REDUCING NON-REVENUE WATER: EXPERIENCES OF THE GWINNETT COUNTY DEPARTMENT OF WATER RESOURCES

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Abstract. This paper will chronicle the efforts of the Gwinnett County Department of Water Resources (DWR) to reduce non-revenue water (NRW) and increase our understanding of our system. In 2011 the Georgia Environmental Protection Division began requiring submittal of water audits by all municipalities serving a population over 3,300. The audits are required to be performed using the AWWA Free Water Audit Software. As DWR began filling out the audit and formally tracking NRW, a team was formed to address non-revenue water across every aspect of the audit. The team included members from finance, customer service, field operations, water production, asset management and operations technical services. The team was action-oriented and included the staff that would actually be implementing the work. The team started by brainstorming possible ways to reduce NRW. This included looking for cross-connections to other municipalities, researching parcels in GIS with structures but without a meter, re-establishing breached pressure zones, lowering pressures, replacing inaccurate large meters, performing leak detection and many other initiatives. Over time, action items were aligned with the water audit categories and a formal action plan developed.

Like all journeys, some surprising discoveries were made along the way. We had to go through the process of ruling out possibilities before we could see that, even though our system is relatively young, a significant portion of our NRW is real losses. And it's no wonder. We have over 3,600 miles of water mains and nearly 239,000 connections. We also found that our production meters that we thought were over 98% accurate, were not. This was significantly affecting our NRW calculation.

Perhaps the most meaningful result is the number of programs we initiated or improved to ensure we are properly maintaining our system, which in turn will reduce NRW along the way. Some of these programs include production meter testing and calibration, small and large water meter replacement, leak detection, pressure management, district metered areas, valve inspection and financial reporting and auditing.

There were also unexpected benefits to our NRW reduction efforts. Simply having a multi-discipline team meeting monthly allowed us to learn more about the many functions of DWR, and how we can help each other make the Department as a whole more efficient.

Background. Gwinnett County is located northeast of Atlanta, Georgia and encompasses 430 square miles with a population of just over 800,000. The water distribution system is fed from two Water Production Facilities, Lanier Filter Plant (LFP) and Shoal Creek Filter Plant (SCFP), located on Lake Lanier. The distribution system includes 3,665 miles of water mains and nearly 239,000 service connections. The distribution system is divided into two service areas, each with multiple pressure zones. The Central Service Area includes the Central, South, Knob Hill and Walton Court Pressure Zones and the North Service Area includes the North and Upper North Pressure Zones. The pressure zones are separated by valves. Gwinnett County has been tracking non-revenue water for nearly 20 years and it has varied from 6% to 20%. Over the years, DWR has confirmed that an error in the two key components of the non-revenue water calculation (water produced and water billed) can have significant effects on the percentage. Over the years DWR has had several ad-hoc teams to reduce NRW, which generally would convene when NRW crept higher. These teams provided some beneficial outcomes that informed our renewed effort in 2011.

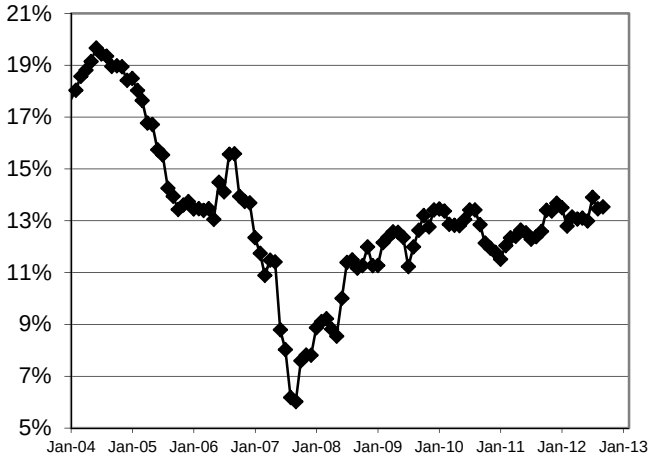

Figure 1. Gwinnett County DWR NRW 2004-2012

In 2011 the Georgia Environmental Protection Division began requiring submittal of water audits by all municipalities serving a population over 3,300. The audits are required to be performed using the AWWA Free Water Audit Software. The first step DWR took when beginning the AWWA audit was to develop a team of senior management including all Deputy Directors and Division Directors to determine the validity scores and begin providing the data for the audit. As data was added to the audit, it became clear that another team was needed of "in the trenches" staff that could begin investigating causes and making changes to reduce non-revenue water. In February 2011 this Non-Revenue Water Sub-Team was developed and included staff from finance, customer service, field operations, water production, asset management and operations technical services. The group initially developed approaches organically by polling what the experienced staff in the room thought was contributing to non-revenue water and then attacking those areas. Over time, action items were aligned with the water audit categories and a formal action plan developed. The team of 21 individuals meets monthly to review action items, discuss results and determine future actions.

