Water Quality Report

City of Streetsboro and Portage County Water Resources

Prepared by:

AECOM

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Table of Contents

List of Figures

List of Tables

Appendices

1 Executive Summary

AECOM has performed a water quality evaluation of the City of Streetsboro (City) Water Distribution System for the City of Streetsboro and Portage County. The City is supplied water by Portage County Water Resources (PCWR). As a consecutive water customer, the City performs system-wide water quality monitoring and hydrant flushing for reasons including maintaining suitable chlorine residual, reducing disinfection byproducts, and removing accumulated sediment. PCWR is committed to supplying quality water to its customers and actively works with the City to do so as provided for in the current City-County Agreement. Overall, the system performs well and does not have any unique or unmanageable water quality issues. This study has identified several minor recommendations to help improve water quality relating to both the distribution system and the source water as summarized below.

Strong Recommendations:

1. Although a pH of > 8.1 is currently mandated by Ohio EPA, it is recommended to negotiate this requirement and reduce the Shalersville WTP pH to 7.6 ± 0.2. Higher pH has numerous water quality issues including an increase in disinfection byproduct formation, high scaling potential, reduced buffering capacity, and limited effectiveness of the blended phosphate used for control of lead corrosion and iron sequestration. PCWR has been and continues to be in discussions with Ohio EPA to lower the pH to levels suggested in this report. The EPA has not been lenient on reducing pH thus far, although there have been very recent activities which indicate they are considering relaxing these high pH requirements. Other water municipalities in Ohio have been making this same argument for reasons similar to those listed above, and PCWR is encouraged to stay committed to continuing to approach Ohio EPA along with the other municipalities. In addition to the water quality benefits, reducing the pH will also save PCWR an estimated $20,000 in chemical cost annually.

2. Based on the available data, it appears that appreciable chlorine decay is occurring prior to entering the City of Streetsboro (observed as 1.5 mg/L leaving the plant and often as 1.0 to 1.2 mg/L entering the City). As water age increases in the City's distribution system, chlorine decay continues, requiring the City to perform hydrant flushing. However, the cause of chlorine decay prior to entering the City is unclear, as the contact time between the plant supply and the City entry point is short (only about 6 hours in average flow conditions). It is recommended that the County coordinate with the City to verify whether or not the City's chlorine analyzer(s) are calibrated by performing secondary sampling. If appreciable decay is confirmed (both samples consistent), it is recommended the County perform chlorine residual sampling upstream of the entry point to identify the location of the chlorine demand and take corrective action. Such action would likely be rigorous flushing. If the source is not identified and the residual decay persists, it is suggested that PCWR boost chlorine residual to a level capable of achieving a residual of 1.5 mg/L as it enters the City (possibly 1.7 to 1.8 mg/L at Shalersville). Although an increase in chlorine can have some risk of increased disinfection byproduct formation, the proposed lower pH will help counteract this drawback.

<u>Other Recommendations or Observations</u>:

1. The City should continue performing the automatic flushing currently employed at Seasons Road and in the Stone Ridge subdivision. The current operation at these two locations flushes an estimated 365,000 gallons per month and results in a water age in those areas of approximately 9 to 10 days. There is also a third flusher on the east side which flushes about 6,700 gallons per week. Flushing seems to be doing an adequate job of maintaining suitable levels of chlorine at this point. There is one additional area in the southeast on SR 14 which could benefit from a fourth flusher. In order to reduce this water age between 9 and 10 days at this location, approximately 5,500 gallons per day needs to be flushed. AECOM will continue to work with the City to identify optimized automatic flushing practices to boost chlorine residual and mitigate disinfection byproducts.

2. When performing spot repairs on cast and ductile iron pipes, the City should consider installing cathodic protection with the repair. This could be of particular benefit in areas identified as having corrosive soils (acidic) or backfill conditions (alkali). These locations generally include waterlines along Diagonal Road, Hudson-Aurora Road, Tinker's Green, Shawnee Trail, Commerce Center Industrial Park, and Seasons Road. If waterlines in these areas require replacement, a PVC material should be considered. A summary of waterline replacement prioritization and costs is provided in this report, which was previously developed as part of the Asset Management Plan.

3. Note that some of the above recommendations are expected to reduce the amount of sediment and scale in waterlines. However, the City should continue to practice manual flushing to minimize customer complaints. The current flushing procedures were evaluated and the City does an excellent job achieving scouring velocities and unilateral flushing with the implemented strategy. Biannual flushing was recently employed in 2018, and these efforts have possibly removed decades of sediment. As such, it is possible that performing biannual flushing is utilizing more water and resources than necessary. There could be an opportunity to perform complete system flushing once a year, with selected areas flushed biannually (specifically areas with cast iron pipes). The fourth occurrence of this biannual flushing occurred in fall of 2019. If little or no sediment was observed during this flush, the City should consider reducing the flushing efforts to save resources.

4. PCWR should consider monitoring TOC levels at individual wells at the Shalersville WTP to identity whether or not any specific wells are seasonally experiencing elevated TOC levels. If any well(s) are experiencing high TOC compared to others, the plant should consider utilizing those well(s) less frequently during late summer and fall months.

5. The City should install an active ventilation system (motorized fan) on the existing elevated tank to force air changes inside the reservoir. Repair and replacement of the spray pump and piping is also required to rehabilitate this system. Doing so will allow the spray aeration system to operate properly and remove TTHM as it is intended.

2 Introduction and Data Collection Overview

The City of Streetsboro (City) owns and operates a consecutive water distribution system which receives drinking water from Portage County Water Resources (PCWR or County). In addition to the City, PCWR also supplies municipal drinking water and operates wastewater treatment facilities throughout Portage County. On the drinking water side, PCWR operates three water treatment plants (WTP) and has two emergency connections with other water utilities. On an average day, the County supplies approximately 3.2 million gallons per day (MGD) of drinking water to customers. The City receives water from the Shalersville WTP (with the exception of a rarely-utilized emergency connection to the Brimfield WTP) and is a major customer that accounts for an average demand of approximately 1.3 MGD, or about 40% of the total water supplied water by the County. City residents have historically experienced water quality issues including discolored water, unpalatable taste and odors, and scaling of appliances among others. In addition to customer complaints, the City has experienced sags in chlorine residual.

The City and County have implemented several major improvements in recent years which have improved water quality considerably, and are summarized as follows:

- In May of 2013, PCWR discontinued use of water from the City of Ravenna's WTP. This plant is a surface water facility which had water quality issues, and the City was receiving a blend of this surface water along with groundwater. The City now receives 100% groundwater (from the Shalersville WTP and the emergency connection to the Brimfield WTPs) which is much less susceptible to issues common to surface water.
- PCWR has recently performed a major pressure filter improvement project at the Shalersville WTP including replacement of media and under-drains. This has resulted in an improved water quality including lower levels of iron and manganese.
- The City has been implementing both continuous (automatic) and regularly scheduled rigorous biannual hydrant flushing activities. Biannual flushing of all hydrants began in 2018, and the City recently completed its third flushing event with the fourth scheduled for the Fall of 2019.

With these improvements and practices in recent years, water quality complaints have virtually been eliminated and a customer complaint has not been logged since October of 2018. Therefore, this study does not consider any water quality data prior to 2014. Data from 2015 through 2017 is noted, but the primary focus is data from 2018 to the present. To help facilitate this water quality evaluation, the City and County provided AECOM with historical operational data, drawings, mapping, reports, water quality results, and related information pertaining to the City distribution system and the Shalersville WTP. In addition to the collected data, AECOM performed water quality sampling and developed a hydraulic distribution system model. Brief descriptions of the collected data and model development are provided in the following Sections, with further data pertaining to Water Quality provided within Section 3.

2.1 Previous Water Quality Report and Model

The City previously commissioned Arcadis to perform a water quality study and model, which was finalized in 2013 and reviewed as part of this effort. The study provided a comprehensive water quality model which simulated water age and primarily focused on free chlorine residual decay and the formation of total trihaholmethanes (TTHM). As noted, this study was performed prior to 2014 and is therefore no longer considered valid in terms of water quality due to the differing source water. PCWR retained the WaterGEMS modelling files from this original study, which was provided to AECOM in February 2019. However, the model's spatial orientation was misaligned with the City's current GIS database and was missing attributes. Therefore, a new model was developed as part of this study.

2.2 Distribution System Information

The City maintains a GIS database which hosts a vast amount of information including the location, size, material, installation year, and condition of infrastructure such as waterlines, valves, and hydrants. Several waterline maps were developed from the GIS database and are included in Appendix A for reference. The database is spatially accurate and was used to create the distribution system model using Bentley WaterGEMS software, which is a GIS-based modelling platform. In addition to the GIS database, other pertinent information was collected from the City and County, including the following:

- Daily readings of chlorine residual, pH, phosphate residual, and hardness at ten sampling locations throughout the distribution system (City);
- Daily elevated tank high and low water operating levels and calculation of turnover (City);
- Log of customer water quality complaints (starting in 2017) including nature of complaint, date, and location (City);
- Record drawings of the Tinker's Green booster station and elevated tank (City);
- Water consumption rates for top water users in the City (City);
- Biannual hydrant flushing protocol (City);
- Information on the City's automatic flushers including estimated flushing volumes (City);
- Supplemental TTHM and chlorine residual monitoring data from problematic areas (City);
- Metered connection readings located between the City and County and Shalersville flow data (Combination of City and County information);
- WaterGEMS model files from the original Arcadis water model, including original .wtg and .sqlite file extensions (County);
- County waterline improvements including "POR-14-3.65 Preliminary Proposed Waterline.pdf" and "Proposed WM Looping to Support SR 14 Widening.pdf" (County);
- Comprehensive operational and water quality summary of the Shalersville WTP as described in the next section (County).

2.3 Shalersville WTP Data

The Shalersville treatment process includes oxidation (either aeration, hypochlorite, or permanganate) and conventional media pressure filtration for iron and manganese removal, ion exchange softening to achieve a finished hardness of about 140 to 150 mg/L as $CaCO_3$, chlorine disinfection with liquid sodium hypochlorite, fluoridation with hydrofluosilicic acid, pH adjustment with sodium hydroxide to approximately 8.2 to 8.3, and addition of a blended phosphate (SAL Chemical SmartPhos 140D) prior to pumping to the distribution system. WTP operational data provided by the County generally applied to all of 2018 (and some data from prior years) and included the following:

- Monthly operating reports (MORs);
- Summary of the total chemical usage and costs;
- Results of coupon testing studies for lead, copper, and steel;
- Historical finished water iron and manganese levels (in addition to those reported on the MORs).

2.4 Model Development Overview

Using the City's GIS database, a new distribution system hydraulic model was developed. A detailed description of this development process is not provided, but a brief summary of key features of the model are highlighted below:

- Approximately 108 miles of waterlines ranging in size from 2-inch through 16-inch and all materials as identified in the GIS database were included. Since system hydraulics / fire flow testing are not the focus of this study, field testing of headloss or flow along with subsequent in-depth hydraulic calibration was not performed. Rather, typical Hazen-Williams roughness coefficients were assigned to individual pipes based on pipe material. Of course, this does assume that City-provided information is accurate, which does run a slight risk of inaccuracies, especially a situation such as an unknown closed valve.
- Approximately 1,020 waterline junctions with water demand assigned throughout the system based on 2018 City water usage records. Billing records for the top 30 users were provided by the City and assigned to actual locations. The total daily water demand used for water quality modelling was 1.3 MGD, and typical diurnal demand curves (*AWWA Manual M32*) were assigned to each node. Elevations of the nodes were automatically imported and assigned using a County contour map database and the WaterGEMS terrain editor feature. Daily data from 2018 corresponding to the City's elevated storage tank water levels (and subsequent tank turnover) was collected to properly simulate tank and pumping operations.
- Other physical attributes from various sources of information were applied to the model. These include pump curves (or design points) for the Shalersville WTP and Tinker's Green booster station, characteristics of the City's elevated tank, pressure reducing valve locations and set points, and simulating the City's hydrant flushing zones by the addition of isolation valves.

