks	23	7	-		30
Main Breaks	1,548	489			2,037
# of service leaks		1	2		3
Service Leaks		100	2,679		2,779
Hydrant/valve leaks		285	450	450	1,185
Other					-
Sub-total	1,548	874	3,129	450	6,001
Apparent Losses					
Billing inaccuracies					-
Meter inaccuracies (1%)					-
Unauthorized usage					-
Sub-total	-	-	-	-	-
Total Kgal Purchased	128,055	96,696	101,418	91,250	417,419
Revenue Water kgal	85,100	78,827	83,671	80,623	328,221
NRW	42,955	17,869	17,747	10,627	89,198
Authorized	147	147	147	147	588
Real	1,548	874	3,129	450	6,001
Apparent	-	-	-	-	-
Unaccounted for water (UFW)	41,407	16,995	14,618	10,177	83,197
% UFW	32.3%	17.6%	14.4%	11.2%	19.9%
Wholesale Cost of UFW	$ 52,586	$ 21,584	$ 18,565	$ 12,925	$ 105,660

* Note – 1st quarter billing reads in 2014 were estimated due to weather difficulties.

The non-revenue water report was completed using data provided by the Village for all 4 quarters of 2014.

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Authorized Water Loss

TREATMENT PROCESSES

Since the Village purchases treated Lake Michigan water from Milwaukee Water Works, there are no treatment processes in place that would contribute to non-revenue water, therefore treatment processes would not contribute to the non-revenue water accounting spreadsheet.

HYDRANT FLUSHING

Performing hydrant flushing in critical areas of a water distribution system were stagnant water is known (such as dead ends) is one component to providing fresh quality water to residents. Water utilities are required under PSC code 185 to flush stagnant water from dead-end mains by flushing hydrants. Water utilities may also implement a uni-directional flushing program to scrub the water main and help remove and particle build-up. Water used for flushing the water mains should be accounted for and recorded on the non-revenue water report and on the annul PSC report as an authorized loss.

The Village did not start reporting hydrant flushing totals on the PSC reports until 2011. The amount of water used for hydrant flushing will vary greatly depending on the flushing strategies implemented by the Utility. Since the Village does not have a uni-directional flushing program the amount of non-revenue water should be approximately 3-5 percent.

FIRE PROTECTION

The North Shore Fire Department uses water for fighting fires and training. They do a good job of informing the village when this happens so estimates of water consumed can be made. We notice that in 2011, 2013, and 2014 these estimates were done but occasionally they have not been included in the annual PSC report. These uses are usually a small total volume on an annual basis even if it is a large flow rate for a specific fire.

Additionally, there are 51 private fire lines in the village. Owners of these systems are required to test the flow and pressures on these lines annually and typically hire a private fire protection company to perform these tests. Usually, NSFD requires notice and record of these tests. The Village should coordinate with NSFD to obtain this information or require notification by the private fire system owner directly. We estimate that the testing of these lines or use of these lines would be about a 0.1 percent of the non-revenue water each year.

CHAPTER 5

Real Losses - System Leaks and Water Main Breaks

Tracking of water system leaks and water main breaks are important for several reasons:

- Required by PSC 185
- Input for water main replacement program
- Estimating known water losses for the annual PSC report audit
- Part of being good water stewards for water accounting program

Shorewood has done a reasonable job of tracking leaks and breaks but has not regularly used the data for water accounting.

WATER MAIN BREAKS

Over the last 3 years, the Village has averaged about 25 main breaks per year. Since the system has 38.1 miles of main, this is a break rate of 0.65 breaks per mile per year. This is higher than the national average in the United States (0.3 breaks per mile per year). However, Shorewood is an older than average water system and contains primarily cast iron and ductile iron pipe which is susceptible to corrosion weakening.

Fortunately, for water loss reasons, the clay soils in the village will usually direct water flow from main breaks to the surface because these tight soils cannot adsorb the flow of water main breaks. Occasionally, a main break will be intercepted by stone trenches for sewers, manholes, and the sewers themselves. When the main break comes to the surface, we find them readily and repair the break before much water loss occurs. Leaks that do not surface can be a major source of water loss and lost dollars.

