PRELIMINARY ENGINEERING REPORT

City of Fillmore, MO

Water Distribution System

Project 21086.000

Bartlett & West

Driving Community and Industry Forward, Together.

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1. PROJECT PLANNING

This study was commissioned by the City of Fillmore, Missouri. The project is to upgrade and replace the City's aging elevated tank and distribution system and develop a long-term and sustainable plan for operating the water system. Alternate solutions for the distribution system piping were evaluated for different levels of system dynamics, pressure sustainability and fire flow capability. Options were also developed for different types and sizes of tanks for finished water storage along with the option of water storage with their supplier, PWSD #3 of Andrew County. Considerations were given to the changing patterns in growth and future needs of the city.

For each alternative, an itemized Opinion of Probable project costs was developed which included construction costs, engineering fees and contingencies. Finally, the annualized capital and O&M costs along with equipment reserves were compared for evaluating long term life cycle costs. A tabulation of this evaluation is provided in the report.

Location

The City of Fillmore is located about five miles north of Interstate I-29 at the intersection of “A” and “H” Highway in Andrew County. The community largely serves the local agricultural community and due to good secondary highways and easy access to I-29, the city is also a bedroom community for residents and families preferring life in a small town. The community is about 22 miles north of St Joseph.

Elevations range from 990' on the southeast side of the city, where the existing elevated tank is located, to 880'. Drainage is to the northwest with the city lagoon system located in that corner of town. Drainage is to a tributary of the Nodaway River. The difference in ground elevation of about 110 feet results in a static pressure difference of approximately 47 psi within the water distribution system.

Environmental Resources Present

Maps of the existing water distribution system along with photographs of the project area are provided in the appendix.

The proposed water line project includes the replacement of existing water mains with new pipelines. The proposed water lines will be installed within the existing street and highway ROW or in yards / private ROW and often following existing water lines which have been previously disturbed. There are no significant drainage or stream crossing in town, however if encountered in design, these will be bored to extend beyond any drainage impact area. All county or state highways will also be completed with directional bore method and encased to lessen the impact on service and ditch and drainage area. Therefore, no environmental impact is expected.

Population Trends

Using US Census information, a review was done of the Fillmore City population and related growth for the past 30 years. From 1990 to 2010, the population saw a slight decline on average of approximately 1.64% annually. The sharpest downturn during that period as noted by census data was from 1990 to 2000 when the population decreased by about 19% or 1.9% annually. The past 10 years however has seen a slight rebound in population with growth of 0.32% annual growth.

And while there are few businesses in the downtown, the past few years there have been encouraging with signs of growth as new homes are either being built or planned for construction and most existing homes being occupied. The investment properties or rental units in town also appear to be mostly occupied. And while some of the existing housing is older the regional school district is strong, an encouraging factor for families to move and take up residence in town.

For this reason, despite the historical decline in population, there seems to be a slight shift where it may be argued that the population has stabilized and even growing. It seems reasonable to anticipate that the population will grow at a rate of something close to about 0.2% annually.

A tabulation of population with associated projections are provided below.

Table 1; Historical and Projected Population and Growth Rates

Population and Growth Projection			
City of Fillmore, June 2022			
Year	**Fillmore Population**	**Projected Population**	**Fillmore Growth Rate Annually**
1990	256		
2000	211		-1.91%
2010	184		-1.36%
2020	190		0.32%
2030		194	0.20%
2040		198	0.20%
2050		202	0.20%
2060		206	0.20%
Note			
1) Population data and estimates from US census data.			

Community Engagement

The community has been engaged and kept updated and informed of this project through City notices on social media such as Facebook and the community betterment web page. Future information will be disseminated in a similar approach or through monthly notices that accompany the current water and/or sewer bill to each residence. The community knowing the age and condition of their water system has generally been supportive of the Mayor and City leaders as they've taken steps to improve and upgrade their water system.

Upon finalizing this report, a notice to the community is planned which will further help them understand the need for the project and update them on the decisions and recommendations of this report. It will also provide them with next steps the council will be taking to secure funding, and the set expectations for the schedule and timeline leading up to project construction.

2. EXISTING FACILITIES

Location Map

Paper maps of the current water distribution system were provided by the City of Fillmore. From these maps, the a hydraulic model of the existing system and copy of maps with details such as the pipe size and material of construction, and the location of hydrants and valve were noted. A copy of this map is included for review in the Appendix.

Currently there are about 90 metered and billed connections on the current water system. All of these meters are residential. The approximate location of existing meters within the system was determined from existing maps and review of housing. Actual placement of new meter pits and service will be located during the final design process.

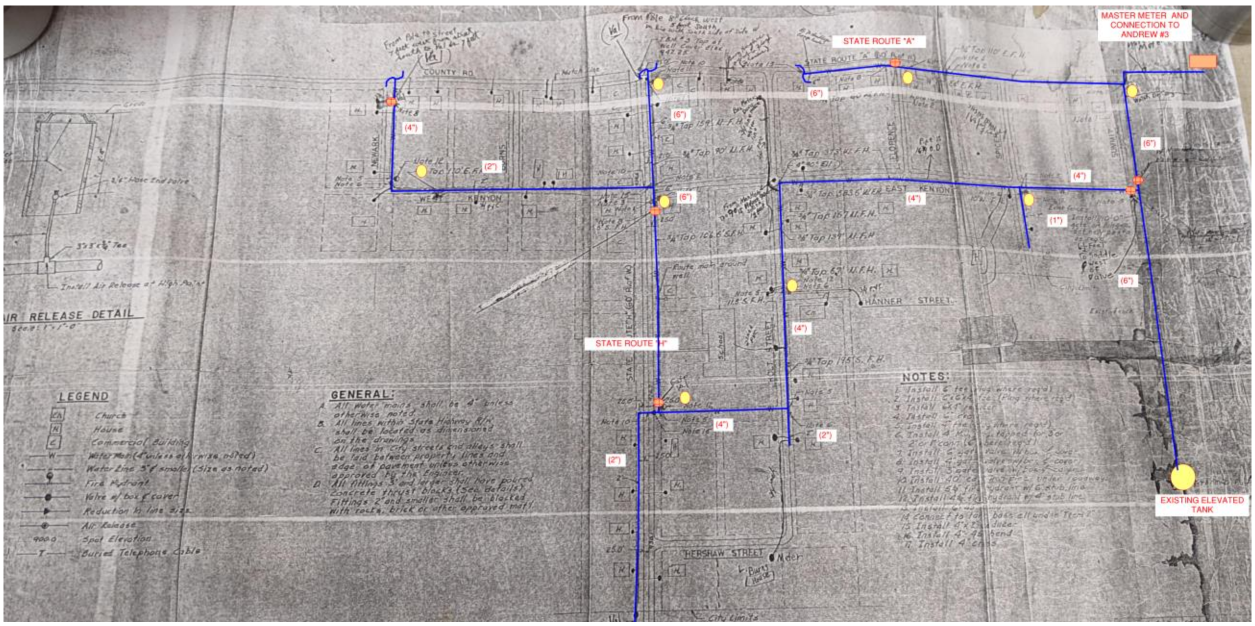


Figure 1; Map of Existing Distribution System

History of Water Distribution System

The main portion of the existing distribution system was constructed in 1965 (approximately 57 years old) and the elevated tank was built in 1964. The system consists of mostly 4-inch and 6-inch transite or asbestos cement pipe and fittings. This has been noted by the current water system staff which has worked for the city since about 2006. There are also some 2-inch and 1-inch smaller diameter lines that are either grey PVC or possibly galvanized pipe. Repair done in recent years on the smaller lines has been on the grey PVC though. It is unknown if this is actually meant for potable water or not as most potable water PVC is either blue or white. The grey color is unusual and typically reserved for conduit.

A tabulation estimating the approximate pipe by size and material is shown in Table 2.

Table 2; Tabulation of Existing Pipe by Size and Material

Tabulation of Pipe of Existing System		
City of Fillmore, June 2022		
Item No.	**Pipe Size / Material**	**Length (ft)**
1	1-inch Galvanized/Grey PVC	915
2	2-inch Galvanized/Grey PVC	3,721
3	3-inch PVC	320
4	4-inch Asbestos Cement Pipe	5,660
5	6-inch Asbestos Cement Pipe	4,000
	Total (ft)	**14,616**
	Fire/Flushing Hyrants (size varies)	12 units

Water Source

The distribution system when originally built connected to City wells on the west side of town. That 3-inch main along with the wells have since been abandon. The city currently has a connection to and purchases their water from Andrew County PWSD #3. An above-ground master meter station on the east side of Fillmore meters the water as it is delivered to town. A solenoid operated control valve opens and closes to fill the City's elevated tank based on water pressures inside the meter station. A 6-inch main delivers water from the meter station to the distribution system and elevated tank. The above ground meter and control valve for the City's connection and meter structure is as pictured below.

Andrew County PWSD #3 purchases most of their water from the City of Savannah but also indirectly (via Andrew PWSD #1) from Missouri American in St Joseph, MO. Both water sources are softened water. Savannah uses gas chlorine or free chlorine for disinfection which Missouri American uses Chloramines.

Figure 2; Above-Ground Metering and Control Structure

Pressure gauges in the meter station indicate an upstream pressure (PWSD #3 side of system) of over 117 psi with about 46 to 47 psi on the City's side of the system.

A copy of the Water Purchase Agreement between Andrew County PWSD #3 and the City of Fillmore is included in the Appendix. The Agreement was signed in 19xxx and is renewed every xx years.

Condition of Existing Facilities

Elevated Tank

The City of Fillmore owns a welded steel four-legged tank that was constructed in 1964 by Pittsburg-Des Moines Steel Co. It has a volume of storage or capacity of approximately 50,000 gallons and a height to high water level of 76’-3” (LWL =61’-3”). The tank has a 6” inlet and what appears to be about a 3’-0” diameter wet riser at the center of the tank.

The City currently does not have a contract for maintenance and inspections of the tank. In 2018 the City contracted to have the tank cleaned and inspected however the tank company upon determining that the tank did not have a catwalk choose not to climb or to access the bowl siting the lack of safety and need for a platform for the team prior to accessing the tank bowl.

The wet riser at the center of the tank has had multiple leaks and has been spot repaired with welded plates. Some of these spot repairs can be noted in the pictures below. At several other locations rusting spots are visible on the wet riser which will likely result rust through and produce added leaks. There is also visible rusting in the bottom of the tank bowl and where the tank bowl and legs and structural wet riser come together. Closer inspection is needed to determine if the structural integrity of the tank has been compromised though it seems this is not just surface rusting.