2.5 Hydrant Flushing

Beginning in 2018, the City has implemented biannual hydrant flushing to scour lines and remove sediment. This involves isolating a zone in the distribution system, flushing hydrants in that zone, and moving to the next zone. A total of ten zones are flushed and includes all 929 City-owned hydrants in addition to a portion of the 1,389 privately-owned hydrants. A complete flush typically takes the City about two weeks to complete. At the time of this report, the City had completed its third flush, with the fourth scheduled for fall of 2019. Since biannual flushing began, the water quality complaints have virtually stopped. A further discussion of biannual flushing is presented in Section 3.6, and a map of the individual flushing zones is also included in Appendix A as Figure 1.

3 Water Quality Analysis

3.1 Customer Complaints

The City has received occasional complaints from customers regarding water quality; typically discoloration or issues with taste and odor. Formal tracking of the complaints began after a meeting between the City and PCWR in 2017, and have since been logged in the City's GIS database. When the City receives a complaint, they normally visit the residence to investigate possible causes. The nature of many of these complaints is unknown, although some are attributed to fire or water department activities including hydrant flushing or line repairs. Such activities can stir up sediment causing the potential for discoloration. In an attempt to identify patterns in the complaints, they were organized by date, location, and type. Table 3-1 below summarizes the date and nature of the complaint, as well as whether or not it was of a known cause.

Table 3-1 Date and Nature of Water Quality Complaint

Date	Address	Complaint	Cause
9/5/2017	1735 Cecil Dr	Color	Unknown
9/5/2017	1405 Cecil Dr	Color	Unknown
9/6/2017	1272 St Rt 303	Color	Unknown
9/7/2017	2099 Summers Ave	Color	Unknown
9/14/2017	1800 Miller Pkway	Low Pressure	Unknown
9/15/2017	877 W Kensington Ln	Color	Unknown
9/15/2017	878 W Kensington Ln	Color	Unknown
9/15/2017	823 W Kensington Ln	Color	Unknown
9/18/2017	10150 N Delemonte Blvd	Color	Unknown
9/19/2017	10092 Ridgeside Ct	Color	Unknown
9/19/2017	1203 Tinkers Green Dr	Color	Unknown
9/19/2017	10090 Hazelton Rd	Color	Unknown
9/19/2017	10115 Ridgeside Ct	Color	Unknown
9/19/2017	1179 Tinkers Green Dr	Color	Unknown
9/19/2017	1280 Creekledge Ct	Color	Unknown
9/20/2017	Alden Dr	Color	Unknown
9/20/2017	Apartments on Frost Rd	Color	Unknown
9/20/2017	815 Frost Rd	Color	Unknown
9/20/2017	816 Frost Rd	Color	Unknown
9/20/2017	1034 Alden Dr	Color	Known: Water Dept. Activity
9/20/2017	8876 Falcon Dr	Low Pressure	PRV Failure
9/25/2017	8876 Falcon Dr	Low Pressure	PRV Failure
9/22/2017	1179 Tinkers Green	Color	Unknown
9/25/2017	1784 Luke Dr	Color	Unknown
9/27/2017	1774 Dunlap Dr	Color	Known: Sprinkler Usage
10/2/2017	739 Stewart Ave	Color	Known: Water Dept. Activity
10/3/2017	613 David Dr	Color	Known: Water Dept. Activity

Date	Address	Complaint	Cause
10/4/2017	1551 Sidney Dr	Color	Known: Water Dept. Activity
10/6/2017	804 Fronek Dr	Low Pressure	Unknown
10/9/2017	9244 Gerald Dr	Color	Known: Water Dept. Activity
10/9/2017	9255 Dorothy Dr	Color	Known: Water Dept. Activity
10/17/2017	Fronek Dr	Color	Known: Main Break
10/17/2017	Wiencek Rd	Color	Known: Main Break
10/17/2017	10169 Jenwood Ct	Color	Known: Main Break
10/26/2017	9198 St. Nickolas Dr	Color	Known: Fire Dept. Activity
10/26/2017	9564 Seymour Dr	Color	Known: Fire Dept. Activity
10/27/2017	1272 S.R. 303	Color	Known: Fire Dept. Activity
10/31/2017	1516 Crescent Dr	Color	Known: Water Dept. Activity
11/7/2017	800 Mondial Pkway	Color	Known: Fire Dept. Activity
11/28/2017	662 Edmond Ave	Color	Known: Water Dept. Activity
12/8/2017	9309 Hickory Ridge	Color	Known: Water Dept. Activity
12/19/2017	9860 Creekside Way	Color	Unknown
12/26/2017	9024 Portage Pointe Dr	Color	Unknown
1/16/2018	10149 Kendall Ln	Color	Unknown
2/27/2018	101 Emerald Ave	Color	Unknown
3/6/2018	9345 Flora Dr	Color	Known: Main Break
3/20/2018	1008 S Sagramore Dr	Color	Unknown
3/20/2018	9890 S Delemonte Blvd	Odor	Unknown
3/20/2018	1008 S Sagramore Dr	Color	Unknown
3/20/2018	1189 Apache Pass	Color	Known: Fire Dept. Activity
3/20/2018	1582 Hannum Dr	Color	Known: Fire Dept. Activity
3/21/2018	9083 Redhawk Dr	Color	Known: Fire Dept. Activity
3/29/2018	9728 Sunny Ln	Taste	Known: Fire Dept. Activity
4/10/2018	1446 Gillie Dr	Color	Known: Water Dept. Activity
6/20/2018	1345 Shawnee Trl	Color	Unknown
7/16/2018	8714 Seasons Rd	Color	Unknown
8/6/2018	9515 Kickapoo Pass	Color	Unknown
8/28/2018	8260 Seasons Rd	Low Pressure	Known: PRV Failure
9/2/2018	326 Jade Blvd	Color	Known: Fire Dept. Activity
10/8/2018	595 Edmond Dr	Color	Unknown
10/19/2018	943 Bristol Ln	Odor	Unknown

The complaints having an unknown cause in the table above were then mapped on the distribution system to identify any water quality trends by location. This is shown on Figure 3-1 on the following page.

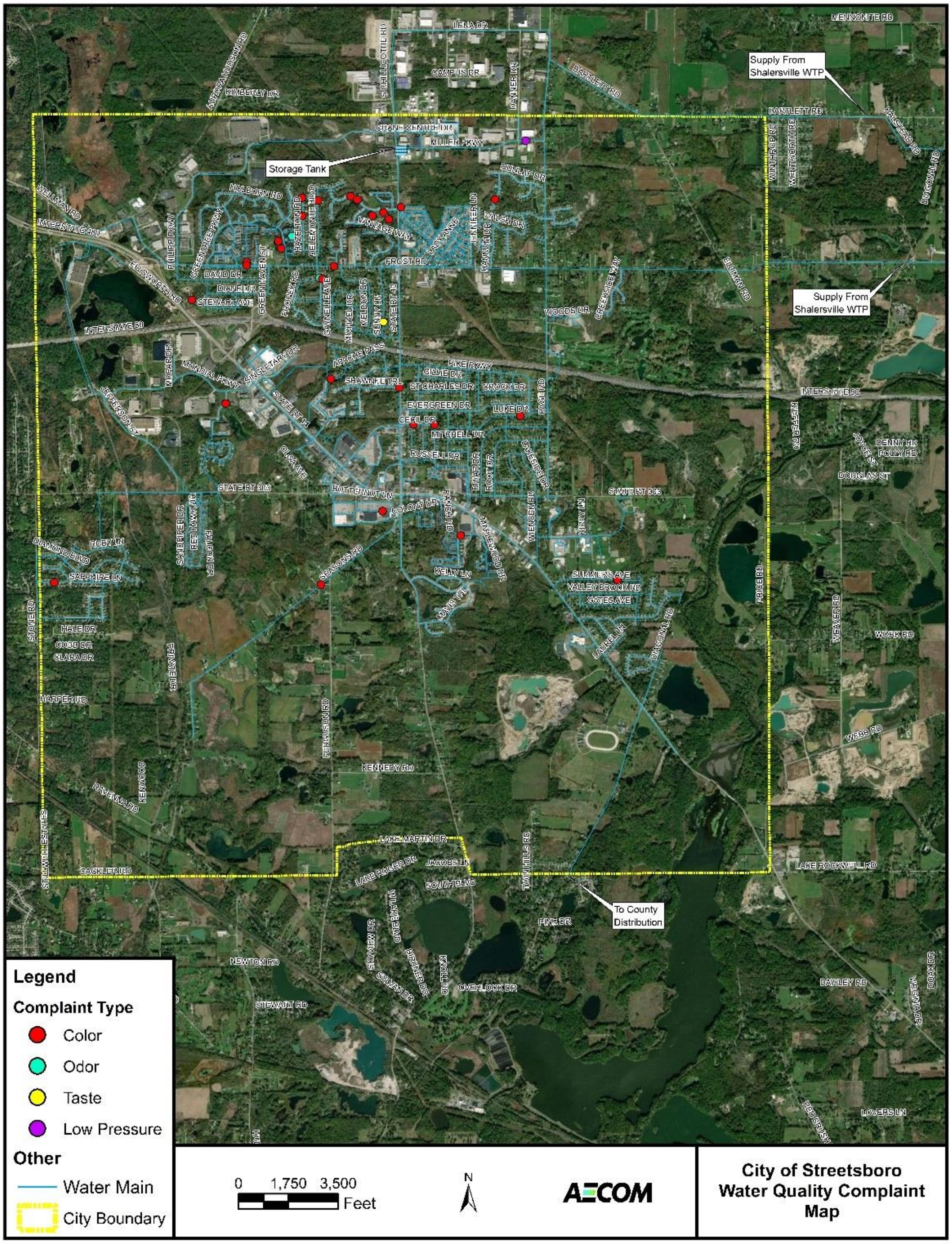
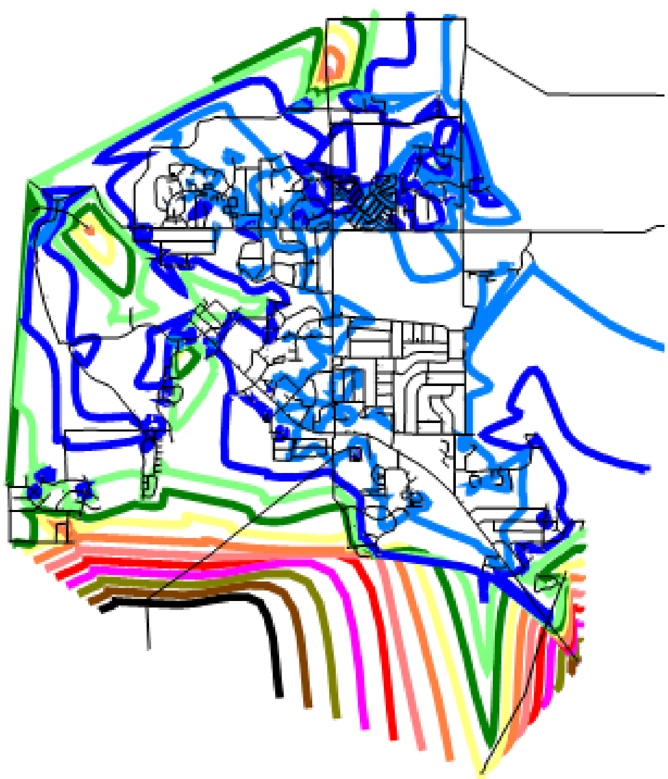


Figure 3-1 Map of Water Quality Complaints of Unknown Cause

The complaints of unknown causes are distributed throughout the City without much of a clear pattern, although there are increased complaints in the northern quadrant. One area that stands out is the Tinker's Green subdivision (which is this north central area), and numerous complaints were logged here in the fall of 2017. This area is actually a separate pressure zone of about 150 homes served by a booster station on Tinker's Green Drive. Booster stations feeding small pressure zones without elevated storage or pressure tanks can have issues relating to reverse flow and hammer, which can cause sediment to stir. Additionally, rather than pressure reducing valves, the zone is isolated by check valves. It is possible that one of these check valves could have temporarily stuck open while the booster station was running. Depending on the controls of the station, a check valve temporarily stuck opened could cause the pumps to run out on their curves, resulting in high velocity in the 8-inch waterlines and stirring sediment. Although these complaints appear to be an isolated event, the City may want to consider replacing one of these check valves with a pressure reducing valve or adding a hydro-pneumatic pressure tank in this zone. Doing so could reduce the number of pump starts and stops per day and mitigate issues such as hammer or short duration occurrences of high velocity. An 8-inch pressure reducing valve costs about $6,000 and can be installed in one of the check valve manholes.