The higher than average break ratio indicates that the village should be aggressive on water main replacement. Over the last 3 years, the village has averaged replacement of just less than 1 percent of the system per year which is good. However, because of the main break rate, we suggest targeting a replacement rate of 1.5 percent per year.

The Utility is currently implementing an aggressive main replacement program that will replace main in conjunction with roadway reconstruction projects that occur every other year. In the off year, the Utility is planning replacement of water main that has been targeted on a *hot spot* list developed by the Utility. The main replacement strategy will replace 1.3 to 2.2 percent of existing mains per year, and would result in total main replacement in 45 to 77 years.

OTHER LEAKS

Other leaks in the water system, while smaller than main breaks, are a significant contributor to real water losses because they do not usually surface and can leak for a long time before repair. We recommend being diligent on repair of the small leaks so system water losses are controlled.

Water service laterals can be a significant source of water loss because they do not always surface and can go undiscovered for years without a regular leak detection program. A single water service lateral leak can result in a loss of 5,000 to 20,000 gallons per day or 1.8 to 7.3 million gallons per year. Therefore a single water service lateral leak can result in 0.4 to 1.6 percent water loss for the entire village system.

Acoustic leak locating efforts can sometimes hear these water service lateral leaks from a block away but many times, the acoustic listening device must be right on the curb stop or on the house plumbing to hear the leak. Hence it is important for a utility to regularly locate and listen at all service lateral lines when water loss is present.

Shorewood has been leak surveying about one-third of the system on an annual basis for recent years. Due to the significant water loss and age of the distribution system, we recommend an annual survey of the entire system until the un-accounted for water loss is below 10 percent. Then the survey can be reduced to every other year.

CHAPTER 6

Apparent Water Losses

Apparent water losses are defined by PSC as the volume of water attributable to customer and station meter inaccuracies, billing and data transfer adjustments, unauthorized consumption, and theft.

CUSTOMER METERS

Revenue for any water utility is directly linked to the accuracy of the utility's meters. PSC and Industry Standards require new customer meters to be accurate to plus or minus 1.5 percent, hence an accuracy range between 98.5 – 101.5 percent. At low flows (1/4 gallon per minute), the standards allow a range of 95 to 101.5 percent. Used meters are required to meet the same standard for medium and high flow rates but are allowed a lower standard for low flow rates. For example, a used single family 5/8 inch residential meter should be between 90 and 100 percent accuracy.

How much can this affect apparent water losses? Low flows are generally considered to be 15 percent of the water consumption in a home. Therefore, if Shorewood's single family residential meters were within acceptable accuracy, but at the low end, approximately 0.9 percent of the annual water purchased would not be measured.

Larger meters are worse culprits in not measuring low flows, especially for multi-family buildings and smaller commercial users. Again the low flow accuracy required for a used meter is 90 to 100 percent. However, the low flow rates for a larger meter are 1.5 gallons per minute for 1 and 1-½ inch meters, and 2 gallons per minute for a 2 inch meter. Compounding this issue, Shorewood is behind schedule in testing these larger meters because they are more difficult to test due to customer owned isolation valves not working properly.

Figures 3 and 4 illustrate the calculated accuracy of the different meter sizes for each flow rate that was tested. The meter accuracy was then compared to the AWWA recommended accuracy for each size meter. The accuracy level for the small meter sizes at the tested flow rates is within the AWWA guidelines.