Pressure Management. One of the first issues addressed was pressure management. DWR has historically operated its system at relatively high pressures (often exceeding 100 psi) which can lead to increased water loss from breaks and leaks. A Pressure Management Team was formed and included members from distribution field operations, modeling, operations technical services and water production. It was quickly determined that pressure zones had been breached over the many years of rapid growth the county experienced from the late 1980's to early 2000's by open valves and non-functioning pressure reducing valves (PRVs). The PRVs were repaired, isolating the South Zone which is fed from the Central Zone through 8 PRVs and sits at a significantly lower elevation than the Central Zone in many areas. Next the North Zone was isolated by closing all valves between the Central and North Zones. Each valve that was closed was painted red to signify to field staff that it should be normally closed and entered into GIS as a normally closed valve for future reference. Then preventive maintenance work orders were entered into the Lucity work order system to send crews to check all isolation valves every 6 months and ensure they are closed.

Once the pressure zones were isolated, Water Production staff was able to carefully, in 5 psi increments, reduce the North pressure 10 psi, from 90 psi to 80 psi. By repairing the PRVs, pressures in the South Zone were reduced by 40 psi.

As part of the Pressure Management Team's work, they noticed significant pressure spikes in the system which appeared to correlate with water main breaks. By overlaying pressure data with valve and pump operations data, the team identified that valve and pump operations were typically causing the spikes. They have worked with Water Production staff to re-program pump and valve operations and have significantly reduced pressure variations. Since the implementation of these changes, the number of water main breaks has been reduced significantly. The team is now working to develop an operations plan for the distribution system which may include more pressure zones and methods to further reduce pressure transient spikes.

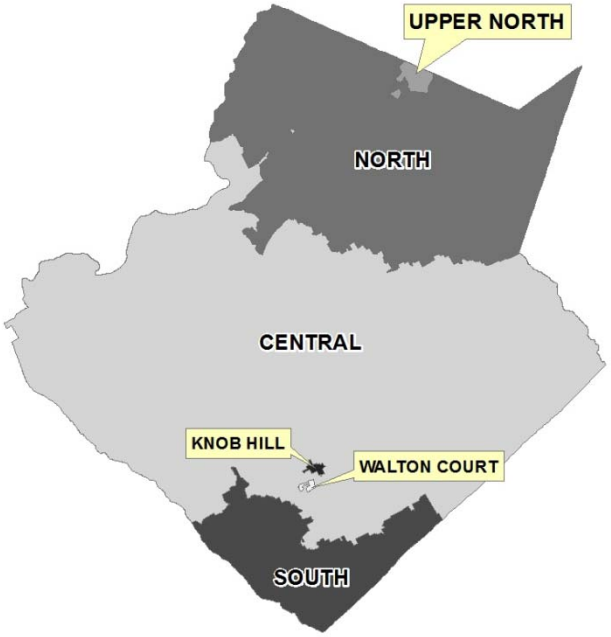

Figure 2 Pressure Zones

GIS. DWR has a very comprehensive GIS. However, the number of meters in GIS has never matched the number of meters in our billing system. An initial query of the GIS system showed 2,245 parcels with structures but no meters. It was found that the main cause was a failure to enter the parcel identification number (PIN) when the meter was entered in the financial system. So the majority of these parcels had meters in the billing system, just not in GIS. Over the course of a year, all of these parcels were reviewed and missing PINs entered. Once this was completed, another query was run and the remaining 700 parcels were field verified to determine if they had a meter, if they were on a well and had no meter or if they had a meter that is not in the billing system. As a result of this exercise, only 40 meters were found in the field that were not in the billing system. These were added to the billing system and GIS. Based on this extensive analysis over the course of two years, it is clear that our GIS and billing system are over 99% accurate. Although this provided a

good check of the system, no significant reduction in NRW resulted from this effort.