3.2 Water Age Simulations

Estimating the water age in a distribution system is valuable when investigating potential causes of water quality issues. Increased water age can lead to problems such as a reduction in available chlorine residual and formation of biofilms, unpalatable taste and odors, formation of disinfection byproducts, and settling of sediment among others. The model was run in an extended period simulation of 1,500 hours (62.5 days) in 1-hour increments with an average demand of 1.3 MGD to identify areas in the system with the highest water age. Figure 3-2 presents the water age under these conditions, without the inclusion of any automatic hydrant flushers (discussed in the following section).



Age (< days)	Age (< hours)	Color
2.1	50	
4.2	100	
6.3	150	
8.3	200	
10.4	250	
12.5	300	
14.6	350	
16.7	400	
18.8	450	
20.8	500	
22.9	550	
25.0	600	

Figure 3-2 Water Age Simulation (No Flushing)

As seen in the figure, problematic areas occur in the extremities of the dead end waterline branches in the southern portions of town. Distribution systems of this size commonly experience excessive age in dead-end waterlines, as it is not often financially feasible to loop such lines. Note the area to the southeast on Diagonal Road which appears to be a dead end branch is an extension beyond City limits servicing other PCWR customers. This connection is metered and experiences a typical flow about 5,000 gallons per day and was simulated in the model. There is also one small area to the north on Route 43 which is modelled as a somewhat high age. However, this may be a nuance of the model as this line has bidirectional flow between Streetsboro and Aurora. Modelling the Aurora water system and demand is outside the scope of this study, resulting in the actual demand and water age in this area being misrepresented. However, the net difference in flow direction is minimal (typically <90,000 gal/day into Streetsboro), and may have little impact. However, since this could not be accurately modelled, it is suggested that the City check chlorine residual in this area to verify whether or not it is a concern.

3.2.1 Automatic Hydrant Flushers

Flushing at dead end locations can help mitigate water age, and automatic (timed) hydrant flushing valves are commercially available. The City has three of these flushing valves which are currently operated as follows:

- Stone Ridge: Located on Stone Ridge Drive south of Victorridge Drive (southwestern area of the distribution system). This flusher runs for 30 minutes every day at an estimated rate of 180 gpm (5,400 gal/day).
- Seasons Road: Located at the end of seasons road (southern portion of the distribution system). This flusher runs for 45 minutes every day at an estimated rate of 150 gallons per minute (6,750 gal/day).
- Police Department: Located at the City's police department on State Route 303 (eastern area of the distribution system). This flusher runs for 45 minutes one day per week at an estimated rate of 148 gallons per minute (6,660 gal/week).

The two daily flushers result in a total flushed volume of about 365,000 gallons per month. The weekly police department flusher adds another 26,000 to 33,000 gallons per month. These three flushers were simulated in the model, and results for the 1,500 hour simulation are shown in Figure 3-3.

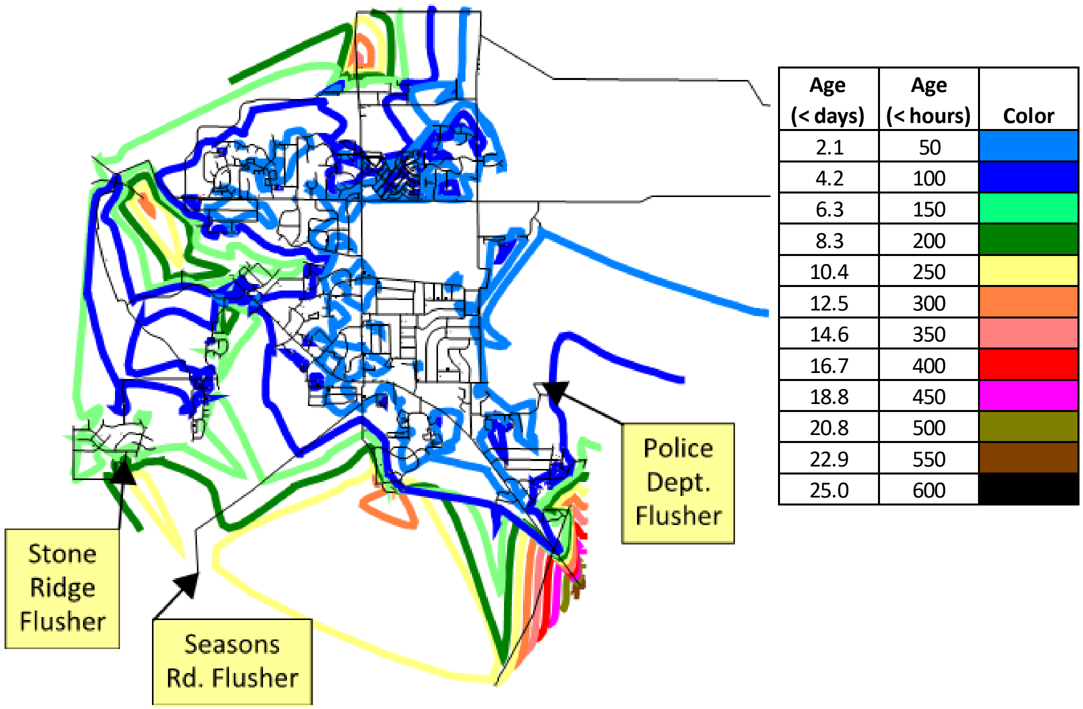


Figure 3-3 Water Age Simulation (with Flushing)

Implementation of the automatic flushers has reduced water age considerably in their installed locations. Modelling results indicate the following:

- Seasons Road: Age reduced from the initial 830 hours (34.5 days) to a range of 225 to 250 hours (9.3 to 10.4 days).
- Stone Ridge: Age reduced from the initial 360 hours (15 days) to a range of 180 to 230 hours (7.5 to 9.6 days).
- Police Department: Age reduced from an initial 150 hours (6.3 days) to 48 hours (2 days) immediately following a flush.

Given this information, it appears that a water age of approximately 10 days or less can maintain acceptable chlorine residuals and will alleviate disinfection byproducts. Although the Seasons Road flusher is an obvious selection for the location (end of a dead end line), the Stone Ridge flusher was evaluated to determine if water age could be further reduced as this area is looped. This flusher was moved to several nearby hydrants in the model, and no reduction in water age was observed (increased in some cases). However, it was found that closing the valve on the waterline between Stone Ridge Road and Sapphire Lane would further reduce water age by about a day at the flusher. However, it is not necessarily recommended to close this line considering the added benefit of redundancy of a looped line. Overall, it is recommended to continue operating these flushers in their current location and flow set points. If the City wishes to further reduce water age in the Seasons Road and Stone Ridge Road areas, Figure 3-4 presents the water age corresponding to the number of minutes each flusher would run per day.

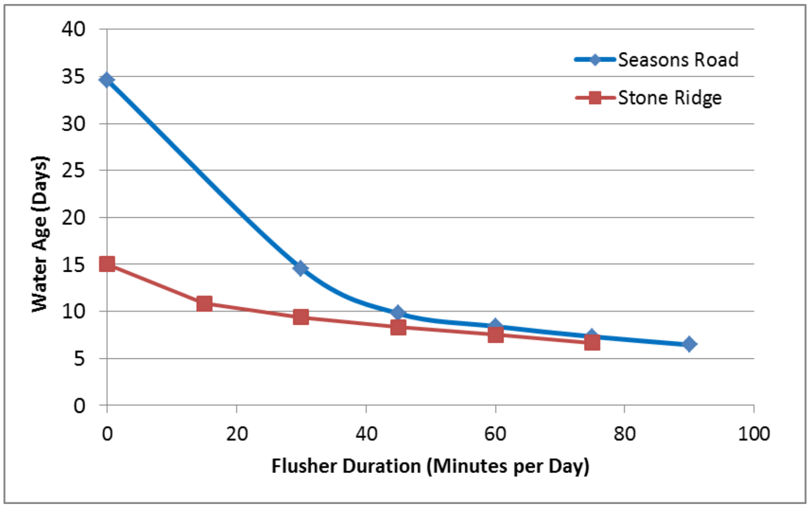


Figure 3-4 Flusher Duration and Corresponding Water Age

> **Recommendation:**
> City should consider adding another automatic flusher on Route 14 to flush an additional 5,500 gallons per day.

One final consideration should be given to possibility of a fourth flusher. The area with the highest age is the far southeast extremity of the system on Route 14. Water age in this area is modelled as approximately 590 hours (24.6 days) at the end of the simulation. It is recommended that the City at least perform chlorine residual in this area to investigate of a problem exists. If there is an issue, it is recommended to reduce the age to 9 to 10 days. This can be accomplished by using an automatic flusher to flush approximately 5,500 gallons per day (for example, 30 minutes at 180 gpm).

3.2.2 Elevated Tank

Water storage facilities occasionally experience excessive water age. The City's new 1.5 million gallon elevated water tower was commissioned in 2015 and is located on the north side of the distribution system along State Route 43. Due to hydraulic grade issues with PCWR storage tanks upstream of the new tower, the maximum allowable water level in the new tank is about 7 feet below the top capacity level (otherwise an upstream tank would overflow). This effectively makes the total storage capacity slightly above 1 million gallons, which is somewhat beneficial in terms of reducing water age. The tank features a passive inlet/outlet mixing system to help prevent stagnation, and the location lends itself to a reduced water age being near the entry point of the PCWR supply. Operational data of daily minimum and maximum water levels indicate a typical tank turnover of about 20% each day, further helping maintain a minimal water age. Water age in the elevated tower was simulated during the 1500-hour duration and the results indicate water age in the tank stabilizes at approximately 4.5 which is not considered excessive. This age analysis included simulating the three existing flushers and results are presented in Figure 3-5 (initial age of 0 hours).

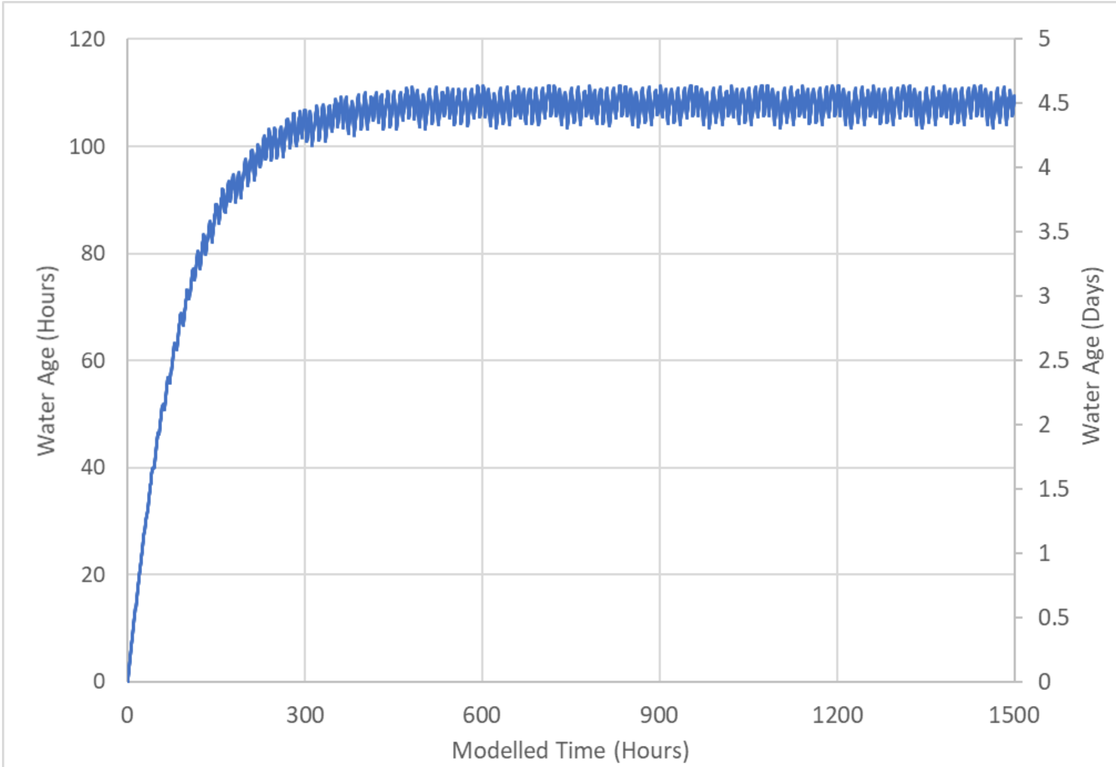


Figure 3-5 Modelled Water Age in Elevated Tank

The original design of the storage tank featured a 100 gpm circulation pump and spray nozzles intended for reduction of disinfection byproducts including total trihalomethanes (TTHMs). Spray aeration creates water droplets which then allow vitalization of TTHMs to the atmosphere, and these have shown to be effective. However, the plastic piping between the spray header and pump failed in March of 2019, which caused flooding in the base of the tank and destroyed over $50,000 in City assets. The City had previously collected TTHM samples upstream of the water tank and from the water tank in 2015 and 2016. This was prior to running the aerator, and results are presented in Table 3-2.