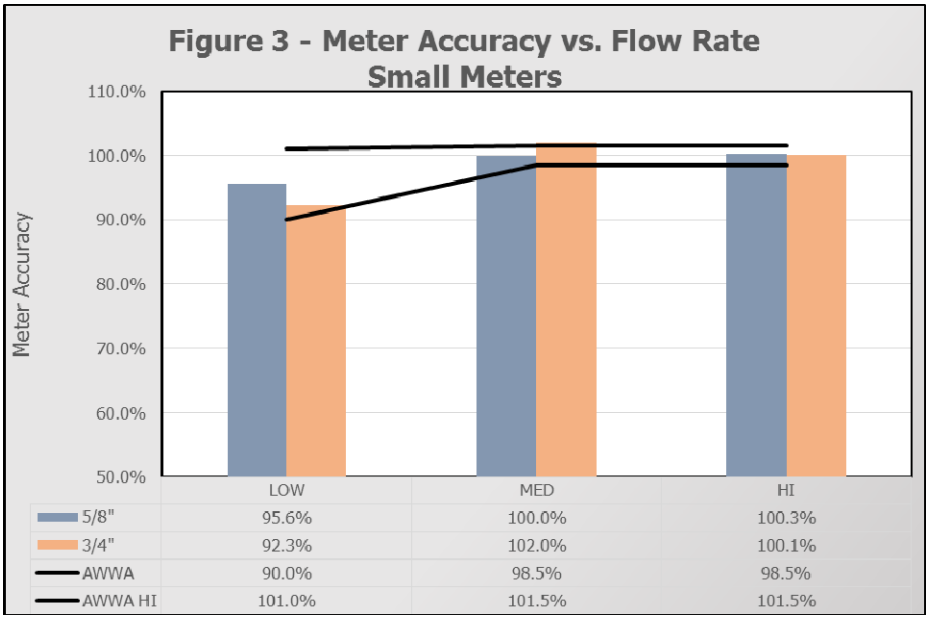
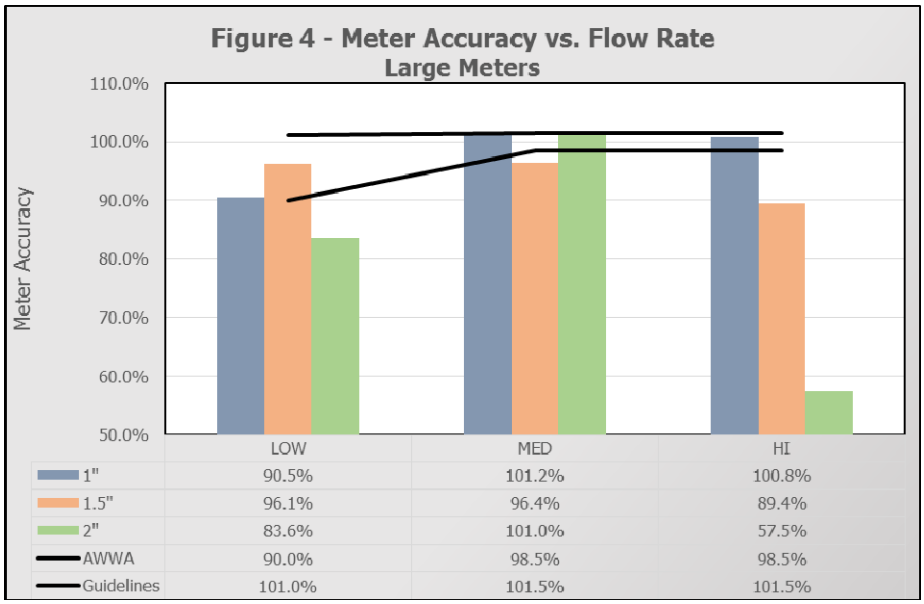


Figure 4 shows the 1-inch meters are within the AWWA accuracy range, however the 1-½ meters are below the accuracy range for the medium and high flow while the 2-inch meters are below the accuracy range for the low and high flow rates. This indicates the utility could be losing revenue due to meter inaccuracies of the larger meters.



Based on the weighted averages set by AWWA (15% high low-70%-medium flow and 15% low flow) the overall accuracy for the meters tested was 97.3%. The weighted averages are guidelines to use during the evaluation process; there is no way to determine the actual average without monitoring the hourly usage from each meter. Meter test results can be found in Appendix B.

