WHITE PAPER

Thomas Hill Public Water Supply District:

A Case Study on Using Hydraulic Models to Optimize Water System Capital Improvements

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SHAFER, KLINE & WARREN

Executive Summary

Aging water storage and distribution infrastructure, coupled with growing customer demand, presents challenges for public water supply districts (PWSD) in Missouri and across the nation. Many PWSD also face funding constraints as public grant and loan money becomes more scarce. As one of the largest rural water districts in Missouri, Thomas Hill PWSD faced these same challenges. By planning ahead and partnering with the consulting engineers at Shafer, Kline & Warren (SKW), Thomas Hill PWSD was able to identify its critical water distribution and storage assets, and prioritize the improvements necessary to maintain service levels in the face of growing demand. By focusing on the most feasible and highest-priority projects, and carrying them out in a cost-effective manner, Thomas Hill PWSD has been able to self-fund the majority of their work to date. Additionally, some of the upgrades are already generating cost savings through lower electricity bills. Thomas Hill's case study offers insight into how water utilities with aging infrastructure can develop a plan to meet customer demand despite significant funding constraints.

– Renick 150,000 gallon Thomas Hill Tower

– Thomas Hill District Office

The Situation

Repairs and upgrades to the water storage and distribution system are often needed to maintain water quality and system reliability while increasing capacity. Utilities have a limited budget for these improvements and traditional financing sources may not be available in the future. Qualifying for state and federal low interest loan programs has also become more difficult to comply with for PWSD across the country. This challenge presents a unique opportunity for rural communities and their PWSD because it reduces the need for federal or state funding and keeps decisions surrounding system improvements at the local level. However, to effectively capitalize on this opportunity these rural communities will need to be more earnest in planning for and finding practical financial solutions that maintain and improve services for PWSD customers. Thomas Hill PWSD turned to the experts at SKW for affordable solutions to meet current water supply needs and to plan for future growth. SKW developed a tool that helped Thomas Hill PWSD identify critical assets, then prioritize repairs and capital improvement projects.

Thomas Hill Public Water Supply District, Missouri

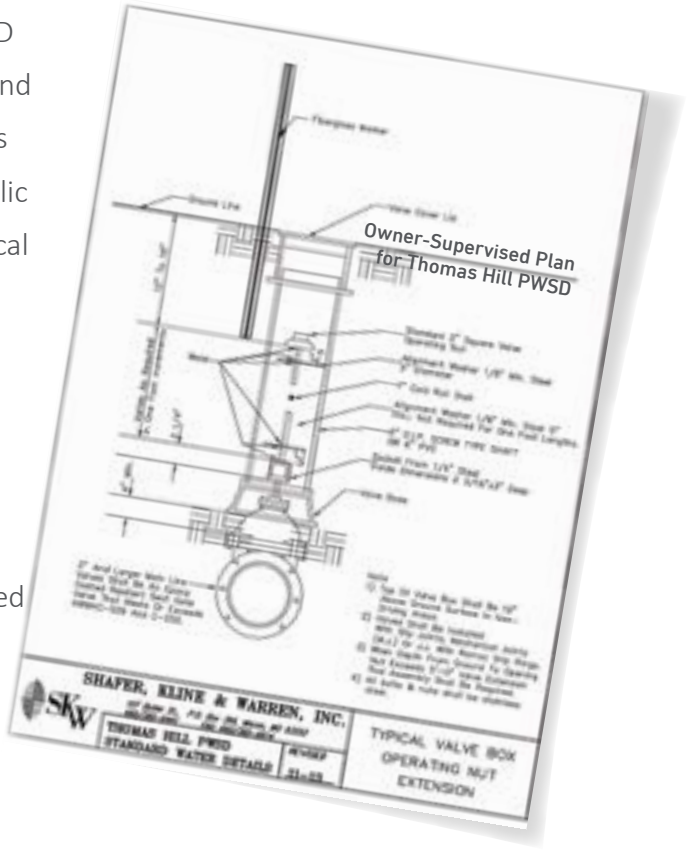
Thomas Hill PWSD is one of the largest rural water districts in Missouri primarily serving rural Randolph County, with approximately 1,100 miles of water lines serving almost 4,200 customers across four counties. The District's primary water source is the Clarence Cannon Wholesale Water Commission. Its distribution lines were installed in four phases beginning in the mid-1970's, and over the years the system has faced typical causes for maintenance and upgrades to their lines.