Table 3-2 Summary of Water Tower TTHM Data

Date	Sample Location	TTHM (µg/L)
10/14/2015	Page Road - Upstream	31.9
	Water Tower	57.4
03/09/2016	Frost Road - Upstream	30.1
	Water Tower	43.8
06/13/2016	Frost Road - Upstream	23.3
	Water Tower	52.5
09/13/2016	Frost Road - Upstream	27.8
	Water Tower	50.9

Recommendation:
City should installing and active tank ventilation system and replace circulation pump and piping. Monitor TTHM removal and consider installing a larger pump capacity if removal rates remain low.

As evident by this data, TTHM formation does appear to be occurring in the tank, which would warrant use of the spray aeration system. A replacement pump has recently been purchased and the plastic segments of piping are planned to be replaced with stainless steel material. However, a spray aeration system also requires continuous air changes inside the reservoir using forced or induced ventilation to remove volatized TTHM. Without this, volatilized TTHMs will primarily dissolve back into the water. An active ventilation system was not installed on the original tank and without one, the spray aerator may not be adding much benefit. It is recommended that the City install an active ventilator on the existing tank vent or reservoir access hatch and proceed with installing the recently purchased replacement pump and new stainless steel piping. Once the system is fully operational, it is recommended the City monitor TTHM removal performance in the summer of 2020. If low TTHM removal (< 20%) is occurring, it is recommended to install a larger pump (up to 200 gpm capacity) and additional spray nozzles to accommodate higher flows. Since the City already has the 100 gpm pump, it is not recommended to install a larger one at this time. The pump should be run continuously during warmer summer and fall months and does not need to be utilized in the winter or much of the spring. 24-hour operation should initially be implemented and can be scaled back if TTHM removal is shown to be effective.

3.3 Water Quality Constituents

3.3.1 Hardness

Although hardness is not regulated by primary drinking water standards, desired levels for total hardness are suggested to be maintained below 150 mg/L as $CaCO_3$; although some sources note up to 180 mg/L as $CaCO_3$. The agreement between the City and County requires the finished water hardness to be between 130 and 175 mg/L as $CaCO_3$. Hard water can cause difficulty in rinsing surfactants (soap, laundry detergent, shampoo, etc.) off of surfaces and it can lead to scaling or failures of water heaters and other plumbing fixtures and pipes. Water heater scaling is further exasperated when the magnesium content of hardness is observed above 40 mg/L as $CaCO_3$. The City has noted issues with customer water heater failures, and scaling may be part of this issue. However, PCWR has indicated water heater failure is not a common occurrence with other customers, so there may be other factors influencing failure. Operating water heaters at too high of a temperature can drastically increase scale formation and cause premature failure. It may be worthwhile for the City to actively engage in public relations or education efforts such as tips for operating and maintaining water heaters to help mitigate these issues. As little data exists pertaining to these water heater failures (age of tanks, operating temperature, amount of sediment or scale observed, etc.), firm conclusions on the mode of failure cannot be made at this time.

The Shalersville WTP utilizes sodium cycle ion exchange for softening, which is commonly implemented at smaller groundwater treatment facilities in Ohio. Shalersville monitors hardness every day (and records were provided to AECOM) although it is only recorded 4-5 times per month on the actual MORs. These reported values averaged approximately 145 mg/L as $CaCO_3$ in 2018 with occasional values of 150 to 160 mg/L as $CaCO_3$ (and an outlier of 232 mg/L as $CaCO_3$ in July 2018). The City also monitors hardness at ten sampling locations in the distribution system and these results are represented in Figure 3-6 (with the point of entry at Frost Road specifically identified).

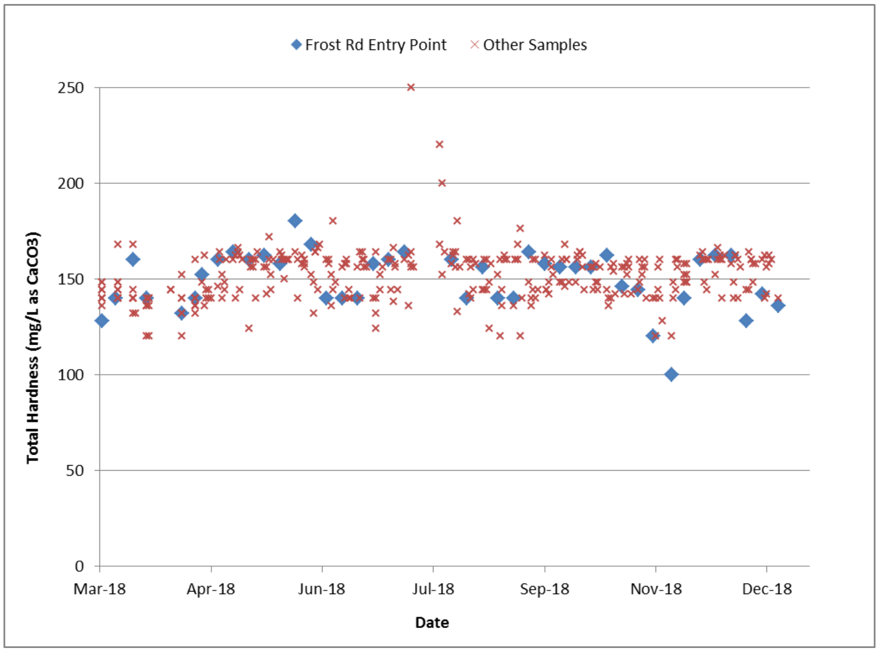


Figure 3-6 Water Hardness throughout Distribution System

> **Recommendation:**
> The City should check their hardness test or analyzer accuracy, as it reads higher than PCWR values.

Values for hardness reported by the City consistently appear to be slightly higher than those reported by PCWR, and it is suggested that the City calibrate and verify the accuracy of their analytical equipment. This could be performed in conjunction with checking the City's chlorine analyzers (discussed in the next section, "Chlorine Residual"). Magnesium hardness was sampled (by lab analysis) as part of this study at the plant and within the City and was observed to be 36 to 40 mg/L as $CaCO_3$. The observed values for magnesium hardness are approaching the suggested limit of 40 mg/L as $CaCO_3$, and lowering the plant finished water target between 130 and 140 mg/L as $CaCO_3$ could help alleviate scaling issues. Of course, operating at a lower hardness is an added cost for PCWR. Furthermore, a lower hardness may not even be achievable with the Shalersville WTP ion exchange system, as the spent regeneration brine is sent to the Streetsboro wastewater treatment plant. Increasing the total dissolved solids load at this plant would likely result in a discharge permit violation. To mitigate dissolved solids, the Shalersville

WTP would likely need to replace ion exchange with reverse osmosis softening, which is estimated to cost approximately $2 million and have higher operational costs. A lime softening plant is viable as well, but would have a much higher capital cost (over $4 million). A much more cost effective (and cost saving) measure to mitigate scale would be to lower the pH, which is discussed later in this section.

3.3.2 Chlorine Residual

Chlorine residual leaving the Shalersville WTP is reported daily on MORs and averages approximately 1.5 mg/L. The City also performs free and total chlorine sampling every day within their system at ten regular sampling locations plus one random location. Included in the ten locations is the Frost Road sampling station, which is essentially the entry point of water to the distribution system. Figure 3-7 presents the 2018 sampling results for free chlorine residual (which includes the automatic flushing conditions), with the Frost Road point of entry sampling station separated from the other sampling locations.

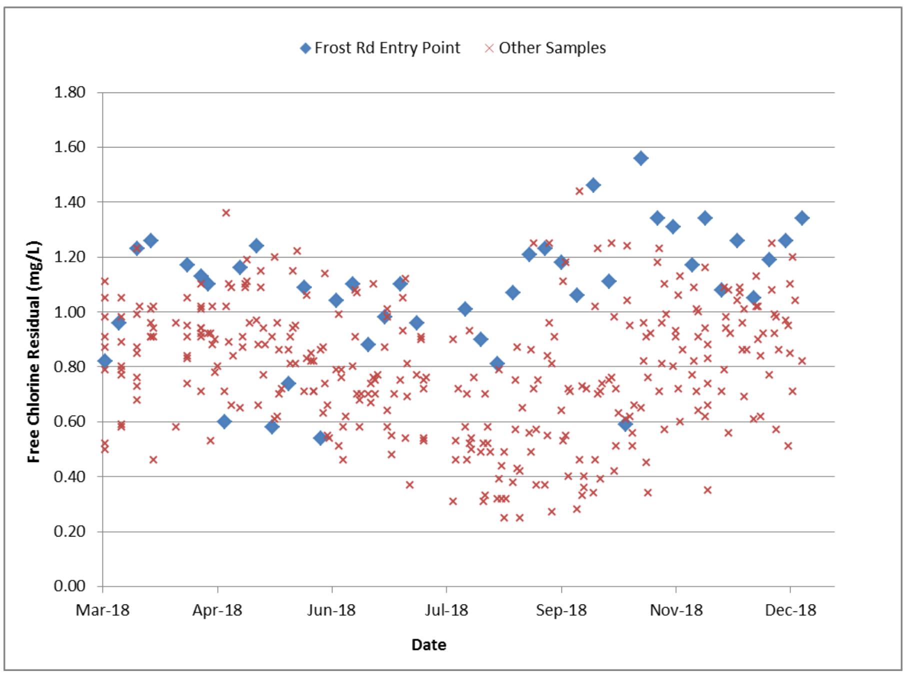


Figure 3-7 Free Chlorine Residual Sampling Results

According to City-collected data from 2018, free chlorine residual at the entry point is often observed several tenths below the Shalersville WTP residual of 1.5 mg/L. This indicates chlorine decay could be occurring prior to entering the system. However, the contact time between the Shalersville supply and City entry point is only 5 to 8 hours based on normal flow

Recommendation:

City should continue to calibrate chlorine analyzers, and PCWR should perform secondary sampling to verify accuracy. PCWR should investigate the cause of residual decay prior to entering the City if this condition is verified.

conditions, and such a decrease in residual is unusual. It is possible that the City's chlorine analyzers require calibration and it is suggested that PCWR perform a secondary sampling event along with the City to verify accurate readings. If the same decay is observed, PCWR is encouraged to perform sampling along the waterline which supplies the City in order to identify the location of any in chlorine residual sink.

Regardless of any initial decrease in residual, it is expected that decay will continue within the system as water ages. The City must maintain a minimum residual of 0.2 mg/L and subsequently implements flushing (corresponding to a water age of approximately 10 days). Although the automatic flushers do a good job in maintaining residual, the City does occasionally need to perform additional manual flushing to boost residual, especially in warmer months. It may therefore be beneficial to have a slightly higher residual as the water enters the systems to prevent additional flushing. Alternatives such as the City constructing a chlorine booster facility within the distribution system are feasible, but not recommended. The capital and annual costs of a booster facility is not expected to offset the minimal costs incurred with automatic flushing. A new booster facility would likely cost in excess of $300,000 to fully commission, and would require continued annual expenses of chemical supply, operation, and maintenance. These expenses compared to the current flushing volumes would not result in a favorable return on investment. More viable alternatives include increasing the flushing to achieve a water age of 8 to 9 days or PCWR increasing the chlorine residual by several tenths (up to 1.8 mg/L) during these summer months. Colder months do not typically have issues maintaining residual (rarely below 0.4 mg/L) and flushing could be reduced or the Shalersville residual could be lowered back to 1.5 mg/L at those times. It should be noted that increasing the chlorine residual could negatively impact the TTHM formation potential. However, this can be mitigated by lowering pH and continued use of flushers at a reduced volume. Ultimately, the automatic flushing likely cannot be discontinued, but some savings in water could be gained with these strategies.