Over 80% of water consumption meters in the village are ¾-inch meters and account for over 50% of the water billed in 2014. Table 3 shows the amount of water billed for each size meter along with the weighted meter accuracy level and resulting cost of unmetered water passing through the meters in 2014. Meter testing was not completed for meters greater than 2-inches; therefore, 90% meter accuracy was assigned until field testing can be completed to determine the actual meter accuracy. Revenue loss was determined based on a volumetric water rate of $2.67 per 100 cubic feet of water or $3.57 per 1,000 gallons.

Table 3 – 2014 Non-Billed Water Amount

Meter Size	2014 Billed Water (1,000 gal)	% of Total Water billed	Meter Accuracy* (%)	Un-metered water volume (1,000 gal)	Un-metered as % of total water billed	Cost of unmetered water
5/8 - inch	18,130	5.5%	99.3%	118	0.0%	$ 421
3/4 - inch	188,913	57.5%	100.3%	(552)	-0.2%	$ (1,971)
1-inch	45,964	14.0%	99.5%	231	0.1%	$ 826
1.5-inch	57,368	17.5%	95.3%	2,681	0.8%	$ 9,571
2-inch	9,510	2.9%	91.9%	773	0.2%	$ 2,761
3-inch	5,283	1.6%	90%	528	0.2%	$ 1,886
4-inch	3,436	1.0%	90%	344	0.1%	$ 1,226
Total	**328,604**	**100%**		**4,124**	**1.3%**	**$ 14,719**

* weighted average

assumed value

MASTER METERS

Master meters or sometimes referred to as station meters were described in Chapter 3. Manufacturers and meter owners are also required to meet the 98.5 to 101.5 percent accuracy standard for these meters. Milwaukee owns these meters. For several years prior to 2013, Milwaukee was not able to properly test the accuracy of these meters because of valves not working in the meter pits. The valves are Shorewood's responsibility.

Now that we have had just over one year of data with new accurate meters installed, we estimate that the old meters were over-registering by approximately 10 percent. The good news is Shorewood's water loss may not have been as high as reported. The bad news is the water Utility paid more than what it should have to the Milwaukee Water Works.

However, going forward with the new meters, we estimate that these meters will operate at 99.9 percent accuracy or will provide a 0.1 percent apparent water gain.

BILLING AND DATA TRANSFER

The Village meter reading, data transfer, and billing systems are largely electronic and are accurate because they have been set up and operating for a few years. Very few corrected billings are necessary.

There is some time lag to collect meter readings (1 – 2 weeks) which creates a slight mismatch in timing compared to master meters. We estimate that the time lag works both ways depending on the time of year so we assume zero for apparent losses in billing and data transfer.

UNAUTHORIZED USE OR THEFT

The Village is unaware of any unauthorized use or theft. We recommend that private fire lines be checked every two years as part of cross-connection inspections to make sure that inadvertent plumbing taps are not made on these lines. Other investigations of surreptitious use would be on a case by case basis.

Leak Detection

In April and May of 2014 City Water conducted an acoustical leak listening survey of the NE section of the Village (see Figure 5). The listening survey was conducted using the Fluid Conservation System (FCS) S-30 Surveyor. The S-30 Surveyor is an enhanced listening device that is placed on distribution system valves, hydrants and random curb stops to detect potential leaks. Each hydrant and accessible distribution valve in the NE area of the Village was used as listening points. In the roadway reconstruction area of the Village, we also listened on any curb stop valves that we located and were able to access the valve.