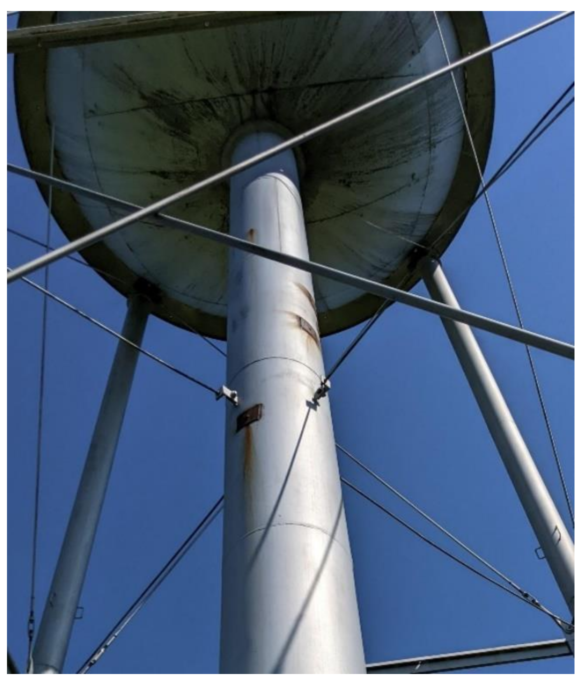


Figure 3; Existing Wet Riser Spot Repairs

As already noted, there is no catwalk, railings or handholds around the top perimeter of the tank when transferring from the roof ladder to the access hatch. This is a safety concern and violation of DNR design standards. There are safety concerns as well related to the integrity of the leg ladder / safety climb, interior of the tank bowl, and bar covers of the wet riser. This tank is in need of major and definite repairs and upgrades to bring it into compliance with the latest OSHA and DNR requirements.

Meter Station

The City's is served by a 1.5" control valve and metering system. The control valve and meter appear to be in good condition though there is some surface rusting on the incoming piping. The maximum flow thru at the control valve is approximately 125 gpm (max continuous) and at the meter (2-150 gpm). This is adequate for filling of the elevated tank and residential use. The bypass would need to be utilized if during a fire additional flow was needed.

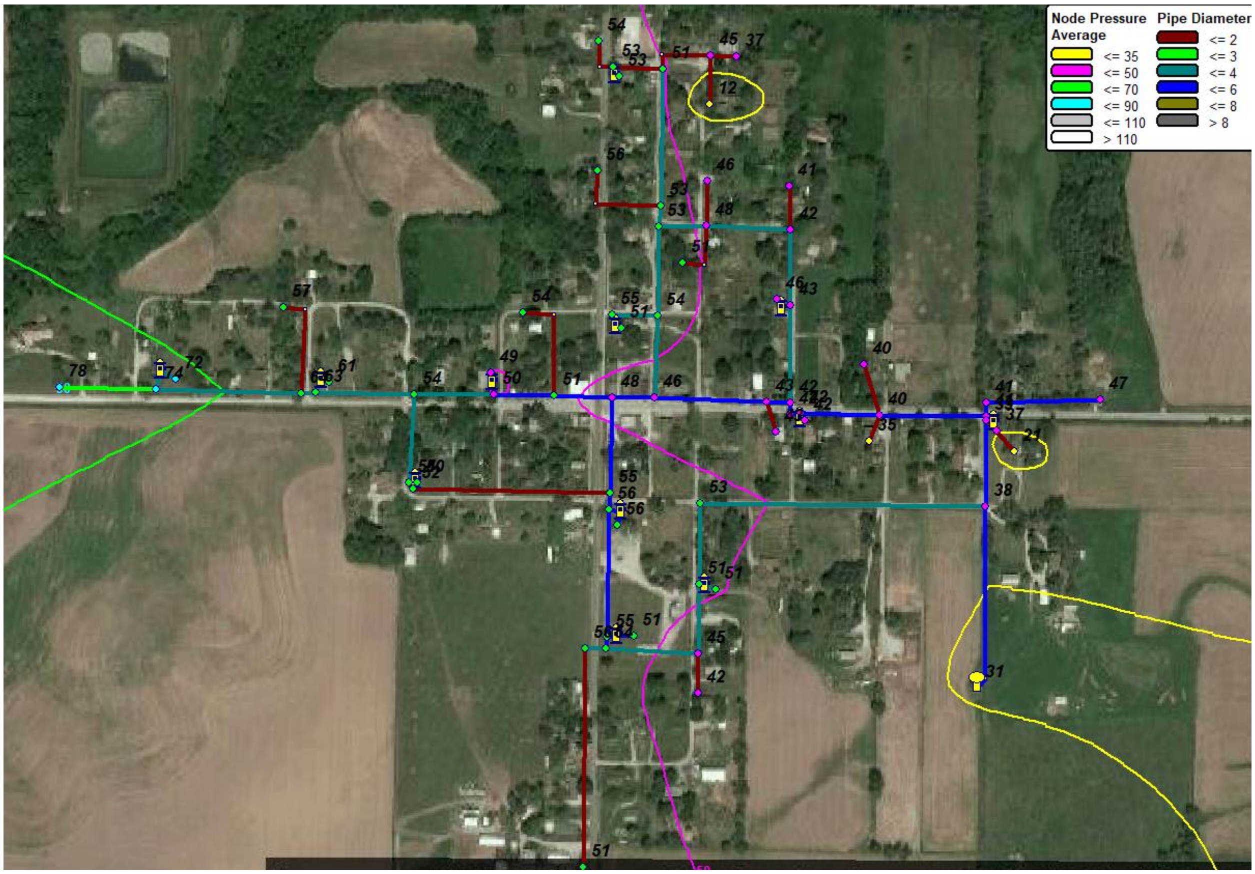
The building is showing signs of age as the heater has recently been replaced and the roof vent appears to be having issues. The vault is easily accessed and is above ground

Distribution System

The core and larger diameter mains system consists of old transite or asbestos cement pipe. This older pipe has outlived its useful life and continued repair and replacement of pieces of the system is not a sustainable option. There have been two to three leaks a year on both the large diameter mains and / or smaller grey lines which have resulted in costly repairs and in some cases city-wide water outages and boil orders. The old transite pipe, weakens as it ages and begins to lose its strength and will continue to deteriorate resulting in more serious leaks.

In most of the community the static pressure based on the elevated tank height and pressure gauge at the metering station, the mainline is 40 to 60 psi and in and along the lower western edge of town the pressures are in excess of 70 psi.

To determine pressure with use or residual pressure, the existing distribution system was modeled using KY Pipe, a water modeling software. The meter and user locations were put into the model and by using the design curve where Flow = # of users ^ 0.515), branch line pressures were modeled. In most locations the residual pressure was above 35 psi however on the end of smaller 1-inch lines pressure dropped at or below 20 psi and similar results at the ends of some 1” service lines.



It should be noted that despite the sufficient static pressure in the main line, several users have also complained of low-pressure problems, and some continued having issues even after replacing service lines from their homes to the meter. Based on the model, these are likely due to homes located above the street and mainline, homes located on smaller 1” and 2” lines in town or scaling and build up on the City’s side of the service line.

To improve residual pressure during water use or demand, the height of the new elevated tank should be raised by about 20-25 feet, lines should be looped whenever possible, and the distribution mains shall be mostly 4” or 6” with limited 2” lines to serve two or three users.

While there are several fire hydrants scattered throughout the community there is limited fire protection. These hydrants are primarily used for flushing the system about twice a year. When the system is flushed or otherwise disturbed, residents note discolored water, including redness and black flecks (possibly iron and manganese deposits) along with taste and odor issues.

Historical Water Use Data

Tabulated and summarized below, in Table 3, is water use information provided by City staff, showing yearly water use based on billing from 2016 to end of 2021. Although the water use is relatively consistent from year to year, the highest volume of demand occurred in 2019 a year with water loss of over 22%.

Using an estimated population of 190 from the census population for 2020, the average water use per person per day, otherwise known as the per capita per day demand (pcpdd) for the study period is approximately 48 gallons per day.

The per person per day water use data of 48 gal./day compares with suggested DNR design criteria of 80 gallons pcpdd when historical records are not available. The DNR design guideline includes water loss and is about 60% higher than water use in Fillmore. While lower than the anticipated DNR criteria the water use is consistent with other nearby smaller communities in northwest Missouri.

The lower than anticipated water use is likely due to a combination of factors some of which may include the following; (1) rate increases or other economic factors that suppress water use, (2) less lawn watering (3) better conservation and use of water by residents, (4) better system metering and management of water loss.

The City meters' water usage at each connection within the system. No larger user within the water system were identified.

Table 3: Historical Average Day Water Use

Historical Water Use Information						
City of Fillmore, June 2022						
Year	**Annual Water Purchased (Kgal.)**	**Annual Water Sold (Kgal.)**	**Water Loss (%)**	**Avg Day Water Sold (gal.)**	**Avg Per Capita Per Day Use (gal.)**	**(1) Peak Day Water Use (gal.)**
2016	3,790	3,235	15%	8,864	47	17,700
2017	4,103	3,521	14%	9,647	51	19,300
2018	3,989	3,304	17%	9,053	48	18,100
2019	4,638	3,606	22%	9,878	52	19,800
2020	3,903	3,225	17%	8,836	47	17,700
2021	3,409	3,008	12%	8,241	43	16,500
	3,971.9	3,316.5				
	Average 2016 to 2021		16.2%	9,086	48	18,200
NOTES						
1) Peak day water use is based on an average to peak day ratio of 2.0.						
2) Average per capita per day use is based on 2020 census population of 190 persons.						

The highest average day use for the study period occurred in the month of June and July. Water use in June averaged nearly 11,460 gallons per day and 10,085 in July. A graph of the average day use in each month for the past five years is shown in Figure 3.