Recommendation:
Automatic flushing typically maintains adequate chlorine residuals most of the year, but summer months may require additional automated flushing or an increasing chlorine residual at the Shalersville WTP.

3.3.3 Disinfection Byproducts

With the City receiving 100% of its water from groundwater supplies and the implementation of automatic hydrant flushing, there have not been TTHM violations. However, they are still observed as approaching the maximum contaminant level of 80 µg/L according to consumer confidence reports (no cited violations). Monitoring results from recent Streetsboro Consumer Confidence Reports (including PCWR Shalersville Reports) are summarized in Table 3-3.

Table 3-3 Summary of Consumer Confidence Report TTHM Levels

Year (Sample #)	City of Streetsboro		Portage County Water Resources	
	TTHM Reported Detection (µg/L)	TTHM Reported Range (µg/L)	TTHM Reported Detection (µg/L)	TTHM Reported Range (µg/L)
2015 (1)	64.48	53.49 to 91.25	35.9	Not Reported
2015 (2)	50.42	41.58 to 63.26	-	-
2015 (3)	66.61	52.02 to 83.24	-	-
2016 (1)	62.19	40.74 to 82.92	46.8	Not Reported
2016 (2)	53.45	42.89 to 64.66	-	-
2016 (3)	69.82	49.76 to 94.68	-	-
2016 (4)	69.28	51.13 to 99.60	-	-
2017 (1)	64.23	48.90 to 63.13	78.6	37.8 to 89.2
2017 (2)	54.37	46.6 to 53.10	-	-
2017 (3)	71.56	56.8 to 64.21	-	-
2017 (4)	68.99	48.67 to 72.30	-	-
2018 (1)	68.30	38.70 to 90.50	73.5	51.6 to 73.5

TTMH formation is a function of total organic carbon (TOC) content, pH, temperature, and water age. Flushing can reduce water age, but the other parameters are generally not changed with flushing. TOC concentration is often low in Ohio groundwater, and a 2008 EPA Groundwater Study reported that over 80% of Ohio groundwaters had TOC content well below their reporting limit of 2 mg/L. As a result, groundwater plants do not often have TTHM issues and this is typically more problematic at surface water plants. Two water samples taken at Shalersville WTP as part of this study both indicated a TOC content of 2.3 mg/L, which is somewhat high compared to typical groundwater in the state. The source of elevated TOC is unknown, although well #4 is located about 50 feet northwest of the Cuyahoga River and the remaining wells are all in the general vicinity of large sand and gravel mining / quarry operations; any of which could be a source of TOC in the groundwater. Further investigation of the source may be worthwhile but would require a somewhat extensive hydrogeological study. Regardless of the cause, it would not be considered cost effective to remove TOC at the Shalersville WTP at this noted concentration, and there are other strategies for TTHM reduction.

Reducing water age through flushing is a simple strategy for TTHM reduction, which also gives the benefit of maintaining chlorine residual. It appears that the City's current automatic flushing schedule is doing an adequate job of maintaining chlorine residual which in turn keeps the TTHM levels below the limit. Another effective strategy which does not add cost (and actually saves cost) is lowering the pH; which is discussed in the next section. A third strategy could be for

> **Recommendation:**
> Minimizing TTHM formation can be accomplished with continued flushing, lowering finished water pH, and more operating wells with lower TOC levels more frequently (if applicable).

PCWR to monitor TOC levels in their wells and run wells with lower TOC concentrations more frequently during summer months. However, if TOC levels are approximately the same throughout all wells seasonally, this is not applicable. AECOM did not perform TOC sampling at each individual well as part of this study (sampling performed on well #4 and on blended raw water at the plant); and it is recommended PCWR further investigate this strategy.

3.3.4 pH

Ohio EPA currently mandates the Shalersville WTP to maintain a finished water pH of 8.1 or higher, and the plant therefore targets a finished water pH value between 8.2 and 8.3. The natural well water supplying the plant has a pH of approximately 7.4 and the plant then adds sodium hydroxide to raise the pH. As a result, sodium hydroxide is a considerable part of the plant's annual operational cost (over $32,000 spent in 2018). Operating at this elevated pH has several adverse effects on water quality discussed in this section.

As discussed, the City occasionally experiences TTHM concentrations approaching the maximum drinking water standard of 80 µg/L. Reaction kinetics of TTHM formation is complicated, but several factors are known contributors including high pH. As such, it would be best practice to operate distribution systems susceptible to TTHM formation at a pH as low as practical in order to reduce the likelihood of formation. Of course, this comes with finding a balance, as too low of pH will result in increased corrosion.

pH has significant influence on water quality indices which are commonly used to express how corrosive or scale-forming water will be. These are discussed further in Section 3.3.5, but in general, the current operating pH is resulting in water with extremely high scale formation potential. PCWR also adds a blended phosphate as a means of lead corrosion control and other metal sequestration. The ideal pH range for orthophosphates used to control lead corrosion is 7.2 to 7.8, and pH values above this range will favor phosphate binding with ions such as calcium instead of lead. Similarly, polyphosphates are most effective below a pH of 8. The use of blended phosphate is therefore doing very little for control of lead corrosion and metal sequestration. However, given the high scaling and precipitation potential, release of these metals is not a major concern.

Buffer intensity is a measure of water's ability to resist changes in pH, and is variable depending on the initial pH of the water. It is beneficial to have high buffer intensity in distribution systems in order to maintain consistent pH and water quality. Buffer intensity is at its lowest capacity when pH is between 8 and 8.5, and is further minimized at lower levels of dissolved inorganic carbon (DIC). The Shalersville WTP water does have the benefit of relatively high DIC at approximately 57 mg/L as carbon, helping reduce the effects of low buffer intensity at the operating pH of 8.2 to 8.3. However, despite high DIC, water within the City's distribution system may experience swings in pH, which can have numerous impacts on water quality (primarily relating to maintaining a low corrosion and metal release rate). A graph of buffer intensity as a function of pH and DIC is shown in Figure 3-8 which illustrates minimum intensity between pH of 8 and 8.5. Note that this figure was taken from the 2016 US EPA Guidance Manual for Corrosion Control, which actually recommends not operating water systems at a pH between 8 and 8.5.

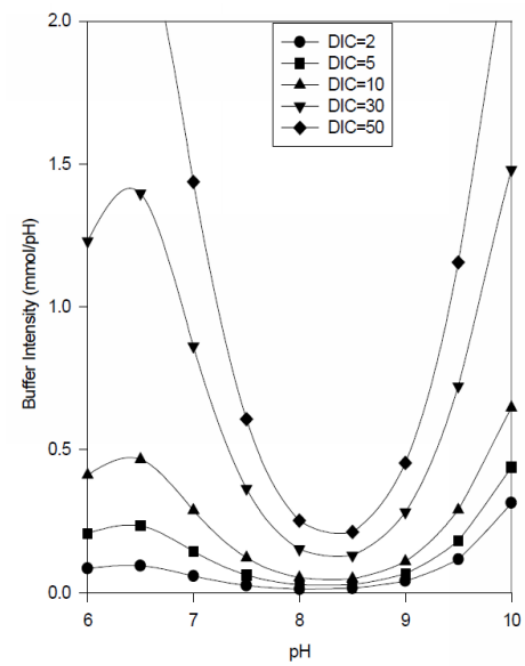


Figure 3-8 Buffer Intensity as a Function of pH and DIC

In summary, adding sodium hydroxide to raise pH between 8.2 and 8.3 is causing more negative impacts than positive. It costs the County unnecessary expenses, increases TTHM formation potential, produces a high scaling potential water, limits the effectiveness of phosphate chemicals, and minimizes the buffer intensity. Unfortunately, this pH target is an Ohio EPA mandated operation. PCWR has previously attempted to negotiate lowering the pH with Ohio EPA without success. It is recommended that the County continue to pursue negotiations to propose a finished water pH requirement of 7.6 ±0.2. This situation is not unique to PCWR and many utilities throughout Ohio have similar requirements with similar impacts. Fortunately, Ohio EPA has recently begun to acknowledge the negative impacts of high pH on water systems, and the current requirement may have been a kneejerk reaction to recent corrosion control publicity. On April 19, 2019, the EPA released a formal response to comments document regarding optimal corrosion control guidelines. Within this document, similar arguments were made and the EPA is acknowledging the negative impacts which will likely lead to changes in the guidelines.

Recommendation:

The current pH of 8.3 is causing numerous issues, and it is recommended that PCWR continue to negotiate with Ohio EPA to reduce this to a pH of 7.6 ± 0.2.

3.3.5 Water Indices

There are several water chemistry-based indices which give qualitative characteristics of the water relating to corrosiveness (corrosion control discussed further in Section 3.4). Water quality data from historical records and the sampling events performed in this study were used to calculate these indices with results presented below. Note these values are calculated using current plant operational parameters including a pH of 8.3 and an assumed temperature of 55° F.

- **Calcium Carbonate Precipitation Potential (CCPP)**: Calculated as 25.2 mg/L as $CaCO_3$. The index is largely a function of pH and hardness and it is favorable to have a high CCPP values (above 4 mg/L as $CaCO_3$) to inhibit corrosion. However, as values of PPCC get above about 10 mg/L as $CaCO_3$, there is little additional benefit and this can lead to excessive scale forming in pipes and plumbing fixtures / appliances.
- **Langelier Saturation Index (LSI)**: Calculated as +0.9. This index is similar to PPCC and is a representation of the corrosivity or scaling potential of water. Ideally, an LSI of 0 would be a good balance of preventing both corrosion and excessive scale formation. Although published guidelines are not well established for preferred LSI values, widely accepted goals generally range between -0.3 and +0.5. In any case the value of +0.9 seen here is relatively high and would be considered high scale forming potential.
- **Chloride to Sulfate Mass Ratio (CSMR)**: Calculated as 0.67 based on four sampled locations in the distribution system. Research has shown that CSMR values greater than 0.6 can lead to an increase in corrosion of steel or iron pipes. The elevated level is therefore of some concern regarding corrosion.
- **Dissolved Inorganic Carbon (DIC):** Calculated as 57 mg/L as Carbon. Waters with a DIC concentration lower than approximately 5 mg/L as C can be highly corrosive. The Shalersville WTP is well above this minimum threshold and the DIC levels are therefore not a concern.

Of these indices, CCPP, LSI, and CSMR are all outside of recommended (or typical) ranges. For CSMR, there is little that can feasibly be done at the Shalersville WTP to lower this ratio below 0.6. Technically, the solution would be to remove chloride or add sulfate. However, chloride removal is not practical (and also removes sulfate), and addition of most sulfate containing chemicals used in drinking water applications would not be suitable for use at Shalersville (coagulants, acids, or oxidant scavengers). Coupon studies have shown that the water is corrosive to steel (discussed in section 3.4.2), and the elevated CSMR could be a possible culprit. However, no steel pipes are present in the City's distribution system and the information is not pertinent.

Although mitigating the CSMR ratio is difficult, managing the CCPP and LSI indices have relatively simple solutions. Reduction in finished water hardness will help, but the easiest, most effective, and lowest cost (actually cost saving) measure would be to lower the pH to the previously-recommended value of 7.6 ± 0.2. Table 3-4 presents a comparison of theses water indices at current 8.3 pH and the proposed 7.6 pH.

Table 3-4 Water Indices and pH

Index	Ideal Range	Value at pH 8.3	Value at pH 7.6
CCPP	4 to 10	25.2	9.15
LSI	-0.3 to +0.5	+0.9	+0.2

3.3.6 Iron and Manganese

Iron and manganese are not regulated by primary drinking water standards but do have secondary standards 0.3 mg/L for iron and 0.05 mg/L for manganese. Values above those concentrations can cause water discoloration including staining of laundry and plumbing fixtures. Values below these limits can also result in sediment buildup and discoloration. Specifically, iron can produce an orange discoloration whereas manganese is typically observed as black. The Shalersville WTP utilizes oxidation and pressure filtration for removal of these metals and AECOM reviewed several years of historical Shalersville operational data pertaining to finished water iron and manganese levels. Throughout 2018, the filters were overhauled and received new media and associated filter equipment, with the project finishing in the fall of 2018. Since then, levels of iron and manganese have been comfortably below the criteria. However, prior to this, there were occasions when manganese was observed over the EPA's secondary MCL of 0.05 mg/L (occasionally 0.08 to 0.1 mg/L). Iron did not have any recorded exceedances during this period. The historical iron and manganese results at the Shalersville WTP are provided in Appendix B for reference.