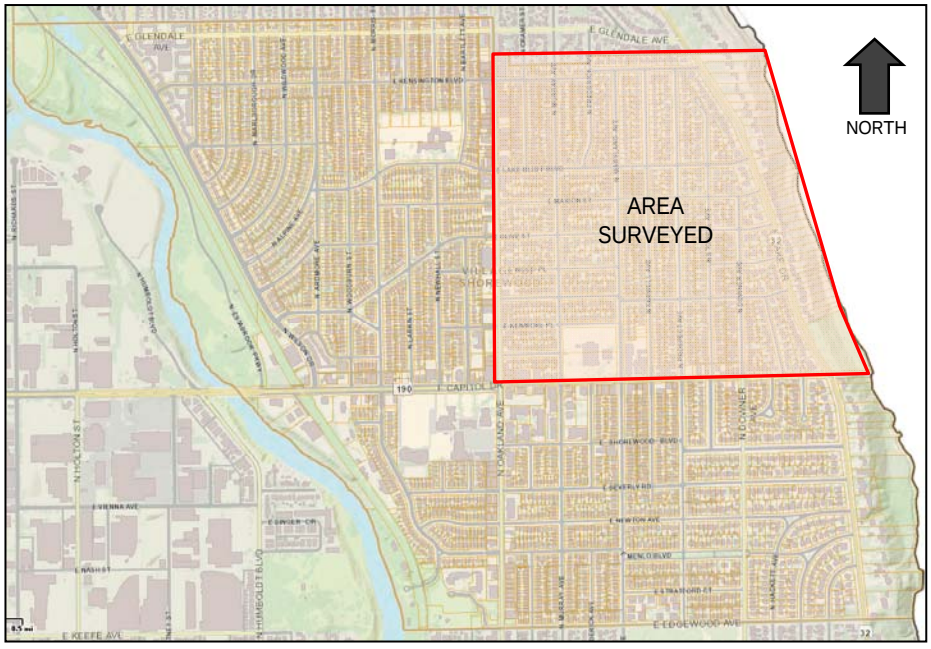


Figure 5 – Leak Detection Area

A total of five leaks were located in the NE area of the Village. There were two service lateral leaks, one hydrant lead leak, and two hydrant leaks. A leak report was completed for each leak location and can be found in Appendix C. Included with each leak report is an estimate of the gallons per day of the water leakage. Table 4 is a summary of the leaks found in the NE area of the Village.

Table 4- Leakage Summary

Type	Location	Estimated leakage (gpd)
Hydrant Lead	NE Corner of E. Capitol Dr. & N. Murray Ave.	5,000
Service Lateral	1925 E. Elmdale Ct.	18,000
Service Lateral	4125 N. Lakeshore Drive	15,000
Hydrant	NW Corner of E. Capitol Dr. & N. Stowell Ave	3,000
Hydrant	NE Corner of E. Olive St. & N. Downer Ave. - **fixed**	1,500
	Estimated Leakage Total	42,500

Determining the estimated quantity of a leak is difficult, but we use our years of experience with the operation of other water distribution systems. Pipe size, material, system pressure, size of the leak and ground conditions will affect the sound of a leak. The estimated quantity of water that is leaking in the surveyed area of the Village is 42,500 gpd. Using a purchased water price of $1.27 per 100 cubic feet of water purchased from Milwaukee Water Works the leaks identified in the survey were costing the Utility approximately $54/day or over $19,700 annually. The cost of the leak detection survey will easily be paid for within 4 months.

According to the 2013 PSC report the unaccounted for water in the Village for the year was approximately 23% of the total water purchased from Milwaukee or a total of 103,182,000 gallons. The leaks identified in the survey would account for approximately 15,512,500 gallons for a year, or approximately 15% of the unaccounted for water in the Village. We strongly recommend the Village expand the leak detection survey into the remaining areas of the Village as soon as possible to continue to reduce the unaccounted for water and increase cost savings.

