How a Growing Asset Management Program Helped to Identify the Infrastructure Rehabilitation and Replacement Needs for the Tampa Water Department

Brian D. Pickard and Amanda Schwerman

The City of Tampa Water Department (department) has a mission to deliver high-quality water and provide exceptional customer experiences in a safe, reliable, efficient, and sustainable manner to a population of 620,000 people within a 220-sq-mi area. This article focuses on the department's expanding asset management program and how it supports the pipeline rehabilitation and replacement (R&R) program necessary to fulfill its mission.

Summary statistics for this infrastructure are as follows:

- 2,160 mi of piping
- 49,704 valves
- 14,273 hydrants
- 144,555 service connections
- Assets aged up to 99 years

The department's efforts to address aging infrastructure have been ongoing for many years. Due to the aging infrastructure concerns, recent efforts have focused on pipeline R&R, with expanded emphasis placed on risk-based prioritization and rate of replacement. These efforts are closely coupled with the department's ongoing efforts to improve its asset management program.

Tampa Water Department Asset Management Program

Quantifying needs and available resources, along with evaluating existing organizational processes, are admirable first steps towards understanding how to best address R&R gaps. The department began to tackle this through assessing its asset management program and other organizational dynamics as part of its 2015 potable water master plan update. This process compared department procedures with the ISO 55000:2014, asset management standards. The comparison resulted in several incremental steps for the department to improve its existing operation across the entire utility, including its R&R program.

The department has since made considerable asset management program improvements, including the following:

- Goal development
  - The department will operate sustainably and be rated competent or better in all ISO 55001:2014, asset management and management system requirements, and maturity assessment categories.
  - The department's asset management program will pursue a sustainable and optimal balance among delivered service levels, risk, and total life cycle cost.

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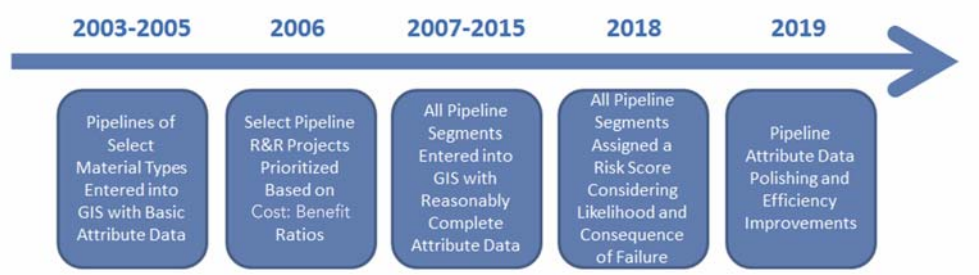
- Five-year strategic asset management plan and framework development
- Improved capital improvement needs forecasting
- Risk score assignment to all pipe and valve assets
- Water main break metric compilation
- Improved document control and recordkeeping for department policies, standard operating procedures (SOPs), operation and maintenance (O&M) manuals, strategic plans, and technical manuals

Next steps for the department's asset management program include the following:

- Developing individual asset management plans for key asset types (pipes, valves, meters, hydrants, etc.)
- Polishing existing databases
  - Asset installation year and material types
  - Main and service breaks
  - SOPs for database maintenance
- Improving computerized maintenance management system (CMMS) utilization
  - Expand the vertical asset registry to include 100 percent of vertical assets
  - Improve capture of asset condition and criticality information with minimal additional effort from department O&M staff
  - Improve capture of valve condition information
- Finalizing an American Water Works Association (AWWA) M36 water audit
- Generating a department technology master plan

Figure 1. The department continues to build on prior efforts to improve its pipeline rehabilitation and replacement program.



- Generating a department resource plan
- Updating the department's technical manual

Recent accomplishments related to improved R&R planning rely on prior accomplishments. The department's use of geographic information systems (GIS) to prioritize pipeline R&R projects began in 2003 or earlier. By 2006 all known unlined cast iron, galvanized, and asbestos cement pipe segments were loaded into the department's GIS and assigned a R&R priority based on a cost-to-benefit ratio. By 2015 all department pipelines, along with reasonably complete attribute data, were entered into the department's GIS. As of 2018 all department pipeline segments have been assigned an R&R prioritization score based on a complete risk assessment, incorporating both likelihood and consequence of failure.