Boundaries. Initially, staff felt that there must be one, large source of NRW somewhere in the distribution system. One thought was that maybe we had a valve open to another jurisdiction that we did not know about and we were giving away water. Field staff checked every boundary between Gwinnett and other counties and cities by systematically valving off water mains at boundaries and determining if any customers of other jurisdictions were out of service. In the end only a few water meters and one boundary breach was found. This was quickly and easily eliminated and no noticeable reduction in NRW occurred. This was another good check of the system with no measurable benefit to NRW.

District Metered Areas. District Metered Areas (DMA) are a means to evaluate water losses in an isolated area which can then be utilized in better understanding of a water loss control program. A DMA is a hydraulically discrete part of the distribution network that is isolated from the rest of the distribution system. It is normally supplied through a single metered line so that the total inflow to the area is measured and compared with actual meter readings. This methodology removes many of the variables associated with water losses and better identifies real losses within the DMA. DWR developed two pilot DMAs: one in the South Zone and one in the North Zone. The South DMA includes 33 miles of water mains and about 2,000 service connections. The North DMA includes 22 miles of pipe and about 2,000 service connections. The inflow was measured over the course of a month and compared to meter readings taken at every service meter at the beginning and end of the month. Initial results showed over 20% NRW in the North Zone. Subsequent leak detection found a large number of leaks which were repaired. Analysis of the data suggests that the majority of our NRW is associated with real losses.

Leak Detection. DWR did not have a proactive leak detection program until Fall 2011. DWR had initially planned to do a one-time pass through the county using a consultant as we had in 2008. DWR hired Cavanaugh & Associates to develop the leak detection contract. As part of their research, Cavanaugh steered the county into developing an in-house leak detection program. The program quickly began producing results, finding a 200 gallon/minute leak under Hwy. 78. They also found a total of 41 gallons/minute over 14 leaks in 22 miles of water main in the North DMA. This totaled 2.3 gallons/minute/mile of water main in the North DMA. If this were extrapolated across the entire 3,600 mile system, the water loss from leaks would represent a majority of DWR's non-revenue water. Over 2012 the leak detection program obtained more equipment and continued to expand. The county has been divided into 238 prioritized areas of about 1,000 meters and field crews are systematically performing leak detection beginning in the most critical areas.

The Audit. Below are actions taken to address some specific areas of the AWWA Water Audit.

Volume from own sources and Master meter error adjustment: DWR has three production meters that measure flow from our two Water Production Facilities. SCFP has a 54-inch electromagnetic (mag) meter and LFP has a 72-inch venturi meter and 48-inch venturi meter. DWR staff initially believed that the production meters were under-reading 1.375% based on 2008 testing data. Due to the configuration of the plants and distribution system, developing a testing procedure for these meters proved very difficult and took over a year. Draw-down tests were finally performed in late 2012 to test the meters. The draw-down tests were difficult because isolating the clearwells proved challenging due to leaking valves and broken valve actuators. In addition storage throughout the system had to be used to accommodate the varying flow rates used during the tests. When the tests were finally completed, they showed that the mag meter was accurate within 2%, but the venturi meters were more than 6% inaccurate, one under-reading and one over-reading.

The wide accuracy range on the venturi meters at various flow rates made determining the 2012 master meter error adjustment very difficult. In addition, the testing results lowered our validity score for volume from own sources due to meters being outside of +/-6% accuracy. Because volume from own sources is a key parameter of the NRW calculation, meter accuracy has a direct significant effect on NRW. DWR is currently developing plans to replace the venturi meters with mag meters and has altered the operation of the Water Production Facilities to put as much flow as possible through the existing 54-inch mag meter, reducing the use of the 72-inch venturi meter.

Water exported: DWR sells water to several other utilities. These meters are tested annually to ensure accuracy.

Billed metered and Customer metering inaccuracies: Nearly 100% of DWR customers have volume-based billing. In the past DWR had a small meter (2 inches and below) replacement program that replaced meters every 10 years. Meter testing on small meters completed by DWR staff has shown that at 10 years most of our meters are still 99% accurate. Therefore, DWR has implemented a replacement program which replaces these meters at 15 years or one million gallons, whichever comes first.

Large meter (3 inches and above) testing began in 2009 and has shown nearly half of our large meters were

outside of +/-6% accurate when initially tested or could not be field tested due to lack of a bypass or other factors. To date, over 300 of the 790 large meters in the county have been replaced and 110 more are scheduled for replacement in the next year. Since over 30% of the billed flows go through these 790 meters, their accuracy is critical to ensure proper billing and reduce NRW. Due to the replacement of these meters the percentage used for customer metering inaccuracies was reduced from 7% in 2011 to 3% in 2012. This resulted in a significant decrease in apparent losses.