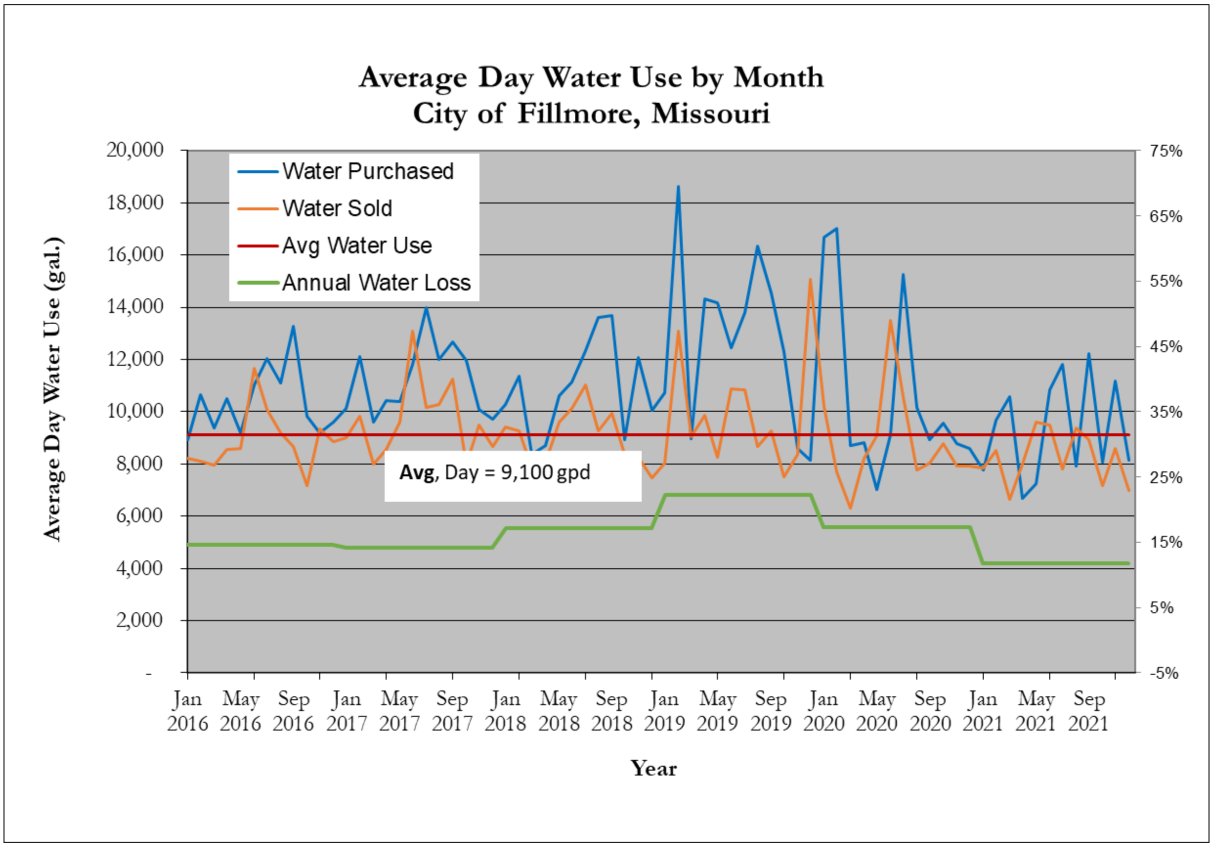


Figure 4: Average Day Water Use by Month

Financial Status of Existing Facilities

As of June 2022, the water rates for the City of Fillmore has a base rate of $31.00 which includes the first 1000 gallons and then $7.00/ thousand gallons of water use thereafter. A tabulation of the water rate is provided below noting that a household using 5000 gallons per month would have a monthly bill of $59.00.

Table 4: Current Water Rates

Residential Water Rates	
City of Fillmore, June 2022	
Water Use (gal.)	**Water Bill $**
0-1000	$31.00
2000	$38.00
3000	$45.00
4000	$52.00
5000	$59.00
6000	$66.00
7000	$73.00
8000	$80.00
9000	$87.00
Min. Base Charge (includes 1kgal)	$31.00
Water Charge per Kgallons is	$7.00
Rates were last adjust March 1, 2022	
Bulk Rate from Andrew #3…	$6.00

The City of Fillmore provided water department budgets and actual expenses for 2020 to February of 2022. These are included in the Appendix for review. A graph was developed showing the average expenses in 2020 and 2021 and future budget of the water department including purchase of water from Andrew #3. The largest expense is the purchase of water along with salaries which account for about 70% of the departments budgeted expense. A graph of these average expenses is provided below in Figure 4.

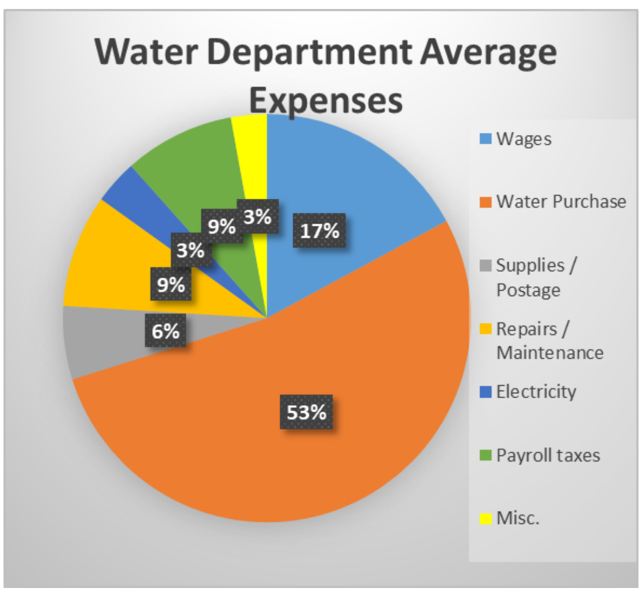


Figure 5: Average Water Department Expenditures

Using the existing rate structure and water use with meter information, annual water revenue was estimated at nearly $50,000 and water expenses estimated at $45,150. An annual positive balance of about $4,500 is anticipated. This compares with the actual City historical budget and expenditures in 2021 to March of 2022 of $46,123. The biggest difference in the two budgets would be the future cost of repairs and maintenance which with a new water system would be less than previously budgeted.

Table 5; Revenue and Expenses with Current Water Rates

Revenue and Expenses using Current Water Rates and Use				
City of Fillmore, June 2022				
				Estimated Annual Revenue / Expense
Revenue				
	Base Rate Revenue			$33,480
	Annual Avg. Water Sold			$16,195
		SubTotal		$49,675
Expenses				
	Cost of Water Purchased			($23,652)
	Wages and Payroll Taxes			($12,500)
	Billing and Admin			($5,500)
	System maintenance and Repairs			($3,500)
		SubTotal		($45,152)
		Estimated Balance		**$4,523**

Water Loss/Energy/Waste Audits

Water loss records were developed comparing the volume of water purchased from the PWSD against the water sold at each connection with the distribution system. The results indicate a water loss on average of approximately 16.2% per year. The highest water loss occurred in 2019 where it exceeded 22.0%. This coincided with the highest amount of water purchased for the five-year period.

The highwater loss relates directly back to several leaks that occurred in 2019, most of those occurred on smaller diameter mains and/or at the connection of service lines. The lowest water loss of 12% occurred most recently in 2021.

Unaccounted for water use reflects water loss due to backwashing, fighting fires, flushing mains and hydrants, system leaks and repairs. Water loss of 12% is commendable for an older distribution system and reflects the effort of City staff to identify leaks, repair old mains, and maintain metering facilities. Water loss greater than 15% to 20% is usually considered higher than normal.

3. NEED FOR PROJECT

Health, Sanitation, & Security

The age and general condition of the water lines represent a health risk for the community. The weakening of existing lines and scaling and buildup of mineral deposits within the small diameter pipes and service lines result in low pressure issues and related health risk.

This risk is especially true when there are mainline breaks or unrepaired leaks within the system. This scaling also represents a risk for biofilm and bacteria growth, especially for residents on the end of lines where there is less turn over and the chlorine residual maybe less than adequate. Regular flushing of the lines may help reduce these risks but there are also limited hydrants and flushing devices available.

Transite / Cement Asbestos Pipe

The distribution system within the city has what is referred to as transite or cement asbestos pipe in much of the town. The biggest health risk of asbestos cement pipe is when handling and repairing the pipe. When cutting or disturbing the pipe there is the danger of inhaling asbestos fibers once they are released into the air. This existing pipe has reached its useful age and as this pipe continues to weaken the risk while making repairs will only increase.

Studies have been done by WHO and EPA on asbestos cement pipe and drinking water. There does not appear to be conclusive evidence on the health risks of ingesting drinking water conveyed by asbestos cement pipe. However, as this pipe continues to age it seems reasonable to assume that with cracking and wear of the cement lining the potential for the leaching of asbestos fibers into the drinking water would also increase.

This project will address these risks by replacing this older pipe.

Water Pressure Issues:

While static pressure in the larger diameter mainlines is above 35 psi, there are homes and people in the community where the water pressure is not satisfactory. The pressure issues appear to be most likely related to elevation of homes above the mainline, smaller 1" diameter branch lines and number of users on those lines and/or the build-up of scaling and corrosion. The latter can be an issue of partially plugged service lines and / or plugged tap and connection of the service line to the main lines. Given the age, size, and condition of these lines, flushing and pigging the lines is typically not a solution and the best option is to replace the service line connection and meter pit and the smaller diameter lines. Low pressures can result in contamination of the lines resulting in a health concern which is addressed with the project improvements.

Backflow Prevention at Service Pits

Most of the meter pits do not have backflow prevention or check valves with the meter setters. Check valves are only included in a select few meter pits where newer setters have been installed. This presents a potential risk of contamination to the larger distribution system. This project will address the issue on a systemwide basis by providing new meter pits and setters at each location and provide the system protection needed.

Improper Flushing of Lines

Fillmore is limited in their ability to properly flush portions of the system due to.

- Lack of working cleanouts and poor condition of flushing hydrants
- Water hammer issues in the old transite piping- note, the operator is concerned to flush the lines hard due to the age of the water lines.
- Insufficient velocity to scour and clean some lines due to line size and volume issues within the system.

Problems due to improper flushing of water lines are a serious health issue. Improper flushing of older lines increases the scaling and tuberculation on the inside of pipes, providing places for bacteria to hide and grow. Flushing when done properly also allows the City to deal with low chlorine residuals during seasonal periods and eliminate the potential of biofilm slime developing in their water system.

This project addresses this health issue by the following:

- Installing cleanouts and replacing flushing hydrants.
- Replacing small diameter water mains with PVC pipe that are less subject to bio-film issues;
- Providing additional valves within the system which allows lines to be isolated to improve velocity during flushing.

Aging Infrastructure

The elevated tank is nearly 60-years old and is badly in need of repairs with visible leaks and rusting at the bottom of the bowl and along the center wet riser. In addition to the visible deficiencies are concerns to the integrity of structural elements and the interior of the tank. Several upgrades related to safety requirements including railing and ladder safety climbs are also needed to bring it into compliance. The cost of repairs and upgrades were not determined but given the age and maintenance of the tank, it has outlived its useful life.

The main portion of the existing distribution system consisting of the asbestos cement main was constructed in 1965 and is now nearly 60-years old. Based on the flow rates at flushing hydrants and the number of leaks it is in poor condition. Other smaller water lines that were installed at the same time are also likely to have lost a portion of the internal diameter to scaling and with limited flushing are likely in poor condition and are recommended for replacement.

Depending on the water quality and the aggressiveness of soils, the life expectancy of asbestos cement pipe is estimated at between 50-70 years. Actual service life will vary though depending on working conditions and system pressures. While the exterior of the lines in Fillmore do not appear to be excessively corroded, staff and City residents attest to the buildup and scaling in existing lines as they've tapped to replace service lines and make repairs. These conditions are most likely to be found where the City is unable to provide adequate flushing. This is one task for the proposed project to address. However, the pipes must be replaced to have a fresh start and an adequate flushing capability to maintain it into the future.

The original asbestos cement water lines have outlived their useful life and have deteriorated with corrosion and weakened with mineral deposits on the inside of the lines. This is substantiated by the number of leaks that occur. The reasonably high static pressure in the lower parts of town has also added to the poor condition and deterioration of the joints and mainline.

Reasonable Growth

For the purposes of this study, future water use projections will be determined using 50 gallons per person per day with 10% water loss. This is less than the MDNR recommended standard but seems to reflect the historical water use. The projected water loss also reflects that of a new water system. In addition, in conjunction with Missouri DNR guidelines, this report will make use of population projections to estimate future water use.

Data for peak day water use was not available from the City of Fillmore. Where historical data is unavailable, MDNR guidelines recommend for smaller communities a factor of 2.0 as the ratio of the maximum day to average day flow. This is commonly used in smaller community water systems throughout the region.

A tabulation of the present and projected water uses to the year 2060 for the City of Fillmore is tabulated in Table 5 below. Water use projections are determined using the estimates of population growth presented earlier in this study, and a water use rate of 50 gallons per capita per day and water loss of 10%.