These recent asset management program efforts have made significant strides toward the ability to forecast long-term pipeline R&R needs and improving the efficiency and accuracy of R&R prioritization.

Identifying Infrastructure Needs

The department routinely updates its master plans by leveraging ever-improving technology that allows better decisions to be made regarding how to best utilize available funding. The most recent distribution system master plan update improved the methods used for:

- Quantifying the gap between pipeline R&R needs and available funding
- Pipeline R&R prioritization

Pipeline Rehabilitation and Replacement Prioritization

The necessity of leveraging technology to process the large amounts of data needed to effectively prioritize projects is an ongoing challenge facing most water utilities. Fortunately, the department has heavily invested in GIS and the corresponding databases that warehouse many asset characteristics and maintenance records. The most recent distribution system master plan update was completed in 2018 and improved upon past practices. Specifically, a commercially available software package was utilized to better automate risk-score calculations for nearly 90,000 pipeline segments owned and maintained by the department.

Risk is defined as the product of likelihood of failure (LOF) and consequence of failure (COF). The department hosted multiple workshops to identify scoring criteria and the corresponding weightings. The selected criteria to quantify risk for the department's pipelines are shown in Tables 1 and 2.

Considerable effort was expended to format and generate databases capable of being processed by the software package. The effort associated with estimating remaining life for each pipe segment is of particular interest and assists with both prioritizing replacements and identifying funding needs.

The department's GIS and main break database were utilized to estimate pipeline life expectancies; specifically, survival curves were extrapolated to estimate the age when 50 percent of pipeline segments made from a particular material are expected to fail. It was noted that this threshold can be increased or decreased based on each utility's individual policies or circumstances. Although this topic has been studied extensively by others, the effort to compare department estimates with AWWA-published estimates (Table 3) was considered valuable to understand the department's specific conditions.

The resulting risk scores are color-coded in Figure 2. The city uses this as a tool to efficiently shortlist pipe segments for R&R consideration. Segments are then manually reviewed to validate model results prior to being added to the city's capital improvement program. An effort is made to replace segments "street corner to street corner" and to combine higher-risk pipeline segments within the same neighborhood into single projects. This is believed to minimize overall neighborhood disruptions and has an added benefit of simplifying recordkeeping requirements.

Table 1. Likelihood of Failure Criteria and Weightings

CRITERIA	WEIGHT
Breaks on Individual Pipe Segments	45%
Remaining Life	45%
Aggressive Soil Area	10%

Quantifying Pipeline Needs

Water pipeline needs have three primary drivers, as shown in Figure 3.

The methods used to quantify the needs of each category vary. Pipeline R&R needs were based on the risk prioritization described previously, with a high weighting on remaining useful life. The

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Table 2. Consequence of Failure Criteria and Weightings

CATEGORY	CRITERIA	WEIGHT
Social/ Health/ Safety	Critical Customer Impact	10%
	Population Density	10%
	Repeatable Breaks on Individual Pipe Segments	5%
	Contaminated Soil	5%
	Additional Fire Hydrants	5%
	Modeled Velocity/High Head Loss	10%
	Available Fire Flow	10%
	Service Line Replacements	5%
Economics	Right-of-Way Ownership and Crossings	5%
	Water Demand	10%
	Diameter	10%
	Interconnect Location	10%
	Planned Paving Projects	5%

Table 3. Department's Pipe Life Expectancy Estimate Versus AWWA-Published Estimates

MATERIAL	AVERAGE LIFE EXPECTANCY (YEARS)		
	DEPARTMENT ESTIMATE	AWWA – 2012 REPORT	SELECTED
Asbestos Cement	46	90	46
Cast Iron	86	110	86
Ductile Iron	88	80	88
Galvanized Pipe	101	*Not Available*	101
High Density Polyethylene	78	*Not Available*	78
Polyvinyl Chloride	77	55	77
Unlined Cast Iron	80	*Not Available*	80