A unique challenge the District faces however is its size and topography. The system's size and terrain mean the Thomas Hill PWSD is divided into five pressure zones to ensure customers are able to receive a reliable supply of water at an acceptable pressure. To achieve these conditions each zone contains a pump station and a water tower, but the drawback to this design is there are minimal connections between each zone. These limited connections between zones inhibits the ability to transfer water from one zone to another if a pump station fails or loses power. In such a case the zone must largely rely on its water tower reserve and its emergency interconnections, which presents relevant concerns for emergency preparedness.
In conjunction with these circumstances, Thomas Hill PWSD continues to grow. The District is adding approximately 40 new customers annually, and recently expanded by incorporating a neighboring water system. In order to provide an adequate supply of safe and reasonably-priced water to its customer base,

the District must prioritize repairs and upgrades within the water distribution and storage system. This is particularly difficult to manage in light of the limited funds available to support infrastructure projects and forces the District to constantly balance customer needs with affordability of system maintenance and improvements.

Solutions

For more than 15 years, SKW has provided Thomas Hill PWSD with advice and engineering solutions for its water storage and distribution system. In 2014, SKW performed a Critical Assets and Infrastructure Analysis, including comprehensive hydraulic modeling and analysis of the system in order to identify critical assets and make recommendations for short- and long-term infrastructure improvements.



Simultaneously, SKW prepared an Owner-Supervised Program (OSP) for Thomas Hill PWSD. An OSP is a document that describes a water supplier's plans for system design, construction and construction supervision. It contains detailed information about the District's planned upgrades and the construction materials to be used, measures to be taken to ensure that water mains are protected from contamination during construction, and specifications for disinfecting the distribution system prior to placement in service. Under state regulation 10 60-10.010, once the Missouri Department of Natural Resources approves an OSP, the utility can carry out the work described in the plan without seeking further approvals. This pre-approval, valid for five years, has enabled Thomas Hill PWSD to save on capital expenditures by using their own equipment and personnel to expedite the design and construction process for many water lines.

System Mapping and Hydraulic Analysis

To begin the Critical Assets and Infrastructure Analysis, SKW mapped all components of the Thomas Hill PWSD storage and distribution system. The expert team used this map to make a hydraulic model. In order to predict the potential impact of failures of the various system assets, SKW ran the model for a variety of possible operating scenarios. Based on the modeling results, SKW identified 32 assets (lines, valves, storage tanks and supply points) as potentially critical system assets.

Determining the Relative Criticality of System Assets

SKW next developed a method to determine the criticality of the various components of the District's storage and distribution system[1]. It could be argued that every part of the system is critical. However, the goal was to determine the relative criticality of different assets to prioritize repairs and capital improvements. For each of the 32 potentially critical assets, SKW's model computed a "Criticality Factor" based on three variables — likelihood of failure, consequences of failure and feasibility of short-term replacement.

1. Likelihood of Asset Failure

The model considered asset age, condition and the prior history of the asset. Age is particularly relevant for active components of a system such as pumps and valves. Infrastructure condition, while also important, is difficult to determine for assets that are inaccessible. The history and experience that the Thomas Hill PWSD has had with an asset was one of the most influential factors in determining the likelihood of failure because an asset that has previously failed several times, or is known to contain defects, is more likely to fail in the future.

2. Consequences of Asset Failure

The model considered the potential reduction in customer supply and service levels, actual costs of repairing the asset, potential for collateral property damage, legal and environmental costs, as well as social costs such as loss of public confidence in the event of asset failure. Assets that were more likely to cause damage were prioritized over those with a lower potential impact.

3. Feasibility of Short-Term Replacement

The model recognized that it could be impossible or impractical to replace certain assets; therefore, feasibility of asset replacement was given a significant weight in computing the Criticality Factor.