Table 6: Projected Average Day Water Use

Projected Water Use				
City of Fillmore, June 2022				
Design Perimeters	**Present**		**Year 2040**	**Year 2060**
Population	190		202	206
Estimated No. of Meters	90		96	97
Water Use/Capita/Day (gallons)	48		50	50
Water Loss	16%		10%	10%
Avg Day Purchased (gal)	10,800		11,200	11,400
Avg Day Use (gal)	9,100		10,100	10,300
Peak Day Use (gal)	18,200		20,200	20,600
Peak Day Use in 12 hours (gpm)			28.1	28.6
*Instantaneous Peak Use (gpm)			126	127
Using DNR PWS Curve where Q=12(# meters)^0.515 and 2.11 users/meter				

4. TANK ALTERNATIVES CONSIDERED

Alternate tank styles and sizes were evaluated and considered for the community of Fillmore. Alternates are based on tank styles and materials that are available and tank sizes needed to meet requirements for a system providing fire flow and those for a system providing partial or limited fire flow. These alternatives are described and laid out under their respective sections with comparative cost estimates for consideration.

Design Criteria

MoDNR indicates that the primary purpose of a public water system is to produce and deliver adequate quantities of safe drinking water to the public. Providing water for fire protection, recreational and industrial uses are of secondary importance (Paragraph 7.1.1 of DNR Design Standards-2013).

DNR design criteria for communities providing Fire Protection:

- Water systems not providing storage that includes a minimum flow of 250 gpm for 2 hours are not designed for fire protection. (Para 8.1.3 of DNR Design Stds-2013)
- Water for fire flow shall be in addition to average day supply.
- Minimum system pressure of 20 psi be maintained during fire flow throughout the system. (Para 8.3 of DNR Design Stds-2013)

DNR design criteria for communities not providing Fire Protection:

- Finished water storage shall be equal to or greater than the average day use (Para 7.1.2 of DNR Design Stds-2013).
- For standpipes, the nominal capacity of storage is only that portion or volume above the 35 psi water level. (Para 7.1.2 of DNR Design Stds-2013).
- Distribution systems shall be designed to provide 60 to 80 psi with a minimum pressure of 35 psi at ground elevation. (Para 7.3 of DNR Design Stds-2013)

Design Considerations

General design criteria for evaluating the tank type and style for the City's application include the following:

Maintenance requirements – such as cleaning, painting and routine maintenance

- Initial construction and life cycle costs
- Ground elevations and required overflow elevation
- Useable storage volume

Description of Storage Tank Alternates

Below is a discussion of the various types of elevated water storage tanks that are available for the volume of water storage needed for Fillmore. Although there is some variation in tank style between manufacturers, the industry has created standards for design and construction. Such standards come from AWWA (American Water Works Association) and ACI (American Concrete Institute).

Tank companies commonly are national companies that travel and build in this specialty market all over the United States. Most will offer to build more than one style of tank; however, some specialize or are seemingly more competitive when bidding a certain size or style of tank. For that reason, alternate tank styles often are bid to maintain a competitive environment.

Two elevated tank styles are presented and reviewed in this report. There are other tank styles, such as the fluted steel column, or glass-fused and welded steel composite tank all of which are not being considered in this application as those styles are more efficient for much larger tank volumes and not applicable for the size of the proposed tank.

In addition to elevated tanks alternatives, ground storage reservoirs or standpipes (as they are called when the height is greater than their diameter) are also presented for consideration. These tanks are similar to a grain bin or silo and are built on grade without any additional pedestal or legs or support structure needed. For that reason, there is typically a cost savings associated with this style of tank. Two styles of standpipes are evaluated that fit the size requirements for Fillmore. The first style is a glass-fused bolted steel tank with an aluminum roof and the second is a welded steel tank with a steel (or aluminum) roof.

Pedestal Style, Spheroid (Pedosphere) or Hydrocone

The spheroid tank is an all-steel tank that looks like a golf ball on a tee. It is a welded carbon steel tank mounted on a round steel pedestal with a flared bottom. Typical pedestal size is 8-10 foot in diameter; however, the flared bottom is larger providing space for storage as well as to mount electrical and control panels. Due to economics, it is most often seen in tank volumes of between about 50,000 to 500,000 gallons.

The hydrocone style tank is a variation of the pedosphere tank. It is also a welded carbon steel tank mounted on a round steel pedestal. However, instead of a rounded top, the tank shape has sharper and more distinct lines and the flared shape of a cone. The hydrocone has the advantage of being easier to manufacturer for some companies and can be more easily constructed in smaller sizes. The nearest example of a hydrocone tank is Craig, Missouri. Typical hydrocone tank volumes are in a range of 40,000 to 250,000 gallons.

Figure 6: Spheroid Style Tank

An access tube and ladder through the tank bowl allow access to the top of the tank from the pedestal without climbing an outside ladder. Handrails are provided at the top of the tank for mounting antenna and to safely access the hatch into the bowl or water storage from the top.

Figure 7; Hydrocone Style Tank

Advantages:

- The smooth lines and rounded surfaces of a spheroid have a nice appearance.
- All ladders and piping are interior and protected against weather and vandalism.
- The flared bottom can be used for alternate uses such as storing hydrants or fittings.

Disadvantages:

- The welded steel requires coating repair and regular painting of both pedestal and tank.
- Welding and painting are extensively done in the field requiring consistent construction observation.

Multi-Column or Legged Welded Steel Tank

Figure 8: Legged Tank Example

The welded steel legged tank as the name suggests has a welded steel tank mounted on top of four or more legs for water storage. It is probably the most common style of tank seen in rural or smaller communities and is similar to the City's existing tank. The tank load is supported by the legs and a center column. Cross bracing and rods/struts are then provided between structural members and the legs for added strength and stability.

The center column can be constructed either with a wet or dry riser. When designed with a wet riser, the center column is filled with water, otherwise as a dry riser, a ladder may be placed inside to access the bottom of the tank. In either design, a ladder is provided on one of the other tank legs for climbing to the balcony and then to the top of the tank.

Advantages:

- Initial construction costs are typically lower.
- Welded steel construction allows for future modifications and repairs.

Disadvantages:

- The welded steel tank requires interior and exterior coating repair and regular painting.
- Welding and painting are extensively done in the field requiring consistent construction observation.
- Maintenance and painting costs for the legs and cross bracing is typically higher.

Tank Location and Share Options

One option that was presented with discussion on both sides was the potential for sharing an elevated tank with Andrew County PWSD #3 who is the supplier of water to the City of Fillmore. They currently do not maintain their own elevated tank and are actively pursuing funding for a new elevated tank. Their system is currently pressured by storage at the City of Savannah.

For the City of Fillmore, the benefit would be a partner to share in capital and maintenance expenses along with having access to a larger volume of storage. It would also help address concerns with water quality and turnover if the tank was shared with a larger user.

Given elevations within the rural water district Andrew #3's preferred location for a new tank is near the City of Savannah. The elevations are some of the highest in the district and allows them to serve the south side of their system and float their new tank with the existing tank owned by their source provider.

This location is nearly nine (9) miles from Fillmore and without upgrading water lines does not provide a benefit to the City. Upgrading 9 miles of existing mainline from 6" to 8" main is likely $2.5 to 3.0 million dollars which is cost prohibitive.

There was also some discussion of Fillmore relocating the existing welded steel standpipe that is owned by Andrew #3 closer to the city. This tank is currently located at the intersection of highway 71 and A highway, about five (5) miles east of Fillmore.

Figure 9; Existing PWSD #3 Unused Standpipe

Relocating used welded steel tanks has been evaluated and bid in the past. The process typically includes having the tank cut down in pieces and brought back to the manufacturer's shop to be upgraded to meet current safety codes and structural design standards. Items such as structural members, exterior ladders, railings, safety climb devices, hatches, lighting/control system are repaired or replaced and then the tank is completely sand blasted and primed. It then needs to be shipped back to the new site and welded together where a new foundation is constructed and final painting etc. are completed. Engineering and standard code requirements are the same and DNR and funding agencies will require stamped and certified drawings the same as for new construction. In the past the rule of thumb was a rebuilt tank was about 70% of the cost of new construction.

A call for input was made to Nick Gerard the owner of Gerard Tanks, of Concordia KS on moving a used tank. They are about the closest national tank contractor to Fillmore. His response was,"We have moved several. Used to be some savings, but anymore it is getting hard to save much. We have a few used ones in stock I believe."

Also, while standpipes have the advantage of being a low-cost tank to build, the bottom storage volume of this tank style has limited value, however the water quality of the added volume must still be turned over and maintained. Given the low average day use in Fillmore and unusable storage volume of a standpipe, this is not the recommended tank style and approach for Fillmore.

5. DISCUSSION OF TANK FEATURES, SIZING, AND COST ESTIMATE

Tank Letters, Logo, and Color

An elevated tank or standpipe can be one of the most visible, and publicly recognized pieces of infrastructure in a water system. Usually located along a main highway, and visible from a distance these elements become recognized symbols of pride for communities and the one visible part of the water system. For that reason, it is important to consider and plan a visible color scheme, as well as the location, and size of the logo (if any) and lettering.

These features are best described and specified as part of the project bid process rather than determined during construction. The cost of these features when clearly detailed up front are relatively inexpensive; however, additions or changes later can be costly. Even something simple like a change in exterior color can result in a cost increase as bright colors sometimes require a special clear coating to protect the color's integrity and brightness.

Color Scheme and Pattern

While there are exceptions, most often tanks are finished with either a single or two tone color scheme. Sometimes a single color is chosen for simplicity and economics. If a single color is chosen the tank often is painted white, a light blue or similar equivalent. A light color helps with water quality by not heating the water in the summer month.

A couple of considerations when choosing tank colors. One is bright colors such as yellow or red on the entire tank exterior are best avoided as an additional clear coating or a special produce may be needed to reduce sunlight fading the coating over long periods of time. If a bright color is desired to feature school colors or something special in the community, these are best added as a band or stripe around the tank to limit the area required. Often a color band is placed above and below the tank lettering with the rest of the tank painted a contrasting color, such as a white tank with red color bands and black lettering.

Secondly, the bottom of the exterior of the elevated tank bowl, bottom sides of reservoirs and standpipes will sometimes grey because of mildew when the tank "sweats" during the summer months. It is best if this portion of the tank is not a bright white or other color that will contrast the mildew, but rather hide its appearance with a shadow grey or grey/green color.

Lettering and Logo

The lettering and the logo are some of the more visible features added on the exterior of the tank. Lettering is typically stenciled in black, and then painted on welded steel tanks. A glass-fused coated tank lettering differs by using a 3-M vinyl decal (same as decal for cars) after the tank erection is completed.

Consideration should be given to both the size and orientation of the lettering and logo so that it is visible from nearby highways. It is also important to consider the roundness of the tank to prevent the lettering or logo from becoming too large allowing it to wrap around the back or bottom of the tank and become unreadable from a single location.

Depending on the style of tank, the lettering height is usually 8 to 10 feet, although this can be adjusted depending on the actual number of letters and the number of sides to be lettered.