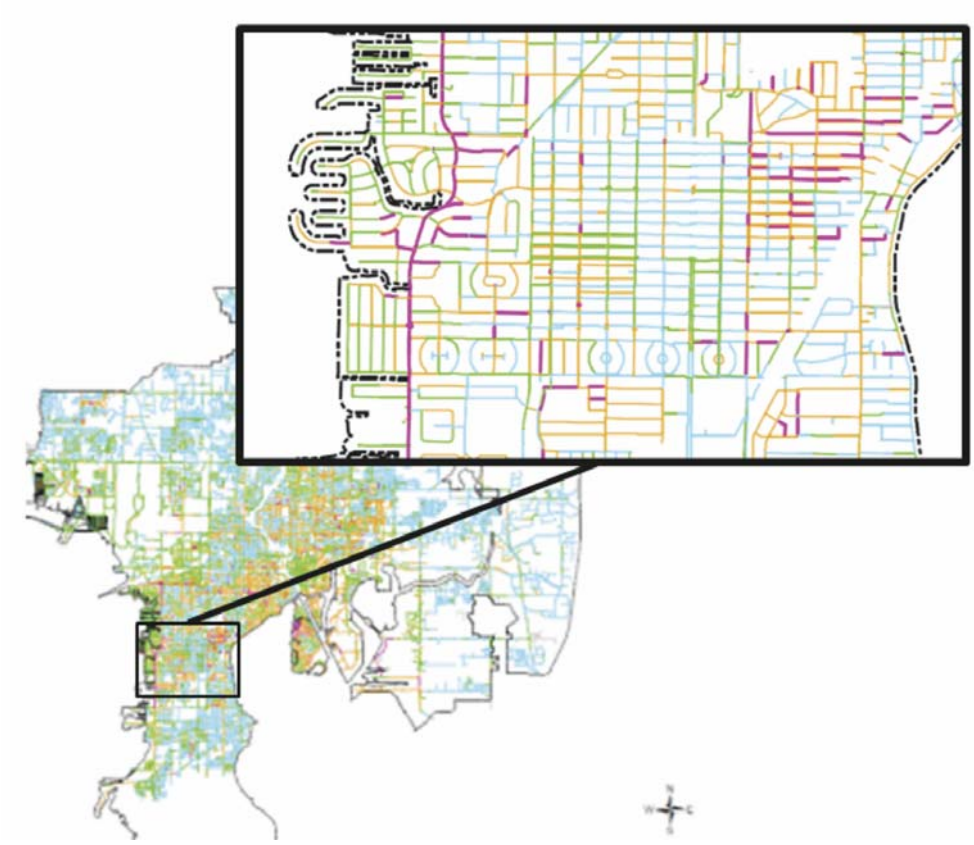

Figure 2. Automated Pipeline Risk Score Results Shown by Color

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2015 distribution system master plan update utilized demand forecasting and hydraulic modeling techniques to identify needs for level-of-service improvements. Development-driven pipeline needs are identified through a utility service application process and funded by private developers. The R&R improvements were identified as the greatest financial need of the three drivers.

Criteria developed for the risk-based prioritization described were built upon to forecast pipeline R&R needs for the next 100-plus years. The department selected a 2018-2103 study period to consider the relatively long lifespan of water pipeline assets. A desktop analysis was completed to estimate R&R needs by year, considering the various pipeline installation dates and lifespan estimates. The spreadsheet model includes the cost of replacing services in conjunction with pipeline R&R projects and occasional fire hydrant rehabilitation at a frequency greater than the pipeline replacement frequency. The result is a spreadsheet model forecasting the replacement value of end-of-life pipelines annually through 2103 (Figure 4). The initial 2018 value reflects department water mains past their estimated useful life.

Two remarkable results were obtained:

- A significant volume of pipeline assets are already beyond their projected lifespan.
- There is a notable increase in pipelines reaching the end of their useful life in 2040.