[1] The methodology was based in part on asset management guidance from the U.S. Environmental Protection Agency (A Handbook for Water and Wastewater Utilities, February 2012) and the New Mexico Environmental Finance Center (Asset Management: A Guide For Water and Wastewater Systems, 2006 Edition).

Prioritizing Repairs and Capital Improvements to Meet the Most Critical Needs

In order to make the best use of Thomas Hill PWSD's financial resources, SKW ranked the assets according to their "Criticality Factor." The highest priorities identified by SKW included:

- Replacement of several defective lines — the sole connections between pressure zones — that have a history for failure. These lines are prone to breaking and needed to be upsized in some cases. The most urgent line replacements were recommended for inclusion in the District's next five-year OSP.
- Replacement of a number of key valves that provide flexibility to the distribution system under different operating conditions.
- Installation of upgraded booster pumps at the Fayette Pumping Station. This station allows water from Fayette to be pumped into the District's distribution system during emergencies.
- Replacement of the Huntsville Tower, which provides essential storage and pressure to surrounding areas.

– Thomas Hill Boring New Water Line

– Route A Pump Station

Thomas Hill **Asset Plan**

Asset	Valves in Phase I	Valves in Phase II	4" Pipe to Wien	Wien Standpipe	Wien Pump	Old PVC line along Hwy 129	Old PVC line on Hwy 3 to Firefly St., (Macon Co.)	Old PVC line on Firefly Street	Old PVC from Rt A to Huntsville	Huntsville Tower	Old PVC on Hwy F (Randolph Co.)	Old PVC on Hwy W and HH (Randolph Co.)	Robintech on Hwy 3 north of Clifton Hill	Old PVC along several County Roads in Randolph Co.	Route A Tower	12" Line from Route A Tower	12" Line to Route A Tower	Route A Pump	Old PVC west of Roanoke along Hwy 129
Asset Age	5	4	4	4	1	4	4	4	4	3	4	4	3	3	2	2	2	1	3
Asset Condition	5	4	2	1	1	5	5	5	5	4	5	5	5	5	2	1	1	1	5
History and Experience with Asset	5	4	2	1	1	5	5	5	5	2	5	5	5	5	2	1	1	1	5
Likelihood of Failure	**5.0**	**4.0**	**2.7**	**2.0**	**1.0**	**4.7**	**4.7**	**4.7**	**4.7**	**3.0**	**4.7**	**4.7**	**4.3**	**4.3**	**2.0**	**1.3**	**1.3**	**1.0**	**4.3**
Cost of Repair	1	1	3	3	1	3	3	2	2	2	2	1	3	1	2	1	2	2	2
Social Costs	3	3	3	2	2	1	4	4	4	3	3	2	3	1	5	5	5	5	1
Repair/Replacement Cost Related to Collateral Damage	1	1	1	1	1	2	4	1	3	2	3	2	3	1	1	5	5	1	3
Legal & Environmental Costs	1	1	2	1	1	1	2	1	1	2	1	2	1	1	2	2	1	1	1
Reduction in Level of Service	3	3	4	2	3	3	5	4	5	2	2	3	3	2	5	5	5	5	3
Consequence of Failure	**1.8**	**1.8**	**2.6**	**1.8**	**1.6**	**2.0**	**3.6**	**2.4**	**3.0**	**2.2**	**2.2**	**2.0**	**2.6**	**1.2**	**3.0**	**3.6**	**3.6**	**2.8**	**2.0**
Feasiblity of Short-term Replacement	**5.0**	**5.0**	**1.0**	**2.0**	**1.0**	**2.0**	**2.0**	**2.0**	**2.0**	**3.0**	**2.0**	**2.0**	**2.0**	**2.0**	**3.0**	**1.0**	**1.0**	**1.0**	**2.0**
Criticality Factor	***436***	***406***	***182***	***196***	***112***	***280***	***312***	***288***	***300***	***284***	***284***	***280***	***282***	***254***	***270***	***162***	***162***	***136***	***270***
Asset Rank	*2*	*3*	*25*	*24*	*31*	*13*	*5*	*8*	*6*	*11*	*10*	*13*	*12*	*18*	*15*	*26*	*26*	*29*	*15*