Tank Lighting

Tank lighting whether it is mounted on the tank itself or set at ground level can make a tank standout at night both within a community and for travelers passing by. While the tank lettering and logo are usually the focal point for lighting, the entire tank outline is highlighted and noticed at night in a way it may be overlooked during the day. The use of LED bulbs has helped to lower the cost of electricity and may also provide a longer lasting bulb.

Standpipes versus Elevated Tanks

Standpipes typically have the advantage in most applications of providing the most volume of storage for the lowest construction cost. However, depending on the ground elevation, the volume of water stored within the lower portion of such tanks often has limited value, especially where fire suppression needs to be met and conditions where the minimum mainline pressure to be maintained must be 20 psi or greater. This lower storage volume must also be turned over and mixed regularly to maintain water quality, limit disinfection byproducts, and prevent freezing.

Thus, the useable storage volume of a standpipe within the distribution system is not comparable to the useable storage volume within an elevated tank where the entire head range or tank volume is useable. This matter becomes a larger issue as regulations with disinfection by-products become more stringent.

Alternate Tank Sizes

Because elevated storage typically has a useful life more than 50 years or more and is a costly investment it is important to consider the long term when building. The average day water use for the system is about 11,000 gallons per day. For water systems providing fire protection, the minimum volume in addition to the average day use is fire flow of 250 gpm for a period of 2 hours. More reasonable though is for the tank volume for fire protection to be sized to nearly match the capacity of fire hydrants within the distribution system. Note this is not entirely possible because hydrant flow may vary considerably based on proximity to the tank and elevations.

Another consideration is that most elevated tanks are bid and constructed in nominal standard sizes of 50,000, 75,000 or 100,000 gallons. Although some customizing is possible, it would typically come at a price with little savings for a smaller 40,000-gallon spheroid tank due to the special design and cost of manufacturing. The smaller hydrocone style tank does come standard in the 40,000-gallon

A tabulation using DNR criteria of having average day storage with related fire flow for a 2-hour duration is provided below. Note the 40,000-gallon tank is the smallest tank size that meets the minimum DNR fire flow requirements of 250 gpm for 2 hours.

Table 7; Elevated Tank Sizes vs. Fire Flow

Standard Elevated Tank Sizes and Fire Protection			
City of Fillmore, June 2022			
Design Perimeters			
Elevated Tank Size (gallons)	40,000	50,000	75,000
Average Day Demand (gpd)	10,000	10,000	10,000
Useable Fire Protection Volume (gal.)	30,000	40,000	65,000
Resulting 2-hour Fire Flow gpm	250	333	542
Average Day Turn Over	4.0	5.0	7.5

Environmental Impacts

Painting and Setback Requirements

The further the tank setback from streets or distance from housing the less potential there is for drift or overspray during painting of a welded steel tank. In the initial construction, the primer coat is often done in the factory and the final coats can be rolled on in the field. Later however this may be an issue when as part of coating replacement, the tank is sand blasted and a new primer coat is completed. The cost for repainting the tank will substantially increase if a containment curtain or similar mitigation is required to prevent paint drift during maintenance work.

The existing elevated tank location in Fillmore is relatively remote and meets the setback and distance requirements for painting and construction. The existing tank property is over 200 feet from the nearest building.

Also while the current property is not large enough for a second tank, the landowner of the surrounding property is willing to swap land offering such that parcels and The existing tank is also located one a hill and at one of the higher elevations in town. This location works well and is sufficient in size as the location for the construction of a new tank.

Sustainability Considerations

Tank Maintenance and Life Cycle Costs

All tanks require some upkeep and regular inspections to detect coating failures and prevent long-term structural failure. Regular inspection and maintenance of a coating system will not only prevent structural damage to a tank, but also extend the life of the coating. While the outside of a tank may appear to be in good condition the inside, components may have suffered damage due to vapors from chlorinated water or ice buildup.

When considering tank replacement and evaluating the long-term viability of a tank, one of the main considerations must be the cost of maintenance and upkeep for the 40 to 50-year life expectancy of a tank. Depending on the style of tank, this maintenance expense can be significant and must be compared with the feasibility and life cycle cost of replacing the tank with a newer tank with less maintenance.


Figure 10; Interior Tank Damage

Of the style of tank presented in this report, the tank with the least maintenance requirements is the pedestal style tanks. These tanks still require maintenance and regular cleaning and inspection, but do not have the legged support and exterior ladders, bracing, turnbuckles to repair or replace.

Turnover

One ongoing water quality consideration with new tank construction is the amount of turnover that occurs within the tank. Generally, the longer the turnover the warmer the water temperature and lower the chlorine residual. Also, the greater the possibility of developing higher chlorine disinfection byproducts (DBP) levels. For these reasons a tank volume that exceeds the average day use in more than an estimated four (4) days is not recommended.

Tank Mixing Systems

Mixing systems in tanks help to maintain water quality, reduces ice formation and damage to the inside of a tank. The mixing system can improve water quality within a tank by helping maintain chlorine residual levels and thereby reduce the overall chlorine dosed for disinfection. This has the benefit of lowering (DBP) levels, a problem often identified with stagnant water and poorly mixed storage tanks.

Two types of tank mixing system will be discussed in this study, passive and active mixing systems. Mixing systems are not mutually exclusive and when used in combination seasonally or year around mixing systems can reduce operating costs and improve water quality.

Passive Mixing Systems

As the denoted by the name, passive mixing system mix entirely by the flow of water in and out of the tank without a mechanical device. This most often occurs by a manifold pipe with valves inside the tank and occurs mostly with the flow of water into the tank. An example of this is the Tideflex Mixing System (TMS) where a combination of duckbilled check valves "jet" the water into the tank and create a circulating flow of water while filling. The jets passively close when the tank is full and check valves at the bottom of the tank allow one-way flow out of the tank. This creates the mixing and circular flow. Other companies offer similar types of valves and systems.

Figure 11: Passive Mixing Example

Active Mixing Systems

The second type of mixing system is an active system where a dedicated pump or mixer is installed inside the tank which continuously circulates water. These pumps can be installed either at initial project construction or as a retrofit to an existing tank. The pumps may also be installed in conjunction with a passive system.

Example of these units is the PAX Active Jet mixer by PAX Water Technologies and Solar Bee which is like a submersible pump anchored at the bottom of the tank. As the size and type of mixing systems varies with manufacturer it is best to contact and work directly with a factory representative to determine the best model for each tank application.


Figure 12: PAX Active Jet

Cost Estimates

The following estimates for tank improvements are provided for comparison of alternatives and for future planning. Costs are developed from previous bids, discussion with suppliers, tank manufacturers and work experience on similar types of projects with suppliers and contractors. Actual competitive bid prices at the time of construction may vary higher or lower depending on local contractor's workload, material prices, and other variables such as the cost of raw steel, PVC resin and petroleum.

The probable project cost for elevated storage including construction costs and engineering, legal and other costs is tabulated below in Table 6. The budgetary costs were developed based on a shallow matt type foundation system and tank overflow elevation of approximately 120 feet. The cost does not include specialty items such as a valve vault and controls, or extensive yard piping etc. as these are included in the distribution estimate. For comparison purposes costs are provided for different tank sizes along with the unit cost per gallon of storage.

Note that typically the larger the tank volume the lower the unit price of the tank capacity becomes. This is due to the fixed costs for such a project such as the land purchase, contractor mobilization, soil testing etc. are nearly the same regardless of the tank size. Increasing the diameter by a small amount will have little impact on the cost of materials and construction but will increase the volume. This is due in part to the relationship between circumference and volume (i.e. increasing the circumference by 20% = 44% increase in volume). Also the pedestal for most of these smaller spheroid tanks is the same diameter regardless of the tank volume.

Soils

Cost estimates are based on finding soils with a bearing capacity of 2500 psf. This would allow for a typical foundation system. If after geotechnical work is completed, it is determined that soils do not meet this requirement or other problematic issues are discovered than it may be necessary to consider an alternate site or to construct with a deep foundation system. A deep foundation system could add about 10-20% or more to the overall project costs.

O&M costs for each system alternative is included in the life cycle cost analysis.

Table 8; Elevated Tank or Standpipe Cost Estimates

Elevated Tank, Opinion of Probable Costs				
City of Fillmore				
Description	**Unit Cost Per Kgal.**	**Construction Costs (1)**	**Other Costs (2)**	**Project Costs**
Legged Tank				
50,000 gallon	$25.27	$ 972,000	$ 291,600	$ 1,263,600
75,000 gallon	$17.47	$ 1,008,000	$ 302,400	$ 1,310,400
Spheroid or Hydrocone Style Tank				
40,000 gallon	$32.16	$ 989,400	$ 296,820	$ 1,286,220
50,000 gallon	$26.52	$ 1,020,000	$ 306,000	$ 1,326,000
75,000 gallon	$18.34	$ 1,058,000	$ 317,400	$ 1,375,400
Note:				
1) Tank costs include $25,000 for site piping, $35,000 for mixing system and $45,000 for electrical and controls.				
2) Project costs include 30% for contingency legal, engineering, geotech, and				
3) Costs are based on height to HWL of 120', standard foundation (2500 psf soils).				

6. DISTRIBUTION SYSTEM ALTERNATIVES CONSIDERED

Alternate distribution system improvements were evaluated and considered for the community of Fillmore. Alternates are based on pipe sizes and hydrants to meet requirements for a system providing partial or limited fire flow. And for a system served by a City tank or a jointly owned elevated tank. These alternatives are described and laid out under their respective sections with comparative cost estimates for consideration.

Design Criteria

MoDNR indicates that the primary purpose of a public water system is to produce and deliver adequate quantities of safe drinking water to the public. Providing water for fire protection, recreational and industrial uses are of secondary importance (Paragraph 7.1.1 of DNR Design Standards-2013).

DNR design criteria for communities Not providing Fire Protection:

- Distribution systems shall be designed to provide 60 to 80 psi with a minimum pressure of 35 psi at ground elevation. (Para 7.3 of DNR Design Stds-2013)
- Minimum size of water main for systems not providing fire protection is 2-inch in diameter and should be 3-inches in diameter. (Para 8.1.2 of DNR Design Stds-2013)

DNR design criteria for communities providing Fire Protection:

- Water systems not providing a distribution system with a minimum flow of 250 gpm for 2 hours are not designed for fire protection. (Para 8.1.3 of DNR Design Stds-2013)
- Calculated fire flow at hydrants shall be for a duration of 2 hours. Use of Insurance Services Office (ISO) Guide for a reasonable approximation of needed fire flow.
- New systems to provide for one major fire in the design area per IOS or local requirements.
- Minimum size of water main for fire protection and hydrants is 6-inch in diameter. (Para 8.1.2 of DNR Design Stds-2013)
- Hydrant spacing is to be from 350 to 600 feet.
- Minimum system pressure of 20 psi be maintained during fire flow throughout the system. (Para 8.3 of DNR Design Stds-2013)

Water System Computer Modeling

A model of the new water distribution systems was developed in the software known as KY Pipe to assess capacities at various points in the system. The pipeline sizes, node elevations, and meter locations within the system was developed and incorporated into the modeling software.