Although water leaving the plant has not typically experienced elevated levels of these metals, samples were collected by AECOM throughout the distribution system as part of this study. Lab analysis revealed three samples were below the detection limits, but a sample collected at Frost Road reported iron as 0.145 mg/L, and a sample from Stone Ridge was 0.597 mg/L. The elevated levels of iron in the distribution system could indicate a continued accumulation from the supply, or that the cast or ductile iron pipes are releasing some iron. Cast iron pipes can be notorious for rusting and releasing iron. Coupon testing revealed that the Shalersville water is corrosive to steel (discussed in Section 3.4.2). However, there are no steel pipes in the system and steel is not necessarily comparable to cast or ductile iron. One possible explanation for the presence of iron is that biofilms formed on the interior of cast or ductile iron pipes could contain iron reducing bacteria, which effectively release dissolved iron into the water. This is less likely for ductile iron, as those are typically cement-lined. It should be noted that the presence of biofilms is speculative and no evidence of this exists in the City's distribution system. However, if segments of cast or ductile iron pipe are removed during upcoming repairs, it is suggested that they be evaluated for the presence of such biofilms.

The Shalersville WTP currently feeds a blend of poly- and ortho-phosphate, which should help sequester some of this iron (due to the presence of the polyphosphate). However, the elevated pH is likely inhibiting the ability for polyphosphate to sequester iron. At a pH above 8, polyphosphate is less effective and iron will rapidly oxidize to its +3 state and precipitate with hydroxide ions rather than bind with polyphosphate. As the source of iron is not known, the best strategy appears to be continuing to flush waterlines to release any accumulated sediment.

3.4 Corrosion Control

Preventing corrosion of lead and copper service lines (in addition to other materials) is an important part of treatment and distribution system operation. This section discusses the current County and City prevention strategies along with possible improvements.

3.4.1 Corrosion Inhibitor Feed

As discussed, the Shalersville WTP feeds a blend of ortho- and poly-phosphate (SAL Chemical SmartPhos 140D) to help prevent corrosion in the distribution system and sequester metals. According to MORs, the plant achieves an average residual of approximately 2 mg/L (±0.2) as PO_4 and subsequently spends about $23,000 annually on the chemical. In addition to phosphate residual being monitored and reported at the WTP, the City has taken the initiative to sample for residual phosphate levels throughout the distribution system. The same ten locations monitored for chlorine residual and hardness serve as the location for phosphate monitoring, and Figure 3-9 presents the results for 2018. The figure also identifies the Frost Road entry point sampling station separated from the other sampling locations.

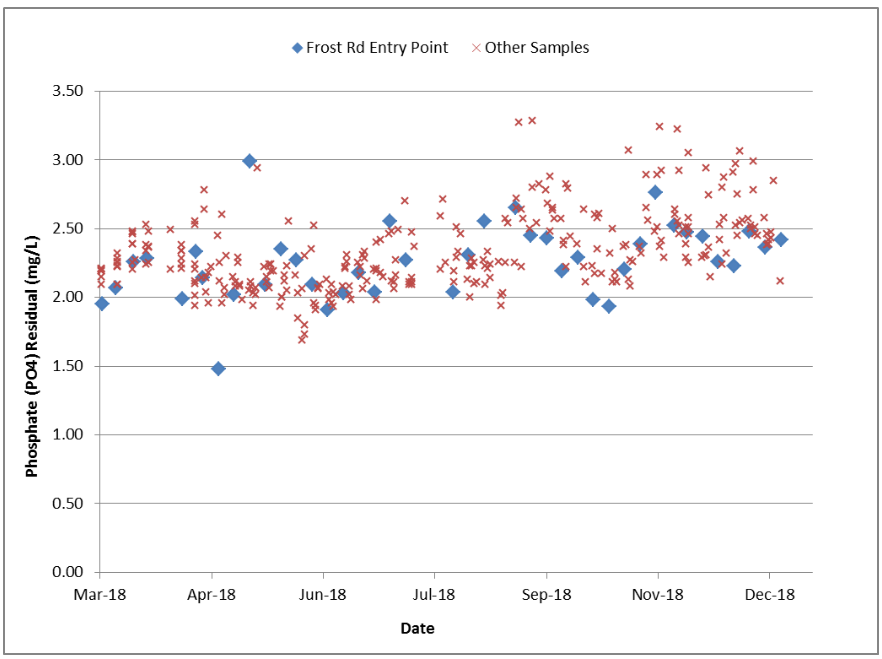


Figure 3-9 Residual Phosphate (as PO_4) Sampling Results

As seen in the figure, phosphate residual remains relatively constant throughout the year and at different locations in the system. It is often observed as slightly higher than the average concentration reported at the Shalersville WTP MORs, but this is likely due to the sampling technique employed by the City, which is not required to be reported. Regardless, given the consistency of the results, it is evident that little consumption of phosphate is occurring within the distribution system, which is expected for a system that has established a coating. However, as discussed, orthophosphate for lead control is optimal at a pH between 7.2 and 7.8, and higher values give preference to binding with other cations (such as calcium and magnesium) over lead. Since Shalersville operates at a pH of 8.2 to 8.3, the addition of orthophosphate is effectively doing little for prevention of lead corrosion. This is not, however, to suggest that lead corrosion is occurring, as higher pH will effectively mitigate corrosion. Similarly, polyphosphates are optimal below a pH of 8.0 for other metal sequestration. Once again, operating at a lower pH would be recommended in order to effectively utilize the currently fed corrosion inhibitor.

Recommendation:
The corrosion inhibitor is less effective at the elevated pH, and pH should be lowered to realize its benefit.

3.4.2 Coupon Study

The County performed a coupon study using Shalersville WTP water for lead, copper, and mild steel, the results of which are provide in Appendix B and summarized in Table 3-5 below.

Table 3-5 Summary of Shalersville WTP Coupon Study

Trial Period	Lead (mils/year)	Copper (mils/year)	Steel (mils/year)
6-21-17 to 8-17-17	0.10	0.4058	8.0865
8-17-17 to 10-12-17	0.30	0.5126	11.0241
10-12-17 to 12-14-17	-	0.5229	12.102
Average	**0.20**	**0.480**	**10.404**

Lead and copper corrosion is considered mild based on these test results. Although steel is observed at a higher rate, the results do not have significant meaning for the Streetsboro water system, as there are no steel pipes. Steel and ductile/cast iron pipes both primarily contain iron oxides, but the carbon content of cast/ductile iron is much higher than steel, making corrosion results incomparable. Values of CSMR above 0.6 have been noted to increase steel corrosion, which may be helping facilitate steel corrosion in this case.

3.4.3 Pipe Materials and Corrosive Soils

Although changes in water chemistry can be implemented to help prevent corrosion inside of pipes, there is also the possibility or risk of pipes (or bolts / fittings) corroding from the outside due to corrosive soils or backfill conditions. AECOM contacted the Natural Resources Conservation Service to obtain 2018 soil survey data, and subsequently generated a soil acidity map for Streetsboro using the NRCS Web Soil Survey application tool. This map is presented as Figure 3-10 on the following page. City-wide soil acidity is generally neutral with some pockets of moderately alkaline (pH 7.9 to 8.4) and moderately acidic (pH 5.6 to 6) soils. However, there are areas of strongly and very strongly acidic soils (pH 4.5 to 5.5). These predominantly exist in the (largely undeveloped) eastern and southeastern regions of the City limits, although some pockets are found in other areas.

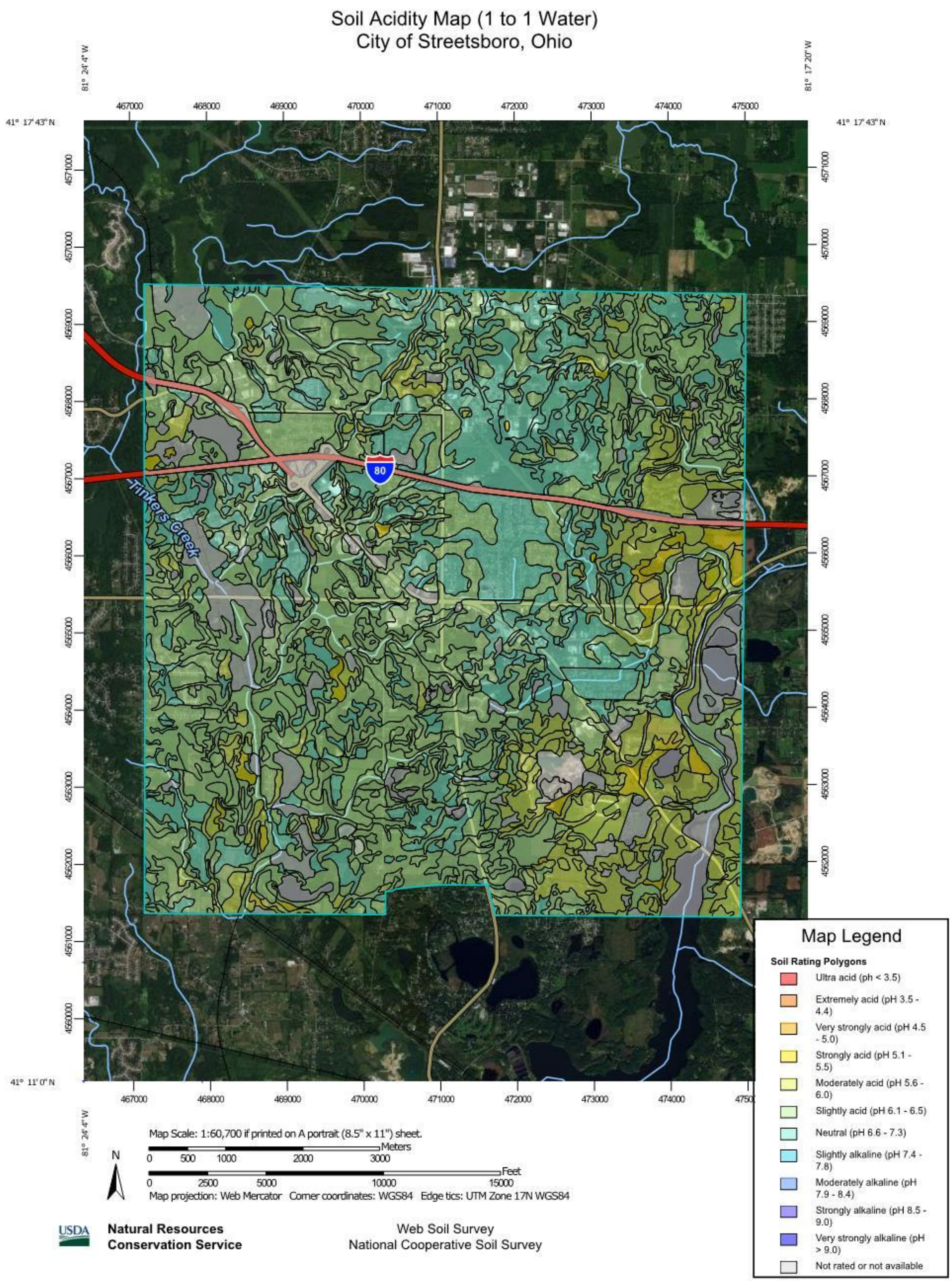


Figure 3-10 Soil Acidity Map (1973 Study)

The City also noted that certain areas have waterlines where limestone backfill was used during construction. As limestone dissolves in groundwater, it can produce alkali water which can be corrosive to metals. These areas include the Interstate Commerce Center industrial park area and Seasons Road. Specifically, the City has noted that the nuts/bolts on the fittings of this piping experience severe corrosion. The cast or ductile iron pipes in these areas would be the material most susceptible to accelerated corrosion due to pH, and a map of the City waterlines by pipe material is provided in Appendix A as Figure 2.