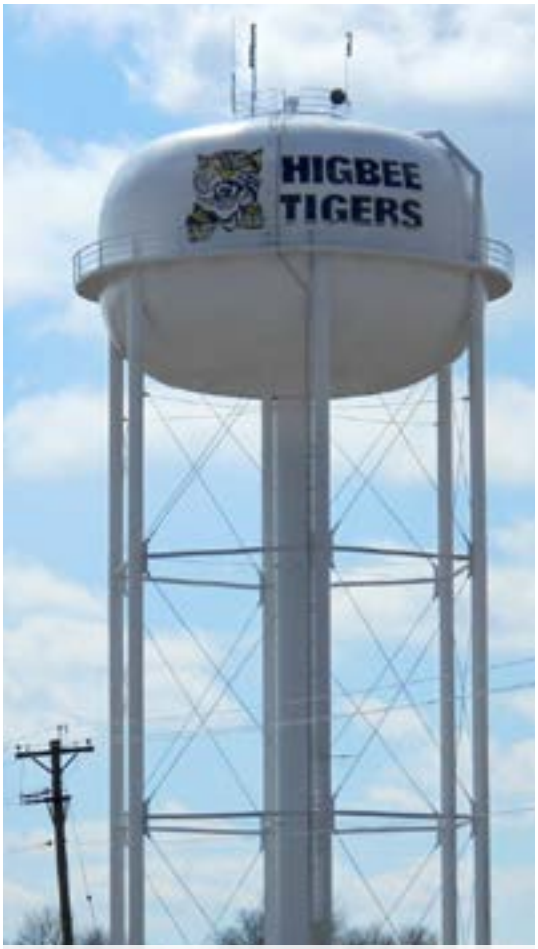
Asset	Old PVC along Hwy 3 between Hwy 24 and Hwy 129	Moberly Tower	Moberly Pump	6" Line from CCWWC Meter to Moberly Tower	8" Line from CCWWC Meter to Renick Tower	Renick Tower	10" Line to Higbee Tower	Higbee Pump	Higbee Tower	Old PVC along Hwy B east to Roanoke (Randolph & Howard Co.)	Old PVC along Hwy 3 south of Roanoke	3" Line Into Prime Area	Fayette Pump Station
Asset Age	4	3	1	4	4	2	3	1	1	3	3	4	5
Asset Condition	5	1	1	2	2	1	2	1	1	5	5	2	5
History and Experience with Asset	5	2	1	3	2	3	2	1	1	5	5	2	3
Likelihood of Failure	**4.7**	**2.0**	**1.0**	**3.0**	**2.7**	**2.0**	**2.3**	**1.0**	**1.0**	**4.3**	**4.3**	**2.7**	**4.3**
Cost of Repair	3	2	1	3	4	2	4	2	1	3	4	1	2
Social Costs	3	2	3	3	3	3	5	5	1	4	2	2	1
Repair/Replacement Cost Related to Collateral Damage	2	1	1	4	5	1	5	5	1	3	3	1	1
Legal & Environmental Costs	3	1	1	2	1	1	2	2	1	2	2	1	1
Reduction in Level of Service	5	3	4	3	3	3	5	5	3	5	3	2	2
Consequence of Failure	**3.2**	**1.8**	**2.0**	**3.0**	**3.2**	**2.0**	**4.2**	**3.8**	**1.4**	**3.4**	**2.8**	**1.4**	**1.4**
Feasiblity of Short-term Replacement	**5**	**3.0**	**1.0**	**2.0**	**2.0**	**3.0**	**1.0**	**1.0**	**1.0**	**2.0**	**2.0**	**3.0**	**4.0**
Criticality Factor	***454***	***246***	***120***	***250***	***244***	***250***	***204***	***156***	***108***	***298***	***286***	***258***	***358***
Asset Rank	*1*	*21*	*30*	*19*	*22*	*19*	*23*	*28*	*32*	*7*	*9*	*17*	*4*

The remaining assets studied were deemed to be critical but not in need of short-term replacement. For these, SKW suggested long-term monitoring and scheduling of eventual replacement.