Storage features were then added to the model and the pipe material was updated to reflect the internal roughness for evaluation using the Hazen Williams formula. The system models were evaluated both on maintaining an instantaneous flow to each connection and per fire flow requirements.

For the evaluation of fire flows several hydrants were located within the model on 6" and 4" lines to evaluate the difference in fire flows with different scenarios. Fire flows were analyzed based on a hydrant constant (representing headloss thru the hydrant) of 110 and a minimum pressure for fire flows of 25 psi and minimum pressure of 20 psi. Hazen Williams C factor were assigned as 145 for new PVC pipe mains. Fire flows were evaluated while providing the peak day flow to users within the system.

The model to evaluate pipeline size per instantaneous flow was done using a feature known as rural analysis. The rural analysis feature allows water lines within a distribution system to be evaluated based on the instantaneous peak water use and the demand diversity curve. The demand curve recommended by the Missouri DNR Design Standard to determine peak instantaneous water use is noted as; Flow = 12 x (#of Users)^0.515 or 1.0 gpm whichever is greater. The previous standard until 2013 for Missouri was the curve where Flow = 9 x (#of Users)^0.515 or 0.75 gpm. The newer DNR standard was used to evaluate the existing and proposed system.

Description of Distribution System Alternates

Two different distribution system alternatives are developed for comparison and evaluation. The difference in the alternatives is the size of the water mains and the level and amount of fire protection and whether the source is a new tank within town or within Andrew #3.

Alternative A provides maximum fire protection with a mixture of 8" and 6" PVC water mains. The mainline is 8" between the elevated tank and the connection to Andrew #3. The core or backbone of the water system along portions of Main Street and the south side of "H" Highway are all proposed with 6" main. All of the branch lines serving 2 or 3 users are 2" PVC lines. There are 28 new flush and fire hydrants estimated in this alternative.

Alternative B provides limited fire flow with a mixture of 4" and 6" mainline within the distribution system. The core of the distribution system is 6" mains however along some of the side streets where there are fewer users, there is also a mixture of smaller 4" PVC mainlines. There is still a new 8" water line connection from the Andrew #3 meter pit and the new City elevated storage tank.

Alternative C is similar and has same pipe sizes as Alternative B however it considers the use of HDPE (High Density Polyethylene) as an alternative to the use of ASTM or C-900 PVC. This is largely due to the recent high cost of PVC which is making other pipe materials more competitive in price. HDPE pipe is a high-quality material though the installation does offer some challenges. In particular that the joints all need to be thermally fused together with special couplers or equipment. This can easily be managed by requiring contractors to have certified installers do joining. Most local repair contractors however are not as experienced with doing repair work with this type of pipe.

All the alternatives provide service to 100 users and includes the associated meter pits and service line to the edge of the street Right of Way (ROW). Service line from the meter pit to the user home is not included in the project costs. Each alternative attempts to limit the number of dead-end mains and provide looping in several locations. Each alternative also uses some new 2" lines to provide service in areas where there are only 2-3 users.

A summary comparison of the alternatives and fire flow for review is tabulated below.

Table 9; Comparison of Distribution System Alternatives

Description	Alternative A	Alternative B & C
Mainline Size	Mostly 6” & 8” PVC	4”, 6”, & 8”
No. of Hydrants	28 hydrants	28 hydrants
Estimated Fire Flow Range	~1000 gpm	~500 to750 gpm
Nominal Tank Sizes		
Elevated Tank	50,000 or 75,000 gallons	40,000 gallons

Maps

Maps showing each of the alternate distribution system improvements are provided in the appendix. The proposed location of the elevated storage is noted on the drawings.

A screenshot of the distribution Alternative B KYPipe model with a mixture of 4”, 6” and 8” PVC main and resulting estimated fire flow for comparison purposes is provided below. Similar models were developed for Alternative A.

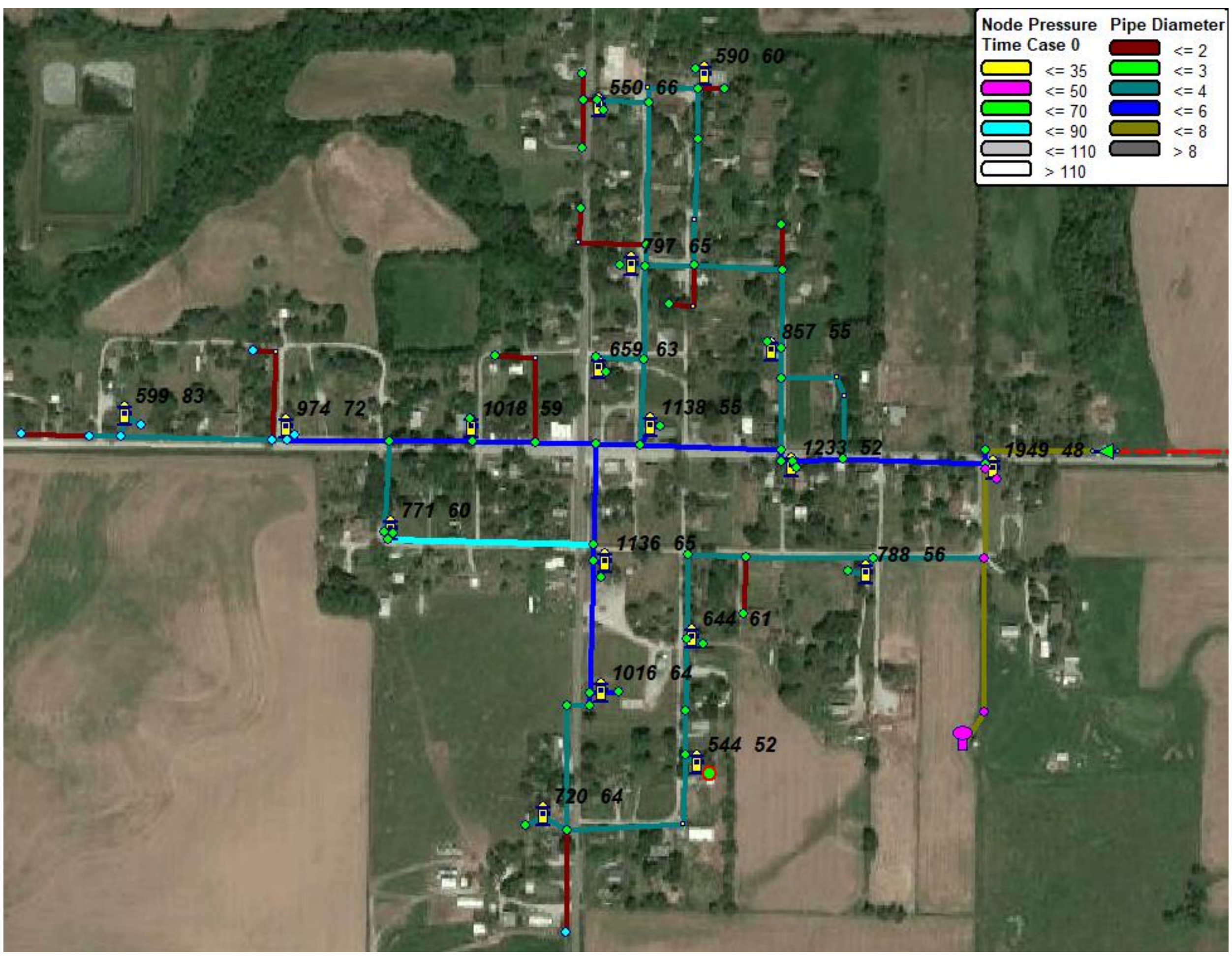


Figure 13:Map of Alternate-B Distribution System Model (4”, 6” & 8” Dia. PVC)

Environmental Impacts

The proposed water line project will be installed within the existing street and highway ROW or in yards which have been previously disturbed. By project specifications, the following summary of mitigation measures will be undertaken to minimize the impact of project construction on local residents and the local environment.

- Crossings of wetlands or drainage ways or streams will be avoided to the extent possible, but when necessary, will be completed by a directional bore that extends beyond the potential impact area.
- Highway crossings (such as “H” or “A” Highway) will be bored and cased as required by MoDOT permitting without interrupting use of the highway or other major roadways.
- Silt fencing and rock check dams will be installed prior to construction to limit any surface runoff.
- Dust and air pollution control measures including as necessary wetting of the access roads used by the contractors to the project area.
- Water used for flushing and chlorination of the pipelines will either be de-chlorinated or disposed of in an area that will not damage the environment or wildlife.
- Typical warning signage and fencing will be used to warn and isolate residents near the project construction area, in particular at road crossings, and near commercial and residential areas.
- Compaction and reseeding of the trench and site with mulching or erosion control blankets as necessary to reduce site runoff. Water Main Location and Land and Easement Requirements.
- The existing asbestos cement mainlines will be abandon in place. No cut ins or cross connections are anticipated to this existing mainline.

Potential Construction Problems

Project construction will result in some traffic delays and temporary interruption of water services during construction. The impact of such will be mitigated by project specifications and requiring the contractor to bore road crossings, provide signage, give notice to residents of construction on their streets. Communication by door hangers, phone calls, newsletters, etc. will be utilized.

Soils

It is estimated that much of the new mainline will be installed in the right of way and beyond the edge of streets where compaction requirements and the use of bedding material will be minimal. In these areas on site soils will largely be used for backfill. Highway crossings will largely be directional bored with added compaction and bedding materials required for street crossings. Installation in the right-of-way and directional boring highway crossings not only limits problems with compaction and erosion control it has the added advantage of minimizing surface and street repair.

Sustainability Considerations

The proposed waterline will be class 200 HDPE or PVC with a rieber style gasket, which is corrosion resistant and once correctly installed and tested should require a minimal amount of maintenance. Valves will be installed to allow for isolation during repairs to the system and flushing of the pipeline to limit the disruption to a minimum number of users. Quality control and inspection during construction of the mainline and testing of soil compaction and pressure testing of the pipe for leaks will also help prevent long term maintenance problems and issues with erosion.

Directional bored drainageway and road crossings will be completed using HDPE or restrained joint PVC to minimize the possibility of the water line separating and pulling a part. Drainageway crossings will also be buried at an additional depth to mitigate the possibility of being washed out and exposed.

Mainline pipe will be buried with tracer wire to allow the line to be readily located for repairs and other utilities. A locator will be included with project specifications along with training and demonstrating its use to local operators. This is important for longevity and reduced costs in future improvements while also protecting the system when other construction work is being performed.

Service meter pits will be installed as PVC, with service lines completed with 1" HDPE. Service lines crossing under streets will also be bored. Items such as hydrants, valves, and meters will be provided by a single manufacturer to reduce maintenance costs and limit the number of repair couplers and parts needed to repair and maintain the system.

A radio read meter system is also proposed which will help to automate the billing and meter read process. This will allow for timely and accurate reading of the meters for the entire community and help reduce future maintenance and administration costs.

Cost Estimates

The following estimates for distribution system improvements are provided for comparison of alternatives and for future planning. Costs are developed from previous bids, discussion with contractors and work experience on similar type City distribution system projects. Actual competitive bid prices at the time of construction may vary higher or lower depending on local contractor's work load, material prices, and other variables such as the cost of PVC resin and petroleum.