The increased replacement needs starting in 2040 are believed to be correlated with post-World

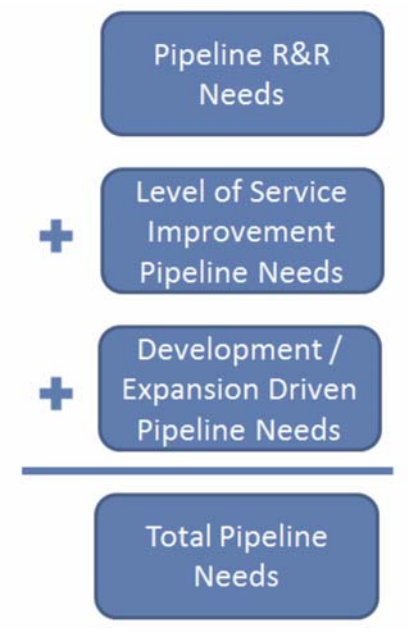

Figure 3. Three Generalized Drivers Impact Total Water Pipeline Needs

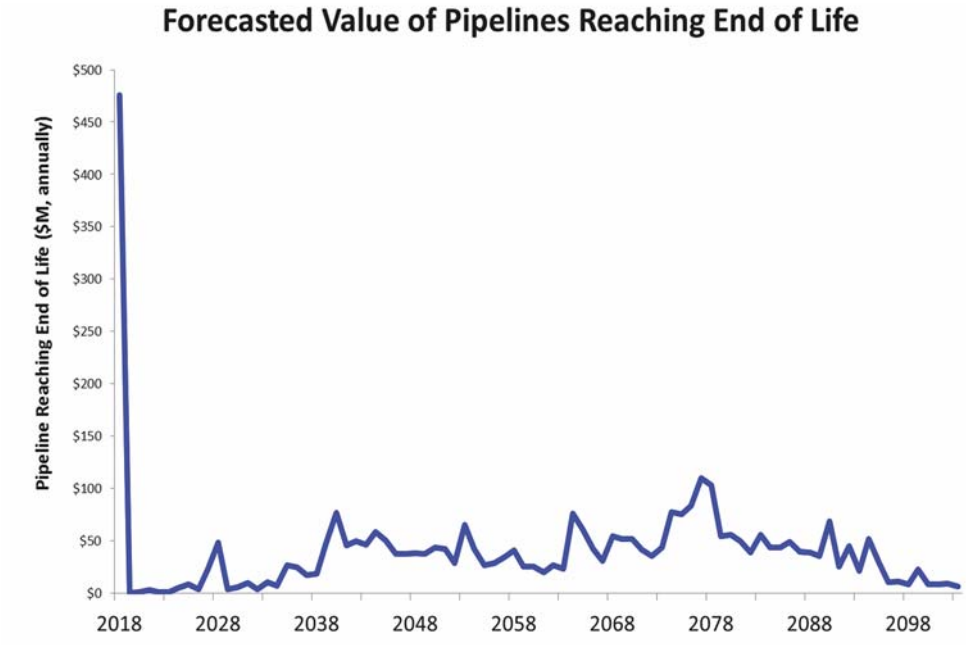

Figure 4. Pipelines Reaching End of Life Forecasted Through 2103

War II growth in the 1950s. This is illustrated by the pipeline installation date distribution shown in Figure 5. Cast iron pipe has an estimated 86-year lifespan (Table 3), so cast iron installed in the 1950s will be due to be replaced after 2040.

Considering the R&R backlog and forecasted R&R needs, the department decided to investigate the funding level required to eliminate the backlog prior to the forecasted increased R&R needs in 2040. An analysis of the department's fiscal year 2017 (FY17) pipeline R&R budget yielded an average pipeline R&R funding level of $9.4 million annually. If the department continued to maintain that funding level, the backlog would continue increasing (Figure 6); however, if the R&R funding were increased to $33.5 million/year, then the backlog would be eliminated, thus freeing future funds to address the R&R needs beginning in 2040. Figure 6 illustrates the projected pipeline R&R backlog at $9.4 million/year and $33.5 million/year funding levels. The R&R "gap" is defined as the difference between the current funding level and the needed funding level.