After completing the Asset and Critical Infrastructure Analysis, SKW developed cost estimates for all of the recommended improvements. This totaled $10.7 million in engineering, construction and other project costs. This figure on its own seemed insurmountable to the Thomas Hill PWSD Board. However, by prioritizing projects based on SKW's ranking system, the District was able to objectively invest in the most critical projects each year without straining the budget. SKW also helped Thomas Hill PWSD to identify potential cost savings when implementing the upgrades. For example, the District can do many of the necessary water line installations itself, using its own equipment, in consultation with the engineering recommendations and OSP prepared by SKW.

Enhancing System Resiliency and Emergency Preparedness

SKW recommended repair and capital improvement projects that will enhance system resiliency and emergency preparedness while ensuring continued compliance with regulatory requirements. Replacement of the Huntsville Tower and booster pump station will increase storage capacity and assist in maintaining adequate pressure in two pressure zones. Line replacements and the installation of additional connections will allow a greater volume of water to be transferred between pressure zones when necessary. Pump station improvements, including connection to back-up power supplies, will support system reliability. The priority projects recommended by SKW, together with connection agreements between the District and neighboring cities and other rural water districts, will help to ensure the District's water storage and distribution system can meet its customers' needs for many years to come.



– New 400,000 gallon Thomas Hill Tower

Moving Forward

Three years into the recommended repairs and capital improvements, Thomas Hill PWSD has begun to benefit from increased system capacity and reliability, while achieving cost savings.

The District is committed to supplying customers with clean and safe water in sufficient volume with adequate pressure. The priority rankings in SKW's Asset and Critical Infrastructure Analysis identified the repairs and upgrades that were necessary to meet these goals. To date, Thomas Hill PWSD has been able to self-fund the majority of the work. By setting appropriate rates and undertaking repair and improvement projects in order of priority, the District has been able to increase capacity and reliability of the system while maintaining a strong financial position.

– Thomas Hill New Line Construction

Undoubtedly, there are circumstances where it is appropriate for a water utility to finance repairs or improvements through loans or revenue bonds. But these instruments are not always available, and cuts to federal grant and low-interest loan programs represent another funding hurdle for PWSD like Thomas Hill. This degradation of traditional funding sources means more PWSD will face debt at market interest rates, which introduces financing costs that must ultimately be borne by customers through higher water bills. Lenders can also seek to impose conditions on a project such as dictating the procurement process or equipment to be used. With this in mind, more PWSD should focus on maximizing the life cycle value of their assets by self-funding as many critical infrastructure repairs and upgrades as they can in order to maintain control of their budget and operations.

To maximize value for Thomas Hill PWSD, SKW also recommended several upgrades that would result in energy savings. For example, SKW suggested installing variable-frequency drives (VFD) at pump stations. A VFD controls the frequency and voltage supplied to an electric motor and allows the motor to ramp down quickly if load decreases. By adjusting the motor speed based on pumping demand, a VFD improves energy efficiency and reduces overall electricity costs of a water distribution system. The District reports that at one pump station, the VFDs have already paid for themselves.

Conclusion

Initially, increases in customer demand were straining Thomas Hill PWSD's aging water supply infrastructure and threatening its bottom line. With SKW's help, the District has been able to prioritize repairs and upgrades and focus first on the assets that are the most feasible to replace and that are critical for maintaining service levels. With assistance from SKW in developing the Asset and Critical Infrastructure Analysis and OSP, the Thomas Hill PWSD Board is fulfilling its fiduciary responsibility to maintain the system, while continuing to ensure affordability for customers and demonstrating value for voters. At a time when existing funding mechanisms becomes more scarce, the District remains confident that it will meet customer needs well into the future.

BIO

Dennis Stith serves as team leader of Shafer, Kline & Warren's water resources – North and office manager for SKW's Macon office. Specializing in the water and wastewater fields, his design and project management experience includes studies, design and preparation of specifications for wastewater collection systems, wastewater and water treatment plants, and water distribution systems.

As a senior project manager for water environment projects, Dennis reviews project progress and monitors timely completion of projects. Experienced in all phases of project development, he coordinates mechanical, electrical, structural, surveying and civil engineering services as required to meet overall project goals and objectives. Stith coordinates his staff to effectively meet project needs within required schedules and budgets.

Notes

White Paper

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