The probable project cost including construction costs and engineering, legal and other costs is tabulated below in Table 9. The budgetary costs were developed based providing the alternates described earlier in the study.

Included in construction costs are the PVC mainline, hydrants, a new meter service along with approximately 100' of 1" service line to each home. This is intended to provide about 40' of service line from the edge of street to the homeowner's house. It is estimated that approximately half of the service lines will need to be bored under the street or highway.

Costs also include new meters and a radio read meter system along with the master meter pit for connection to Andrew #3 PWSD. The radio read system helps lower personnel costs and improves the accuracy of billing. A maintenance and storage shop for keeping repair items such as extra valves and repair couplers with a small amount of pipe and tools is also included.

In addition, 25% was added to mainline costs for valves, crossings, and appurtenances. Included in this cost is a limited amount of asphalt/concrete surface repair to streets, driveway and sidewalks as most of the new water line is assumed to be installed in the right of way. Project costs may be higher if there is substantial street replacement or multiple utilities to contend with during construction.

O&M costs for each system alternative is included in the life cycle cost analysis.

Table 10; Distribution System Improvements, Opinion of Probable Cost

Distribution System Improvements									
Opinion of Probable Cost				**Alternative A**		**Alternative B**		**Alternative C**	
City of Fillmore				**6" & 8" PVC**		**4" 6" &8" PVC**		**PVC & HDPE**	
Item No.	**Description**	**Units**	**Unit Price**	**Est. Quantity**	**Estimated Costs**	**Est. Quantity**	**Estimated Costs**	**Est. Quantity**	**Estimated Costs**
Construction Costs									
1.	8" PVC Pipe	L.F.	$ 50.00	1,230.0	$ 61,500	1,230.0	$ 61,500	1,230.0	$ 61,500
2.	6" PVC Pipe	L.F.	$ 46.00	11,600.0	$ 533,600	3,400.0	$ 156,400	0.0	$ -
3.	6" HDPE Pipe	L.F.	$ 44.50	0.0	$ -	0.0	$ -	3,400.0	$ 151,300
4.	4" PVC Pipe	L.F.	$ 42.00	0.0	$ -	8,200.0	$ 344,400	8,200.0	$ 344,400
5.	2" PVC Pipe	L.F.	$ 38.00	3,000.0	$ 114,000	3,000.0	$ 114,000	3,000.0	$ 114,000
6.	Street Xings, Valves, & Appurtenances		25%		$ 177,275		$ 169,075		$ 167,800
7.	Flush/ fire Hydrants Assembly	EA.	$ 4,200	28.0	$ 117,600	28.0	$ 117,600	28.0	$ 117,600
8.	Cleanouts/blowoffs	EA.	$ 1,200	10.0	$ 12,000	10.0	$ 12,000	10.0	$ 12,000
9.	1" Service Line (100'/connection)	EA.	$ 18.00	10,000.0	$ 180,000	10,000.0	$ 180,000	10,000.0	$ 180,000
10.	1" Service Line Bores	EA.	$ 1,200	50.0	$ 60,000	50.0	$ 60,000	50.0	$ 60,000
11.	Service Meter Pits	EA.	$ 2,100	100.0	$ 210,000	100.0	$ 210,000	100.0	$ 210,000
12.	Radio Read Meter System	EA.	$ 55,000	1.0	$ 55,000	1.0	$ 55,000	1.0	$ 55,000
13.	Storage / Maintenance Shop	EA.	$ 45,000	1.0	$ 45,000	1.0	$ 45,000	1.0	$ 45,000
14.	Master Meter Pit	EA.	$ 125,000	1.0	$ 125,000	1.0	$ 125,000	1.0	$ 125,000
	Estimated Construction Costs				**$ 1,690,975**		**$ 1,649,975**		**$ 1,643,600**
Other Project Costs									
	Contingency	10%			$ 169,098		$ 164,998		$ 164,360
	Legal, Engineering, Contingencies		30%		$ 507,293		$ 494,993		$ 493,080
		Total Project Cost			**$ 2,367,365**		**$ 2,309,965**		**$ 2,301,040**

7. SELECTION OF AN ALTERNATIVE

Life Cycle Cost Analysis

Life cycle costs were developed for each of the tank and distribution system alternatives that were developed for comparing the different options. The purpose of the life cycle costs was to evaluate and include capital costs and future maintenance and operation costs.

In order to accomplish this, the cost of inspecting and replacing the tank coatings over a 50-year period was evaluated as a net present value (NPV). An interest rate of 3.0 percent was used with an inflation rate of 2.0 present. Interior wet surface areas were repainted every 15 years, exterior surfaces every 30 years and interior dry areas every 30 years.

A copy of the detailed analysis for each tank style and size is provided in the appendix but is summarized below in Table 12.

Table 11: Present Value for Tank Coating Replacement

Elevated Tank Improvements			
Net Present Value (NPV) for Coating Replacement			
		Tank Size	
	40k	**50k**	**75k**
Legged Tank NPV			
		$102,572	$121,568
Spheroid and Hydrocone Tanks NPV			
	$126,334	$126,334	$142,586

Finally, the initial project costs including construction and other costs along with annual O&M and the present value of future coatings and short-term equipment costs were added together and compared. The life cycle costs are based on a 50-year period and an interest rate of 3.0%. O&M costs included costs for personnel, administration, small maintenance items, and electricity. Finally, the costs for reserves to fund the replacement of short-lived assets that will need replaced in 15-20 years such as meters, pumps, and controls etc.

A comparison of the life cycle evaluation is presented for the various styles of storage tanks in Table 13 and is tabulated in Table 14 for the distribution system alternatives.

Table 12: Life Cycle Cost Analysis for Elevated Storage

Elevated Tank Improvements						
Life Cycle Cost Analysis, Elevated Tanks						
Description		**Legged Tank**		**Hydrocone / Spheroid Tank**		
		50k	**75k**	**40k**	**50k**	**75k**
Project / Capital Costs (CC)		$ 1,263,600	$ 1,310,400	$ 1,286,220	$ 1,326,000	$ 1,375,400
Annual O&M (Total)		$ 7,300	$ 7,300	$ 7,300	$ 7,300	$ 7,300
	Personnel (wages etc.)	$ 4,000	$ 4,000	$ 4,000	$ 4,000	$ 4,000
	Maintenance Items	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500
	Electricity / Ctrls	$ 1,800	$ 1,800	$ 1,800	$ 1,800	$ 1,800
O&M Present Worth		$ 187,827	$ 187,827	$ 187,827	$ 187,827	$ 187,827
Short Lived Asset Reserves (Total)		$ 157,572	$ 176,568	$ 181,334	$ 181,334	$ 197,586
	Coating Replacement	$ 102,572	$ 121,568	$126,334	$126,334	$142,586
	Mixing Equip/Controls	$ 55,000	$ 55,000	$ 55,000	$ 55,000	$ 55,000
Salvage Value		$ 40,000	$ 45,000	$ 50,000	$ 50,000	$ 55,000
Net Present Value		$ 1,568,999	$ 1,629,795	$ 1,605,381	$ 1,645,161	$ 1,705,814
	Comparison of Costs	100%	104%	102%	105%	109%
Note:						
1) Short-Lived Asset Reserves Assumed to Be Uniform Series For Present Worth Evaluation						
2) Current Interest Rates:						
	Interest Rate (*i*) =	3.0%				
	Years (*n*) =	50				
	P/A =	25.73				

Table 13: Life Cycle Cost Analysis for Distribution System Alternatives

Distribution System Improvements				
Life Cycle Cost Analysis				
Description		**Distribution 6" & 8" PVC Alt. A**	**Distribution 4"6"&8" PVC Alt. B**	**Distribution PVC & HDPE Alt. C**
Project / Capital Costs (CC)		$ 2,367,365	$ 2,309,965	$ 2,301,040
Annual O&M (Total)		$ 15,000	$ 14,000	$ 18,000
	Personnel (wages etc.)	$ 6,500	$ 6,500	$ 6,500
	Maintenance Items	$ 3,000	$ 2,000	$ 6,000
	Admininstrative Costs	$ 5,500	$ 5,500	$ 5,500
O&M Present Worth		$ 385,946	$ 360,217	$ 463,136
Short Lived Asset Reserves (Total)		$ 202,600	$ 202,600	$ 202,600
	Touch Read System	$ 55,000	$ 55,000	$ 55,000
	Meters	$ 30,000	$ 30,000	$ 30,000
	Fire Hydrants	$ 117,600	$ 117,600	$ 117,600
Salvage Value		$ 36,900	$ 36,900	$ 36,900
Net Present Value		$ 2,919,011	$ 2,835,882	$ 2,929,876
	Comparison of Costs	103%	100%	103%
Note:				
1) Short-Lived Asset Reserves Assumed to Be Uniform Series For Present Worth Evaluation				
2) Current Interest Rates:				
	Interest Rate (*i*) =		3.0%	
	Years (*n*) =		50	
	P/A =		25.73	

WEIGHTED DECISION MATRIX

In large infrastructure improvements, such as community distribution and storage, there are non-price factors for consideration such as security, aesthetics, and safety that are not represented in a construction and life cycle cost comparison. In order to capture their value to the community, these non-price features are often included and compared with cost in a Decision Matrix Table. In this table, each feature is given a weighted number of points and then each of the possible tank options are assigned points based on how well the option meets the criteria evaluated.

The weighted value for each set of criteria was determined in coordination with the City. Project cost was considered to be important, but not the most important factor. As such this criterion was assigned a value of 10. Issues such as maintenance and life cycle costs were determined to be more important for the long-term success of the project and were rated a 15. These are reoccurring costs that must be funded in the future to keep the system in good working order and supplying quality drinking water.

The aesthetics was assigned a value of 10. It was determined to be important due to the project visibility and as a community landmark but not as vital as other criteria. Finally, Safety, Security and Operation was again rated as a 15 based the need for the system to be easy to operate safely and to mitigate liability. Points were awarded based on some of the factors noted below.

Construction Costs

- Points awarded on price with the highest points given to the low-cost alternative.

Maintenance / Life Cycle Costs

- Highest points awarded for the lowest O&M and Reserves costs (NPV – Capital Costs)

Aesthetics and Image

- Presents a landmark for the community to be proud of.
- Attractive and modern look without reducing functionality.

Safety, Security, and Operation

- Simplicity and ease of operation and maintenance.
- Reduce the potential for disinfection byproducts stagnation, and other water quality issues.
- Provide fire flow without compromising other key issues such as water quality.

The highest-ranking alternative is to build a 40,000-gallon Hydrocone or Spheroid Style above grade elevated tank. The weighted decision matrix is presented below in Table 14.

A similar decision matrix was created for the distribution system. In this case because much of the system is not visible there was no category for aesthetics. Other criteria were ranked and weighted similarly as the elevated tank matrix. The highest-ranking alternative for the distribution system was Alternative B, construction using 6-inch pipe.