The R&R "gap" was identified by utilizing available GIS information and estimating the service life of Tampa-specific water mains. This

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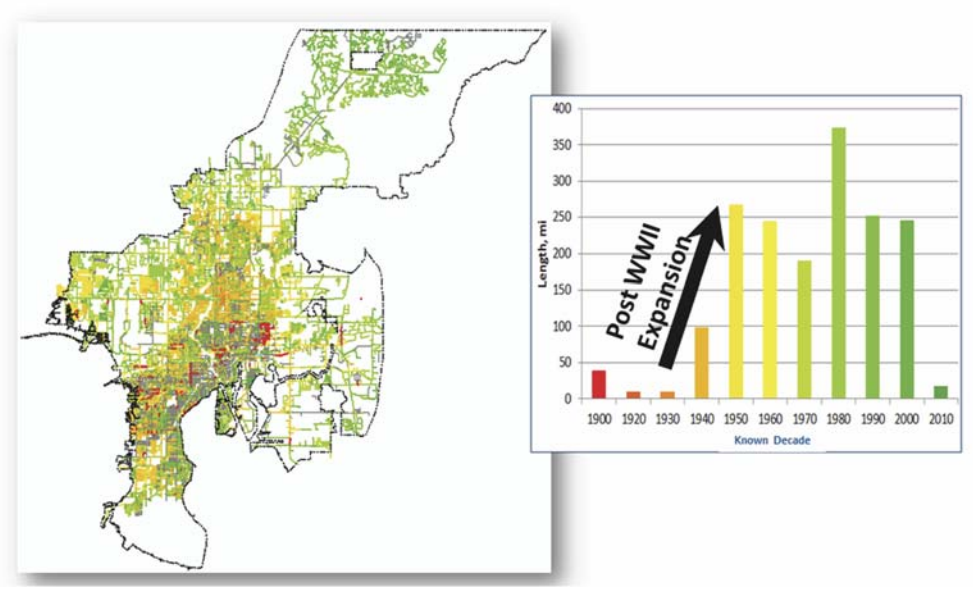

Figure 5. Pipeline Installation Date Distribution Reflects an Increased Number of Pipelines Being Installed Beginning in the 1950s

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process allowed the department to understand the asset volume already beyond end of life and the asset volume that is projected to reach end of life each year for decades into the future. The utilized approach also allows for dynamic risk-based prioritization of distribution system R&R needs. The goal is to reassess the pipeline risk of failure on a yearly basis and to adapt to the ever-changing conditions affecting the distribution system. The concepts and approaches used thus far are key components of effective asset management programs.

Converting Studies and Goals Into Action

Since the distribution system master plan update concluded in November 2018, the department's senior leadership has combined forces to develop a program named Progressive Infrastructure Planning to Ensure Sustainability (PIPES). This multifaceted program includes master planning, rate and fee studies, public involvement campaigns, and right-sizing city engineering and inspection staff to address increasing pipeline R&R workload. The key program message is:

"Healthy infrastructure is the foundation of a strong city…which is why the City of Tampa is investing in Tampa's tomorrow by taking a proactive approach to renew our infrastructure, prevent breakdowns, and provide long-term, permanent fixes to our water and wastewater systems."

The PIPES public involvement campaign includes a website with the following:

- Links to news stories related to pipeline infrastructure failures
- Maps illustrating historic water main break and sewer cave-in locations
- 20-year planned pipeline R&R maps
- Response to rate payer frequently asked questions (FAQs), including:
  - Where can I learn more?
  - Why do we need to do this now?
  - Why didn't we address the needs sooner?
  - How will this impact my bill?
  - How does my water bill compare to others in the area?
  - Will there be more needs to address in the near future?