As a solution, it is generally not financially feasible to perform system-wide replacement of cast or ductile iron pipes with corrosion resistant materials such as PVC, unless the pipe actually experiences a catastrophic failure and needs replaced. A better solution may be for the City to intermittently install cathodic protection on cast or ductile pipes any time these lines are exposed for spot repair of leaks. This is known as 'hot spot' cathodic protection and typically costs $200 to $400 for a magnesium anode bag and wire (depending on the size of the bag), which is a relatively small cost compared to the total cost of waterline excavation and repair. This would be especially beneficial in slowing down the rate of corrosion in areas with highly acidic or alkali backfill materials. In the event of large-scale failure, replacement, or new water construction projects, it is recommended that the City replace cast or ductile iron pipes with PVC at that time. A general guideline of areas containing ductile or cast iron waterlines in corrosive backfill conditions to consider are as follows:

> **Recommendation:**
> When performing spot-repairs of cast or ductile iron pipes, the City should install cathodic protection. Larger-scale repair of cast or ductile iron pipe should involve replacement with PVC.

- Diagonal Road north and south of Route 14, including the Huntington Valley Subdivision (acidic soils).
- Hudson-Aurora Road south of Interstate 480, including the southern waterline extension along the railroad tracks towards Interstate 80 (acidic soils).
- Tinker's Green Subdivision area (acidic soils).
- Shawnee Trail subdivision area (acidic soils).
- Areas with limestone backfill (Commerce Center Industrial Park and Seasons Road)

Regarding waterline materials and replacement, most of the piping within the City is not necessarily approaching the end of its useful life (See 2019 Asset Management Plan by AECOM). However, there are certain pipe materials more prone to failure than others. This would specifically include a small section of Permastran piping in the northwest area and any cast iron piping. Permastran pipe is a fiberglass reinforced plastic material which the City has expressed is having ongoing maintenance issues and should ultimately be replaced. Cast iron pipes have also generally ceased in production and installation and are being phased out due to their tendencies to experience catastrophic failures. Although these pipe materials should ultimately be replaced by the City, they are not perceived to be causing major water quality issues unless a catastrophic failure occurs. With cast iron pipe, there is a possibility that these can make the water appear rusty in color. Although there are methods such as in-situ cement lining of cast iron pipes to alleviate this, continuing to perform flushing is perceived to be more cost effective until these lines are slated for replacement.

3.5 Waterline Replacement

AECOM completed an Asset Management program for the City in the fall of 2018, which provided information pertaining to all City-owned waterlines, including age, material, and estimated cost for replacement. Although the complete summary is available in this Asset Management plan, a prioritized list of waterlines and their associated replacement cost is included in this report.

The City has identified several priorities for waterline replacement. All cast iron pipes are a priority due to failure mechanisms and observed corrosion in areas with acidic soil or limestone backfill. Replacement of 1,100 linear feet of 12" ductile iron pipe along Seasons Road is a priority due to the moderately acidic nature of the soil and the importance of the pipe as a main line. Third, replacement of fiberglass reinforced pipe is also a priority due to age and required maintenance of the waterline. Because of high water pressure in the area of David Drive, Diane Avenue, Stewart Avenue, and Frost Road, the City is also considering installing pressure-reducing valves and expansion tanks at each home when replacing the fiberglass reinforced pipe. Table 3-6 indicates the High Priority waterline replacement due to the issues discussed above along with the estimated opinion of probable construction cost (EOPCC).

Table 3-6 High Priority Replacement Pipes

Street Name	Location	Dia. (")	Length	Year	Material	EOPCC Replace
Navajo Trl	Along Navajo Trl	6	958	1975	Cast Iron	$215,632
Seminole Trl	Navajo Trl to Seminole Trl	6	593	1975	Cast Iron	$133,473
Seminole Trl	South of Seminole Trl N	6	839	1975	Cast Iron	$188,809
Seminole Trl	Seminole	6	86	1975	Cast Iron	$19,451
Apache Pass	Cherokee Trl to Kickapoo Pass	8	1847	1972	Cast Iron	$415,483
Kickapoo Pass	Seminole Trl N to Apache Pass	6	568	1972	Cast Iron	$127,883
Cherokee Trl	Apache Pass to SR 43	8	449	1972	Cast Iron	$101,115
Steffner Dr	Evergreen Dr to Pike Pkwy	6	1425	1972	Cast Iron	$320,708
State Route 43	Along SR 43	6	138	1972	Cast Iron	$31,091
State Route 43	Along SR 43	6	692	1972	Cast Iron	$155,605
State Route 43	SR 43/Ohio Tpke	6	386	1972	Cast Iron	$86,772
State Route 43	North of Cecil Dr	8	189	1979	Cast Iron	$42,506
Cecil Dr	SR 43 to Gerald Dr	6	1175	1997	Cast Iron	$264,438
Walker Dr	Briar Dr to Luke Dr	6	402	1998	Cast Iron	$90,468
Gerald Dr	Cecil Dr to Russell Dr	6	1471	1992	Cast Iron	$331,072

Russell Dr	SR 43 to Gerald Dr	6	1182	1998	Cast Iron	$266,022
Frost Rd	West of Rodney St to Greenhaven St	12	2691	1981	Fiberglass Reinforced	$672,697
Edmond Ave	West of Rodney St	10	539	1982	Fiberglass Reinforced	$134,682
Frost Rd	In Water Vault Frost Rd at Greenhaven St	4	14	1996	Cast Iron	$3,103
State Route 303	Along SR 303	4	12	2000	Cast Iron	$2,681
David Dr	Rodney St to Greenhaven St	6	2134	1981	Fiberglass Reinforced	$480,188
Green Haven St	Frost Rd to Diane Ave	6	927	1981	Fiberglass Reinforced	$208,561
David Dr	Along David Dr between Frost Rd/Rodney St	8	1541	1981	Fiberglass Reinforced	$346,717
Rodney St	David Dr to Edmond Ave	8	801	1982	Fiberglass Reinforced	$180,271
Stewart Ave	Up Rodney St to East of Raymond St	6	1419	1982	Fiberglass Reinforced	$319,366
Diane Dr	Rodney St to Greenhaven St	6	2155	1982	Fiberglass Reinforced	$484,920
Raymond St	Diane Ave to Stewart Ave	6	491	1982	Fiberglass Reinforced	$110,579
Seasons Rd	Between Seasons Rd and SR 43	12	101	1979	Ductile Iron	$25,225
Seasons Rd	South of Clark Rd to SR 43	12	11078	1994	Ductile Iron	$2,769,405

In addition to the High Priority waterlines, the City has approximately 18,000 linear feet of ductile iron pipe with an estimated useful life remaining of 10 years or less. Many of these pipes, however, have a relatively low consequence of failure and were not identified as high priority by City staff. Based on the limited number of breaks and maintenance, these ductile iron water mains appear to be in relatively good condition. The estimated useful life of ductile iron pipe can range from 50 years in corrosive soil conditions to 110 years in favorable soil conditions. The City has opted to focus initially on the high priority cast iron and fiberglass reinforced pipes which have had identified maintenance problems. Note that at the time of this report, a rate study is being conducted by AECOM (to be finalized in 2019) and will be developed to provide funds in reserve to cover the cost of replacing a portion of the ductile iron waterlines as they reach the end of their estimated useful life. Table 3-7 summarizes the ductile iron waterline in the City that has an estimated useful life remaining of less than 10 years and the associated EOPCC for replacing the waterline.

Table 3-7 Pipes with an Estimated Useful Life Remaining of 10 Years or Less

Street Name	Location	Dia. (")	Length	Year	Material	EOPCC Replace	Estimated Useful Life Remaining (years)
Luke Dr	Tower Dr to Page Rd	6	591	1972	Ductile Iron	$133,087	3
Kickapoo Pass	To Apache Pass	6	766	1975	Ductile Iron	$172,280	6
Alden Dr	Gloucester Rd to N Delmonte Blvd	8	989	1976	Ductile Iron	$222,574	7
Hazelton Rd	To Alden Dr to Montclair Dr	8	1860	1976	Ductile Iron	$418,525	7
N. Delemonte Blvd	Frost Rd to Sparrow Run	8	2681	1976	Ductile Iron	$603,173	7
Montclair Dr	West of Hazelton Rd to N Delmonte Blvd	8	798	1976	Ductile Iron	$179,635	7
Crane Centre Dr	SR 43 to Crane Centre Dr	8	1395	1976	Ductile Iron	$313,875	7
Page Rd	North of Luke Dr	6	395	1976	Ductile Iron	$88,987	7
Cherokee Trl	Shawnee Trl to Apache Pass	8	1264	1976	Ductile Iron	$284,404	7
Apache Pass	To Cherokee Trl	8	293	1976	Ductile Iron	$65,976	7
State Route 14	To SR 14	6	80	1976	Ductile Iron	$18,083	7
Poston Rd	Frost Rd to Delores Dr	8	472	1977	Ductile Iron	$106,209	8
Delores Dr	Left fork of Delores Dr	8	443	1977	Ductile Iron	$99,657	8
Maplewood Ct.	Maplewood Ct	8	46	1978	Ductile Iron	$10,420	9
Highland Way	Frost Rd to Vantage Way	8	1205	1979	Ductile Iron	$271,171	10
Vantage Way	To SR 43	8	1516	1979	Ductile Iron	$341,133	10
Highland Ct	To Highland Way	8	242	1979	Ductile Iron	$54,391	10
Woodside Ct	To Highland Way	8	317	1979	Ductile Iron	$71,260	10
State Route 14	At Intersection of SR 14 to SR 43	12	53	1979	Ductile Iron	$13,129	10
Portage Pointe Dr	Along Portage Pointe Drive	8	488	1979	Ductile Iron	$109,845	10
Seasons Rd	Between Seasons & SR 43	12	101	1979	Ductile Iron	$25,225	10

Russell Dr	Along Russel Dr between - Dorothy Dr/Gerald Dr	8	459	1979	Ductile Iron	$103,317	10
State Route 14	9364 SR 14	6	88	1979	Ductile Iron	$19,752	10
State Route 14	9550 SR 14	6	93	1979	Ductile Iron	$20,814	10
State Route 14	9705 SR 14	6	13	1979	Ductile Iron	$2,822	10
Mt Vernon Dr	9130 Mt. Vernon Dr	6	27	1979	Ductile Iron	$6,114	10
Evergreen Dr	Along Evergreen Dr between SR 43/Ellen Dr	8	908	1979	Ductile Iron	$204,212	10
State Route 14	9202 SR 14	6	94	1979	Ductile Iron	$21,163	10
State Route 14	9160 SR 14	6	89	1979	Ductile Iron	$20,020	10
State Route 14	9127 SR 14 in island across the street.	6	86	1979	Ductile Iron	$19,238	10
State Route 14	9052 SR 14	6	66	1979	Ductile Iron	$14,781	10

3.6 Flushing Evaluation

A final consideration of this study was to evaluate the City's biannual flushing procedure which started in 2018. The City provided AECOM their flushing protocol which gives step-by-step instructions of valve closures (to create isolated zones) followed by the order in which hydrants are flushed. A single flushing event flushes all 929 City-owned hydrants in addition to a large portion of 1,389 privately-owned hydrants. Prior to 2018, the City had employed some hydrant flushing, but this did not include specifically isolating zones and may have been limited in effectiveness. Since starting the robust flushing regime, the City has performed three such flushes and the fourth is scheduled for fall of 2019. This renewed flushing effort has likely removed decades of accumulated sediment from the waterlines. In fact, the City even notes that recent fire department activity (which can often stir sediment) has resulted in no customer complaints. In previous years, fire department activity would almost always result in complaints of water discoloration.

The primary purpose of flushing is to scour and remove sediment from waterlines. It should be noted that several of the recommendations in this report are expected to reduce formation and build-up of sediment and scale. However, they are not expected to completely eliminate these issues and flushing is still good practice for systems of this size. The American Waterworks Association (AWWA) Standard recommends achieving a water velocity of 2.5 feet per second to scour loose sediments and 5 feet per second for removal of cohesive and loosely adhered particles and biofilm. Figure 3-11 provides a graphical representation of flows and corresponding velocities for pipe diameters ranging from 4 to 16 inches, which covers the diameters of pipes within the City distribution system.