Table 14: Decision Matrix for Elevated Tank Improvements

Decision Matrix: Fillmore, MO -- Elevated Tank Improvements						
	Criteria Evaluated	Project Costs	Maintenance / Life Cycle Costs	Aesthetics and Image	Safety, Security & Operation	
Alt. Solutions	**Possible Points**	**10**	**15**	**10**	**15**	Total Weighted
Legged Elevated Tanks						
50k	Index Value	$1,263,600	$305,399			
	Score	10.0	15.0	8.0	10.0	***43.0***
75k	Index Value	$1,310,400	$319,395			
	Score	9.6	14.3	8.0	12.0	***44.0***
HydroCone / Spheroid Elevated Tank						
40k	Index Value	$1,286,220	$319,161			
	Score	9.8	14.4	10.0	13.0	***47.2***
50k	Index Value	$1,326,000	$319,161			
	Score	9.5	14.4	10.0	13.0	***46.9***
75k	Index Value	$1,375,400	$330,414			
	Score	9.2	13.9	10.0	13.0	***46.1***
Ratings: Highest value possible is the best						
Highest weighted scores are recommended alternatives						

Table 15: Decision Matrix for Distribution System Improvements

Decision Matrix: Fillmore, MO -- Distribution System					
	Criteria Evaluated	Project Costs	Maintenance / Life Cycle Costs	Safety, Security & Operation	
Alternate Solutions	**Possible Points**	**10**	**15**	**15**	Total Weighted
Distribution System					
Alternative A	Index Value	$2,367,365	$551,646		
6" & 8" PVC	Score	9.7	14.3	14.0	***38.0***
Alternative B	Index Value	$2,309,965	$525,917		
4" 6" & 8" PVC	Score	10.0	15.0	15.0	***40.0***
Alternative C	Index Value	$2,301,040	$628,836		
PVC and HDPE	Score	10.0	12.5	11.0	***33.5***
Ratings: Highest value possible is the best					
Highest weighted scores are recommended alternatives					

8. PROPOSED PROJECT (RECOMMENDED ALTERNATIVE)

Preliminary Project Design

It is the recommendation that the City proceed with and implement the following improvements.

- Proceed with the design, bidding and construction of a 40,000-gallon tank. The tank should be located near the existing tank.
- Bid a base bid for a 40,000-gallon spheroid tank with an alternative bid for a 40,000-gallon hydrocone tank.
- Implement replacement of the distribution system using a mixture of 4-inch, and 6-inch water main along with an 8-inch main between the connection with the district and the new elevated tank. This is what is referred to in the study as Alternate B.

Project Schedule

A preliminary schedule showing some of the sequence of activities and associated milestones was developed from government agency (USDA) submittal to design and construction and finally project closeout. The timeline for such activities is estimated to take approximately two years and are broken down into two phases.

Phase I is noted as project preliminary activities and design is estimated to take approximately six months. Included in this phase is review of this report and project design by the community, funding agencies such as USDA and soil bores and geotechnical report, acquiring land and easements, and advertising and publicly bidding the project.

Phase II is the contracting and construction phase of the project. This commences with the award of contract and is scheduled to take approximately 12 months. The tasks include contracting with the low project bidder, review of shop drawings, mobilization, construction and finally project closeout.

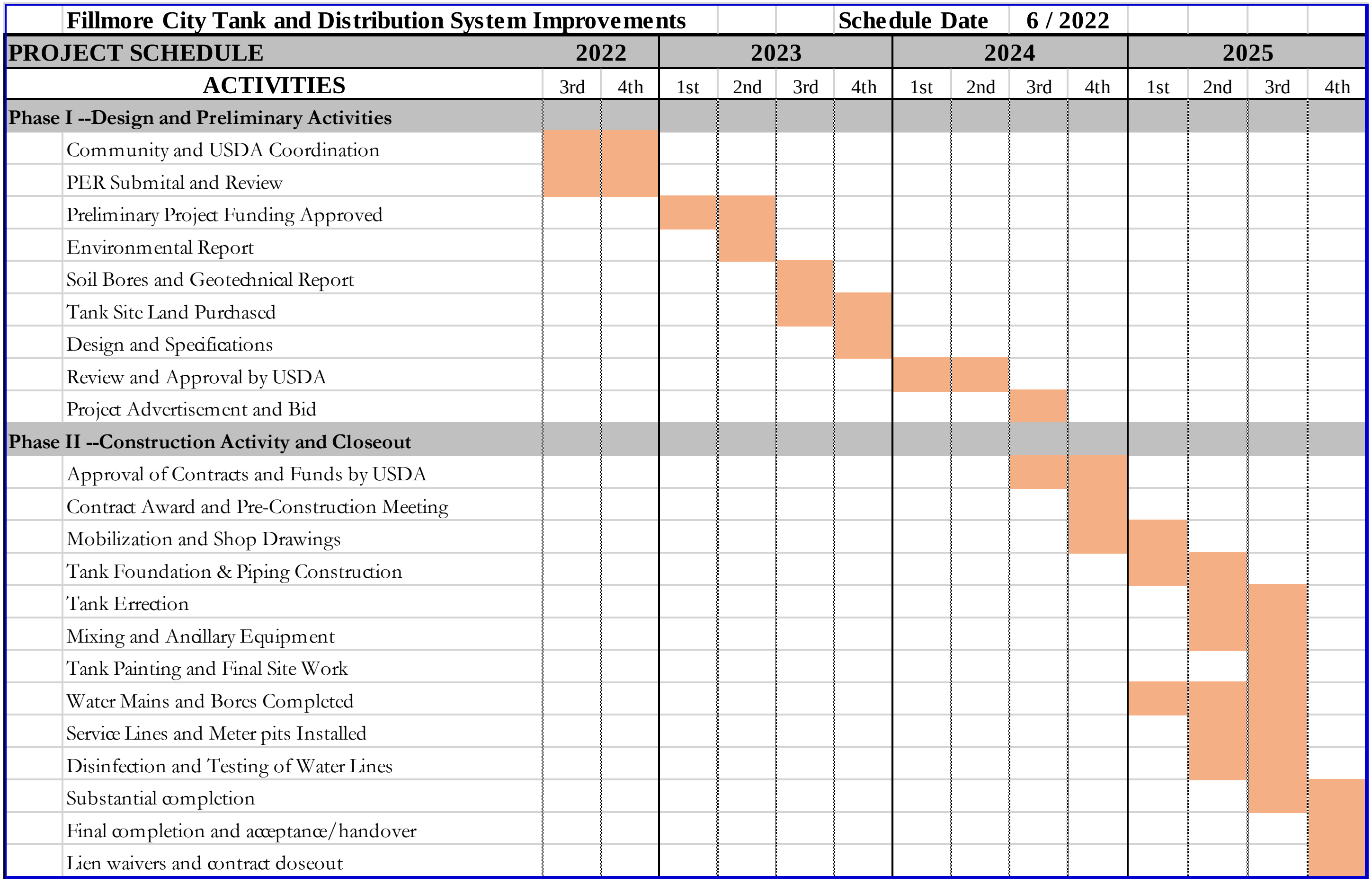


Figure 14; Project Schedule

Permit Requirements

A project construction permit will be required for each of the projects from the Department of Natural Resources (DNR). The application for this permit is submitted after the design phase and when final plans and specifications are ready for bidding. This process typically takes approximately 4-6 months and is included in the project schedule.

Other permits required for project construction include those from the Missouri Department of Transportation (MODOT) for highway crossings and parallel construction along State Highway 111. Those are reviewed and approved from the MODOT office in St Joseph, MO.

Total Project Cost Estimate

The project cost estimate as recommended including the distribution system improvements (Alternate B) and a 40,000-gallon hydrocone / spheroid elevated tank is as follows:

Table 16: Total Project Cost Estimate

Distribution System Improvements	$2,310,000
50,000 Gallon Spheroid Elevated Tank	$ 1,286,000
Total Project Costs	$3,596,000

Proposed Annual Operating Budget

Projected Annual Budget City of Fillmore, MO - June 2022				
Description	**Capital Costs**	**Total Costs**	**Proposed Budget**	
			Annual	**Monthly**
Capital Expenses & Reserves				
Debt Service/Capital Imp		**90% Grant**		
Elevated Tank Improvements	$1,286,000	$128,600	$6,992	$583
Distribution System	$2,310,000	$231,000	$12,560	$1,047
Subtotal	$3,596,000	$359,600	$19,552	$1,629
Short Term Asset Reserves				
Distribution System		$202,600	$10,130	$844
Elevated Tank Improvements		$157,572	$7,879	$657
Subtotal		$360,172	$18,009	$1,501
Avg. Water Purchase (Andrew #3)	$7.0/kgal	$25,550	$25,550	$2,129
O & M Expenses (3)				
Personell (Wages Etc.)		$12,500	$12,500	$1,042
Utilities & Electricity		$1,800	$1,800	$150
Maintenance & Supplies		$3,500	$3,500	$292
Adminstration		$5,500	$5,500	$458
Subtotal		$23,300	$23,300	$1,942
Percent of Costs by Fixed Service Charge				
General Cost of Service			$86,411	$7,201
Avg. Cost per User (90)			**$960**	**$80**

Notes:

1. The Cost of water from Andrew #3 is estimated at $7.00/kgallons.
2. Average Day Water Sold is estimated at 9,000 gpd and Water Loss is estimated at 10%.
3. Capital Improvements are annualized based on a payment terms of 3.5% and 30 years.
4. Reserves are annualized based on 20 years.

The proposed budget is about $86,000, or an increase of about 100% when compared to the previous budget of $43k which is nearly half this amount. Thus, the City will need 90% grant and then double their water rates to generate the revenue and income needed to cover expenses.

Short Term Assets

Below is a list of the Short-Term Assets that were included in the NPV analysis and annual budget.

List of Short Term Assets			
City of Fillmore, MO			
Description			**Estimated Value**
Distribution System			
	Meters		$30,000
	Touch Read System		$55,000
	Hydrants		$117,600
		subtotal	$202,600
Elevated Tank Improvements			
	Coating Replacement		$102,572
	Mixing System		$35,000
	Controls		$20,000
			$157,572

9. CONCLUSIONS AND NEXT STEPS

The next step is submitting this report for review and approval. Once that approval is granted, it is recommended the City pursue a funding application with USDA-RD, MoDNR and CDBG to establish the options for funding, as the project is not affordable without grant assistance.

This process will take some effort in coordinating with regulators, funding agencies and the engineering consultant. It is recommended that the City plan for some added meetings and expense to coordinate the efforts with all entities.

USDA and MoDNR normally both require the water rates to be 2% of the median household income to qualify for grants. This project may qualify for additional grants based on community size and need combined with the income levels of the community. CDBG can provide up to $500,000 in grant funds if proof of low-to-moderate income levels meet the requirements.

It is recommended the City pursue these funding opportunities with the assistance of the engineering consultant and move forward with the recommended project as described above as Alternative B for the water distribution system and the 40,000-gallon hydrocone / spheroid style tank.

APPENDIX

Exhibit 1: City Documents

Water and Sewer Budgets

Elevated Tank Condition

Exhibit 2: Maps of the Existing Water System

Exhibit 3: Model of the Proposed Water System

Exhibit 4: Net Present Value (NPV) For Coating Replacement Costs