Conclusions & Recommendations

CONCLUSIONS

1. The amount of water loss from the Shorewood water system has been significant for over 6 years. The PSC uses an amount larger than 15 percent for this definition. The American Water Works Association recommends a goal of 10 percent or less. The amount of water loss in Shorewood in 2013 was 23 percent or about 102 million gallons. The purchased cost of this water was over $175,000.
2. The Village has two master meter pits where water is purchased from Milwaukee Water. In 2013, the village rebuilt the Downer Avenue meter pit so Milwaukee Water Works could install new magmeters. These new more accurate meters appear to have reduced the amount of non-revenue water because the old turbo meters were over-registering the volume of water purchased by the Utility. The new meters are an important element for the Village to accurately access the non-revenue water loss and address measures for improvement in the future. The new master meters still require manual reading. The Oakland Avenue master meter is the old style turbo but only registers approximately 1 percent of the purchased water volume.
3. The Village has 3,528 customer water meters ranging in size from 5/8 inch to 4 inch. The vast majority, 3,089 of these meters are 5/8 or ¾ inch meters used for residential or small commercial buildings. Meters are considered the cash register of the water utility and need to be accurate to fairly distribute the costs of the water utility and sewer utility.
4. A statistical sampling of the meters was completed for small meters and showed them to be 97% accurate. Meters larger than 1 inch were not sufficiently tested by the utility to represent a statistical sample. Time commitments and faulty customer valves were the blocks to complete this. We estimate these meters to be 90% accurate based on the few that were tested and our knowledge of similar meters in surrounding communities.
5. The Village meter reading system, Sensus touch pad, is an accurate system but does not provide enough data points for good customer information and does not allow a modern water conservation system.
6. The Village billing system is very functional. Bills are sent on a quarterly basis. The industry trend is to go to monthly reading/billing.
7. The Village performs an annual water audit via the annual PSC report. Industry standard is to perform this with each meter reading/billing cycle or quarterly.
8. The Village performs leak surveys on 1/3 of the system every year and has steadily found leakage.
9. The leak detection survey completed by City Water in the eastern 1/3 of the system found 2 service leaks, one hydrant lead leak, and 2 hydrant leaks for a total of 42,500 gallons per day. Repairing these leaks saves the village approximately $19,700 per year in purchased water cost.
10. Over the last 3 years, the village has averaged 25 main breaks per year or 0.65 breaks per mile per year. This is higher than the national average for water systems of 0.3 breaks per mile per year. While this can be expected of an older water system like Shorewood, it is also indicative of the need to replace pipe.

RECOMMENDATIONS

1. Perform quarterly water auditing to compare master meters to customer meters and estimates of non-revenue water. Incorporate estimates of found leaks, main breaks, main flushing and fire department use in quarterly water auditing.

2. Increase the frequency of leak detection surveying to the entire system every year until un-accounted for water loss is reduced to below than 10 percent.

3. Commit to complete testing and replacement of larger than 1 inch meters to improve meter accuracy. This is required by PSC 185 in addition to fairly distributing water system costs and improving water loss management. Implement a meter testing program to verify the accuracy of larger meters. Meters 1-½-inch and 2-inch should be tested once every four years. Meters 3 and 4-inch should be tested every two years. Older lead meters will need to be replaced if the meter cannot be re-installed in the same location

4. Increase the water main replacement program from just less than 1 percent per year to about 1.5 percent per year. After about 20 years at this rate, water main break frequency should normalize and water loss from leaks will be reduced. Customer outages, water system disruptions, and traffic inconveniences will also be reduced.

5. Continue with Phase 2 of this study to further study modern meter reading systems and their costs and benefits. This should include investigation of monthly billing.

6. Install an online meter reading system for the master meters. This is also called a SCADA system and will provide the water system operators a better tool to monitor day to day water system activities, resulting in better management of system operation. On-line monitoring helps alert staff to potential problems to flow, pressure, and leaks in a distribution system. Estimated cost for this system is $35,000.

7. Coordinate private fire line inspections as part of the newly developed occupancy permit ordinance. This will help track the testing of fire lines and alert staff to any unauthorized use.

8. Continue on a 20-year meter change out program for the smaller meters (5/8 and 3/4-inch) as the accuracy level of the smaller meters is has shown to be within AWWA standards.

9. Replace the Oakland Avenue meter pit so Milwaukee can install a new master meter. Estimated cost for this replacement is $125,000. This is important for emergency situations and when peak flows are routed through this master meter.

10. Continue to move forward with the replacement of the Downer Avenue Meter Pit. Estimated cost for a new meter pit - $450,000