The flipside of billed metered is ensuring that what is metered gets billed correctly. The Finance Division worked with IT to develop billed and unbilled reports and we now have a monthly report that compares the total meters in the system to total meter readings to revenue billed. In addition, in April 2012 an external audit was completed and showed that we have a very accurate billing system.

Due to the very low cost DWR pays per meter for manual meter reading and the high meter reading success rate, we have not implemented an automatic meter reading (AMR) program. In 2012 we piloted some AMR meters in a district metered area. The AMR meter accuracy was equivalent to our current meters, but we have not found them cost-effective for DWR at this time.

Billed unmetered: DWR's policy is to meter all flows. We do not have any billing accounts with unmetered flows.

Unbilled metered: DWR has only one meter that is not billed and this is due to a contractual obligation. This meter is still read monthly so that we can include the volume in our NRW calculation and staff is working to get this meter billed beginning in 2013.

*Unbilled unmetered***:** The Fire Department sends DWR monthly reports that estimate their usage. The Field Operations Division provides a monthly estimate of water loss from main breaks and leaks and line flushing. In addition construction projects provide an estimate of the quantity of water used to test new mains. When all of this information is summed, it is significantly less than the 1.25% default provided in the AWWA audit. In 2011 staff did not feel confident in using the lower number. However, after carefully reviewing how the data is determined for each component, DWR decided to use the calculated number in 2012 instead of the default. This significantly lowered our authorized consumption.

Unauthorized consumption: DWR has a policy against water theft and has penalties for violators. We ensure that our construction projects have meters or are estimated and included in unbilled unmetered. In addition, we have implemented a program so that field crews have a point of contact to report violations they see while out in the field. We have not found a way to quantify unauthorized consumption since we would stop any unauthorized consumption we found, so we have chosen to leave this validity score as a 5 which autopopulates an unauthorized consumption of 0.25% in the AWWA audit.

Conclusions. DWR staff has met monthly for two years to identify and minimize NRW. Some of our initiatives have led to a dead end from a NRW perspective, but all of them have proved beneficial to the operation of DWR. The item having the largest effect on our NRW percentage is our water production meter accuracy. The item with the largest effect on our apparent losses is our large water meter testing and replacement program which has significantly lowered the apparent losses.

Table 1 NRW Comparison

Category	2011	2012
NRW (by volume)	13.8%	10.9%
NRW (by cost)	35.7%	15.9%
Real losses (gal/conn/day)	20.62	21.56
Apparent losses (gal/conn/day)	17.45	8.53
Infrastructure Leakage Index	0.94	.93
Validity Score	72	74

Between 2011 and 2012, DWR increased the validity score in five areas of the audit, but reduced the validity score in two areas. Reducing the validity score for Volume from own sources two points affected the overall validity score by five points. This emphasizes the effect of the volume produced on NRW calculations. With so many different programs, it was often hard to quantify the effect of a program on the overall NRW calculation. But certain programs, such as production meter testing and large meter testing and replacement showed clear effects on NRW. In addition the work in the DMAs, combined with the start of a proactive leak detection program showed that DWR has more real losses than we initially thought.

Throughout the process staff has shown a commitment to improving the efficiency of DWR. By gathering everyone monthly, staff is able to see how their work is affecting NRW and this has allowed various divisions to work together to reduce NRW. No one on the team focused on NRW full-time, but everyone, through working in their own area, contributed to improving validity scores and reducing NRW.

It is important to note that a good NRW program includes a few key elements which provide the most direct effect on NRW – production meter testing and calibration, leak detection, a good billing system and service meter testing and replacement programs.

The next steps for DWR's non-revenue water program include replacing the inaccurate production meters, intensifying the leak detection program and focusing on pressure management in the distribution system.

The DWR Non-Revenue Water Sub-Team includes: Alan Berg, Steve Bergbower, Deirdre Blackard, Jeffery Boss, Sean Forester, Peter Frank, Walker Hawes, James Henderson, George Kaffezakis, Karen Kelley, Jerry David Martin, Richard Platto, Lisa Rao, Tyler Richards, Randy Rosbury, Steven Seachrist, Steven Sheets, Rebecca Shelton, Lynn Smarr, Alisha Voutas and William Watkins.