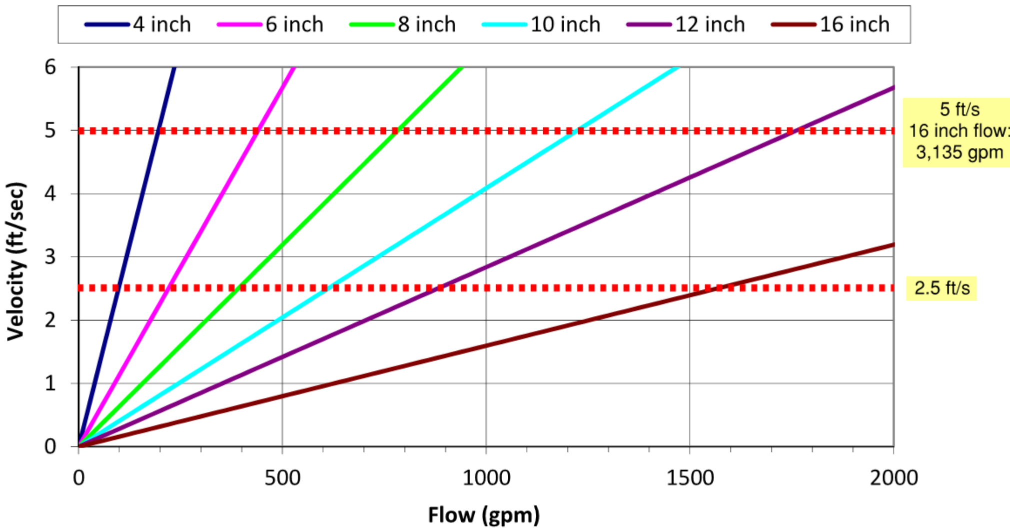


Figure 3-11 Pipe Velocity and Flow

The graph provides a reference for the hydrant flow needed to achieve minimum velocities in a single pipe / direction of flow. Since the City individually flushes all 929 of their hydrants and many privately-owned hydrants, it is doing an excellent job of achieving single-direction flow. The City has noted that a flushing event costs nearly $50,000 in labor (including overtime), water use, and miscellaneous repairs. With customer complaints having ceased since completion of the recent flushes, there may be an opportunity to dial back the flushing efforts. During the upcoming flush (fourth event in the now-biannual protocol), the City should conduct visual sediment tests by collecting water from the hydrants in a white container. If water is running clear after the first few seconds, a flush is likely not needed. If little or no sediment is observed throughout the system, the majority of the lines should be able to be reduced to flushing once per year. However, it would still be good practice to continue flushing cast iron lines on a biannual basis, as these can be prone to discoloring water. The City has a limited amount of cast iron waterlines and they primarily exist in the residential neighborhoods south of the turnpike along Pike Parkway and Apache Pass.

> **Recommendation:**
> If results of the upcoming flush show little sediment release, the City could consider reducing the flushing to once per year (with the exception of cast iron pipes).

4 Summary of Recommendations

This study has identified possible causes of water quality issues along with mitigation strategies. These are summarized in Table 4-1 below.

Table 4-1 Summary of Recommendations

Item	Description	Report Section	Impact	Action by
1	Continue to negotiate with EPA to lower pH to 7.6 ±0.2. This will reduce TTHM formation, reduce scaling, make phosphates more effective, and increase buffer intensity.	3.3.4	High	PCWR
2	PCWR and County to perform sampling of chlorine residual to verify City meters are accurate and if residual consumption is occurring. If residual consumption is occurring, PCWR to investigate.	3.3.2	High	PCWR & City
3	City should continue automatic flushing. Consider adding a fourth flusher on SR 14 if chlorine residual is an issue here. An estimate of flushing 5,500 gallons daily is required to reduce age between 9 & 10 days	3.2.1	Med.	City
4	PCWR should perform TOC sampling at the Shalersville wells to identify any elevated levels. If specific wells are high, use less frequently in warmer months.	3.3.3	Med.	PCWR
5	City to install a mechanical ventilation system on the tank to allow for proper operation of the spray system; and replace the circulation pump and piping.	3.2.2	Med.	City
6	City should continue to perform manual flushing, but may have an opportunity to reduce to once per year instead of twice. Investigate sediment release during next flush.	3.6	Med.	City
7	City to consider installing cathodic protection on cast and ductile iron lines when performing spot repairs (hot spot cathodic protection).	3.4.3	Med.	City
8	City to generally follow guidelines of Asset Management Plan and consider prioritizing replacement of cast iron and Permastrand piping.	3.5	Med.	City
9	PCWR and City to investigate accuracy of City's hardness and phosphate residual analyzers.	3.3.1 & 3.4.1	Low	PCWR & City
10	City to consider replacing an 8-inch check valve isolating the Tinker's Green pressure zone with a pressure reducing valve.	3.1	Low	City
11	City to considering issuing public notices on tips for operating and maintaining water heaters or appliances to prevent premature failure.	3.3.1	Low	City

Appendix A – Distribution System Maps

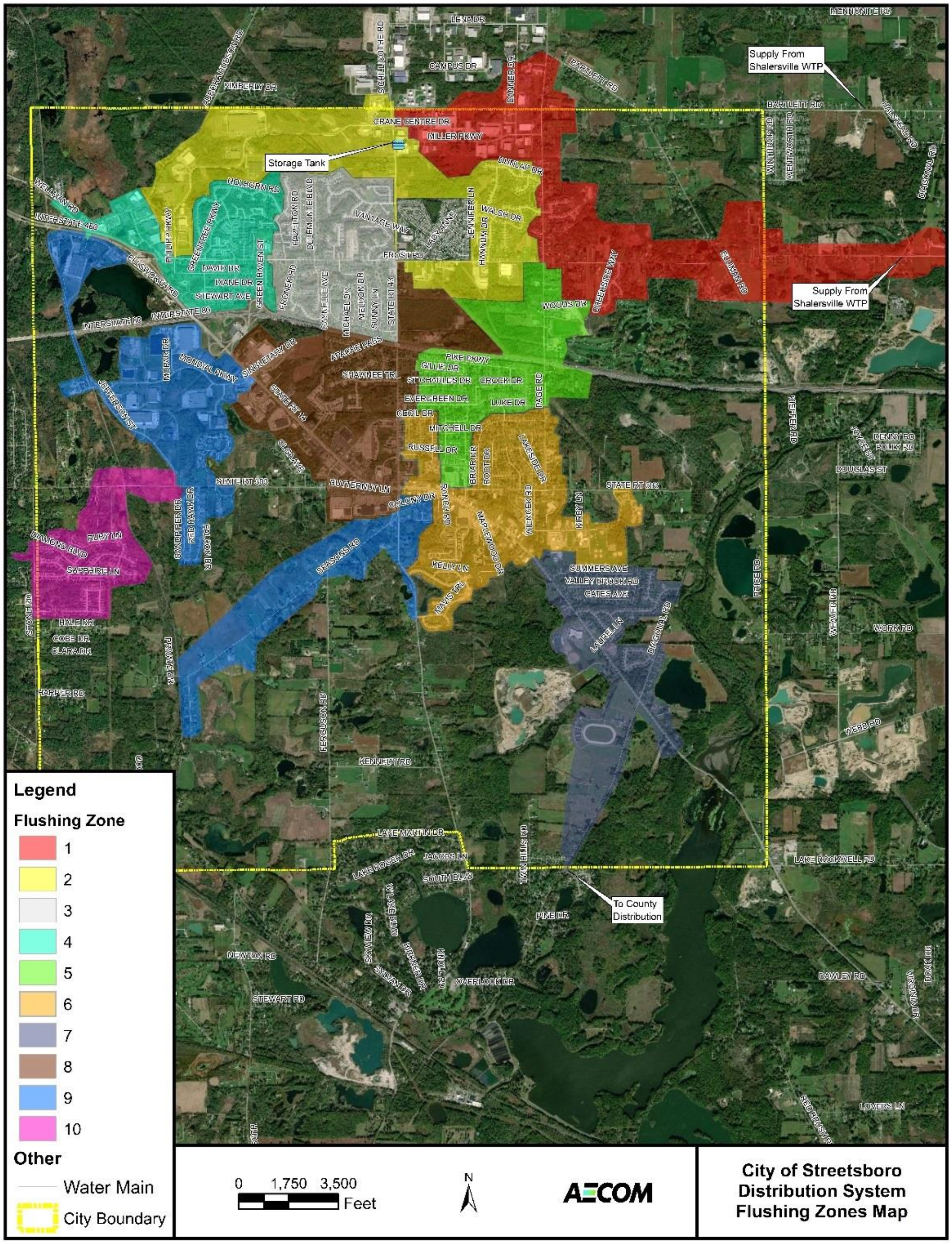


Figure 1 Hydrant Flushing Zones

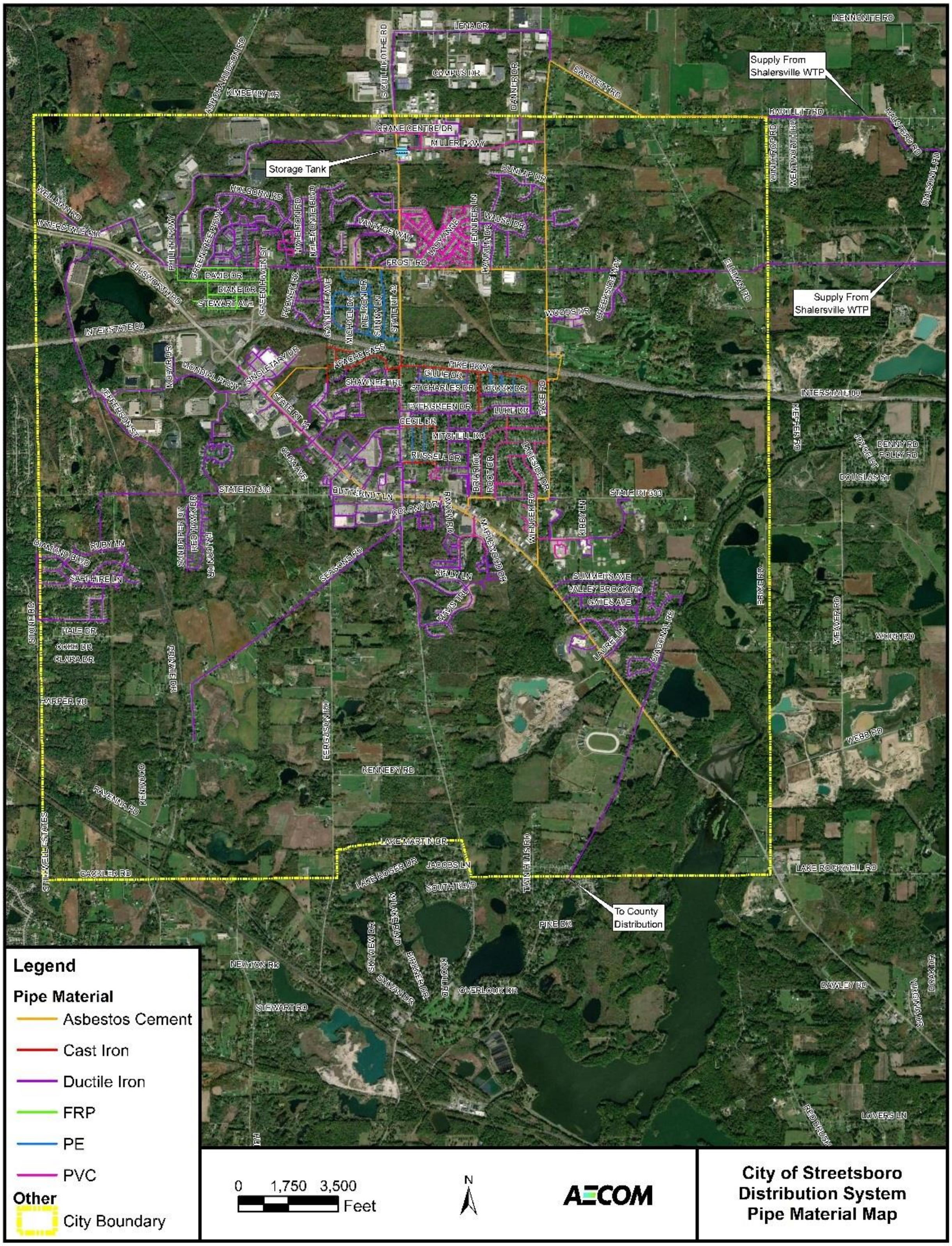


Figure 2 Pipe Material Map

Appendix B – Shalersville Operational Data