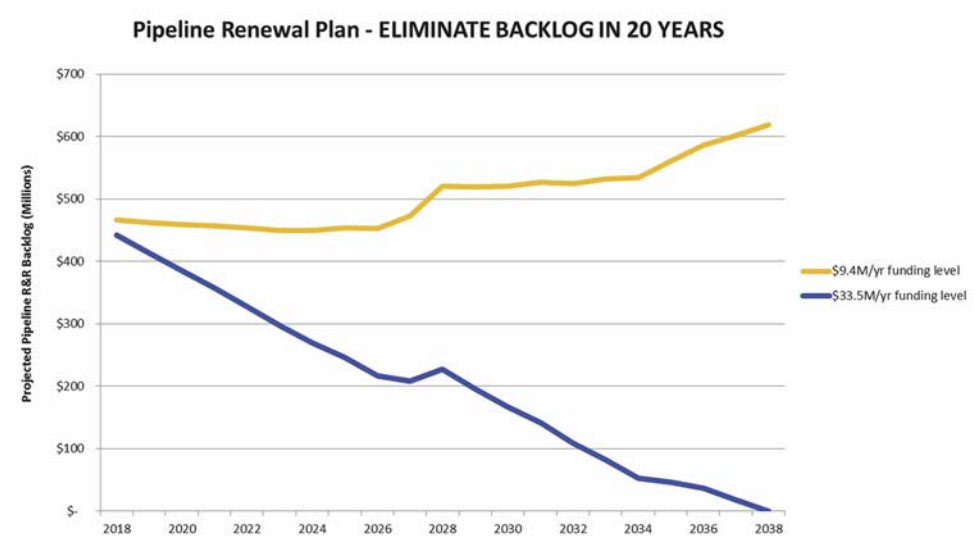

Figure 6. Projected Values of End-of-Life Assets at Existing and Proposed Funding Levels

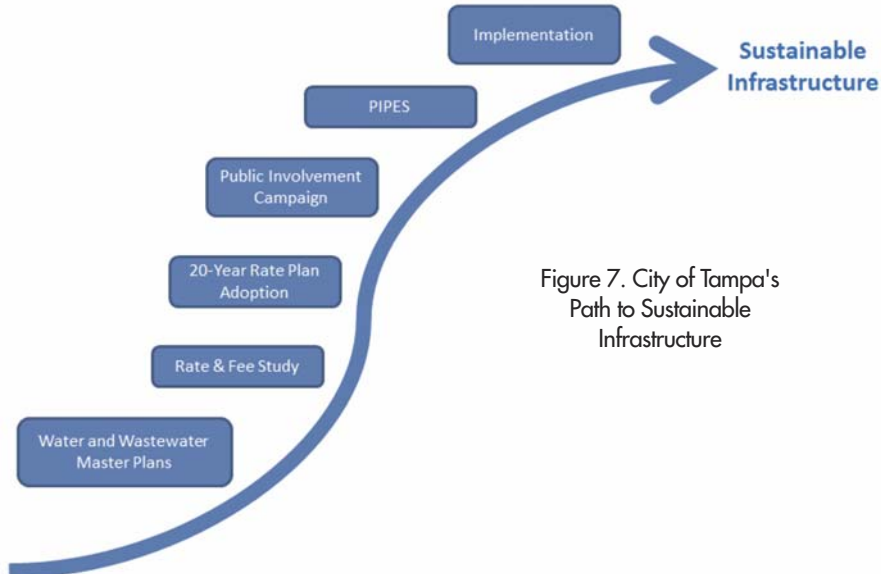

Figure 7. City of Tampa's Path to Sustainable Infrastructure

Conclusions and Recommendations

Key takeaways and lessons learned from recent department efforts include the following:

- Set a goal > generate a plan > work the plan > identify areas to improve > repeat. Modern plans are not static; they must be adaptive to allow utilities to use public resources as efficiently as possible.
- A good GIS database with key attribute data greatly improves the efficiency of R&R prioritization efforts. Effort to improve the GIS and attribute data should be ongoing and are excellent investments.
- Asset management programs address entire management systems, in addition to R&R needs. While R&R projects are usually identified within one or two work groups at a utility, all staff members have a responsibility to perform their roles within the entire asset management system to ensure long-term success of the utility.
- Utility services will always be necessities to a functioning city; therefore, pipeline R&R will always be a continuous process. It's recommended that utilities stay proactive and promptly address R&R needs when assets reach the end of their estimated life.

The department's asset management program has helped it to achieve its mission of delivering high-quality water and providing exceptional customer experiences in a safe, reliable, efficient, and sustainable manner (Figure 7) by identifying pipeline R&R needs, providing the backup data necessary to support funding level increases, and improving information sharing between work groups. This is a process that the department will continue on an annual basis and has become part of the standard workflow.