Update to the City of Dover Water Master Plan

City of Dover, Delaware

July 29, 2021

RFP No. 21-0013WW

DRAFT FINAL

0 Executive Summary

The City of Dover (the City) Department of Water and Wastewater provided water to approximately 11,125 residential users, and 1,370 commercial and industrial users in 2020. The system is fed by twenty one (21) wells; fifteen (15) deep wells which pump directly into the distribution system and six (6) shallow wells which supply water to the City's 3 million gallon per daty (MGD) water treatment plant. Seven (7) elevated water towers maintain system pressures and provide fire and emergency storage. The distribution system consists of approximately 233 miles of pipe comprised of a variety of materials, sizes, and ages.

This updated Water Master Plan incorporates a new 20-year projection for the City's population and water demand through 2040. Included is a complete re-evaluation of the water system which entails:

- A review and update of the projected water demands
- Review of available water from the Columbia, Piney Point and Cheswold aquifers including research for aquifer recharge
- Review of the City's existing elevated water tower inspection reports
- Inspection of the existing well facilities and water treatment plant
- Update to and calibration of the City's existing hydraulic water model to perform hydraulic analysis on the distribution system
- Hydraulic analysis of water age as an indicator of water quality to address concerns
- Evaluation of existing operating procedures including public outreach

Results of the water supply, storage, and distribution system evaluations will be presented in the recommended Capital Improvement Plan (CIP).

0.1 Water Demands

Whitman, Requardt, and Associates, LLP (WRA) reviewed water meter records from 2018 to 2020 to calculate actual water consumption by zoning category. 2020 consumption data was not included in the analysis due to the effect of the COVID-19 pandemic on water usage. Data available for use in calculating future system water demands included residential population projections from the City's 2019 Comprehensive Plan and the State of Delaware's 2020 Population Consortium, and a list of proposed residential and industrial developments provided by the City. Unit demands were calculated utilizing the current population and residential demand as well as current commercial and industrial demands and total acreage, and these unit demands were applied to future population and industrial/commercial acreage. **Table ES-1** and **Figure ES-1** illustrate the projected water demands for the City through 2040, and the detailed demand analysis is included in the **Appendices**.

Table ES-1 – Projected Water Demands

Year	Residential Water Demand (MGD)	Commercial Water Demand (MGD)	Industrial Water Demand (MDG)	Total Average Day Demand (MGD)	Maximum Day Demand (MGD)
2019	2.35	1.45	1.37	5.16	7.79
2025	2.47	1.62	1.75	5.84	8.82
2030	2.55	1.67	2.55	6.77	10.22
2035	2.61	2.01	2.87	7.49	11.34
2040	2.68	2.35	3.19	8.22	12.41

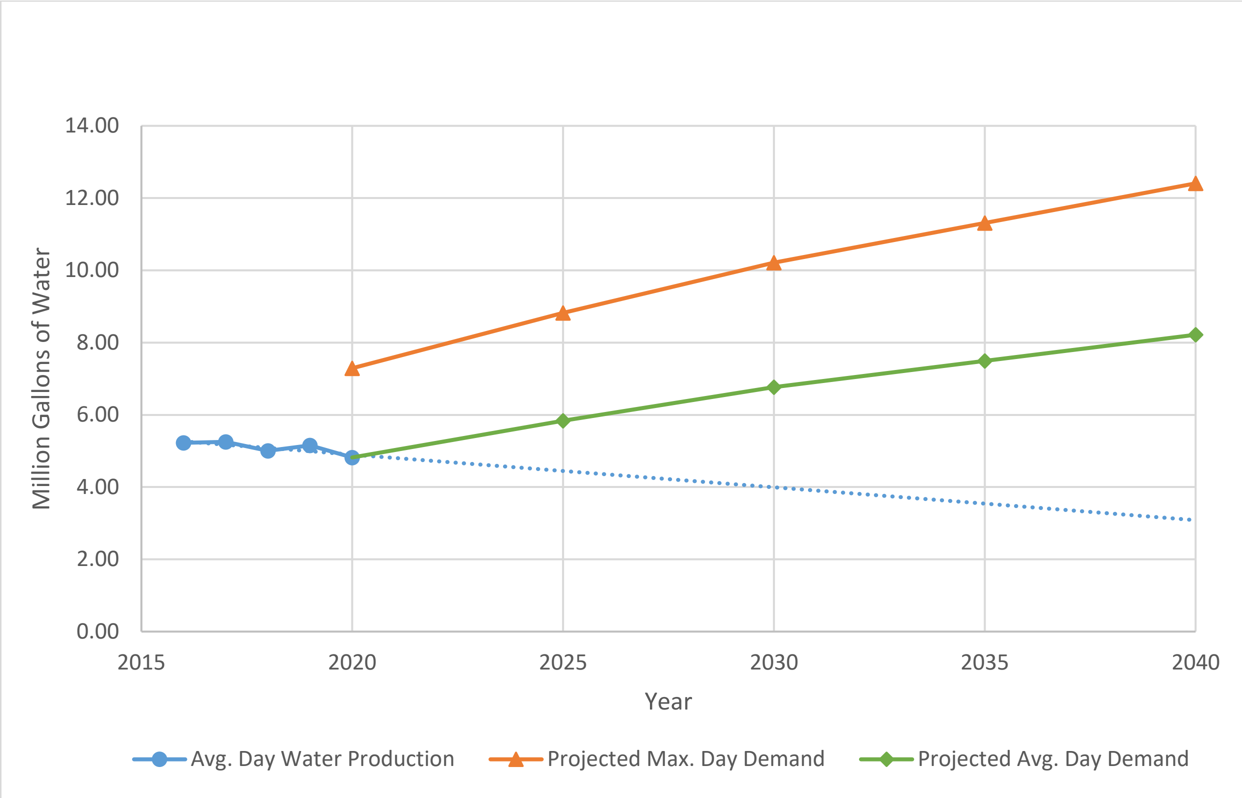


Figure ES-1 – Projected Water Demands

0.2 Water Supply

Groundwater is the sole source of water for Dover. The City of Dover uses the following aquifers (from shallowest to deepest): the Columbia Aquifer, the Cheswold Aquifer, and the Piney Point Aquifer. Water from the deep (confined aquifer) wells in the Cheswold and Piney Point Aquifers is dosed with chlorine and fluoride (Cheswold only) and pumped directly into the distribution system. Water from the shallow (unconfined) Columbia Aquifer wells supply the City's water treatment plant.

The elevations of the potentiometric surfaces in the confined aquifers have dropped from their pre-development levels in response to decades of groundwater pumping by multiple users including the City of Dover. The City has indicated that it plans to manage aquifer withdrawals to address their influence on saltwater intrusion in the Columbia Aquifer, protection of the Cheswold Aquifer, and depletion of the Piney Point Aquifer. The management would entail reduction in use from specific aquifers during certain times of the year. Based on safe yield of all wells, the City has sufficient capacity to meet projected average daily demands. However, additional wells are required to meet future demands as part of the planned aquifer management (**Figure ES-2**).

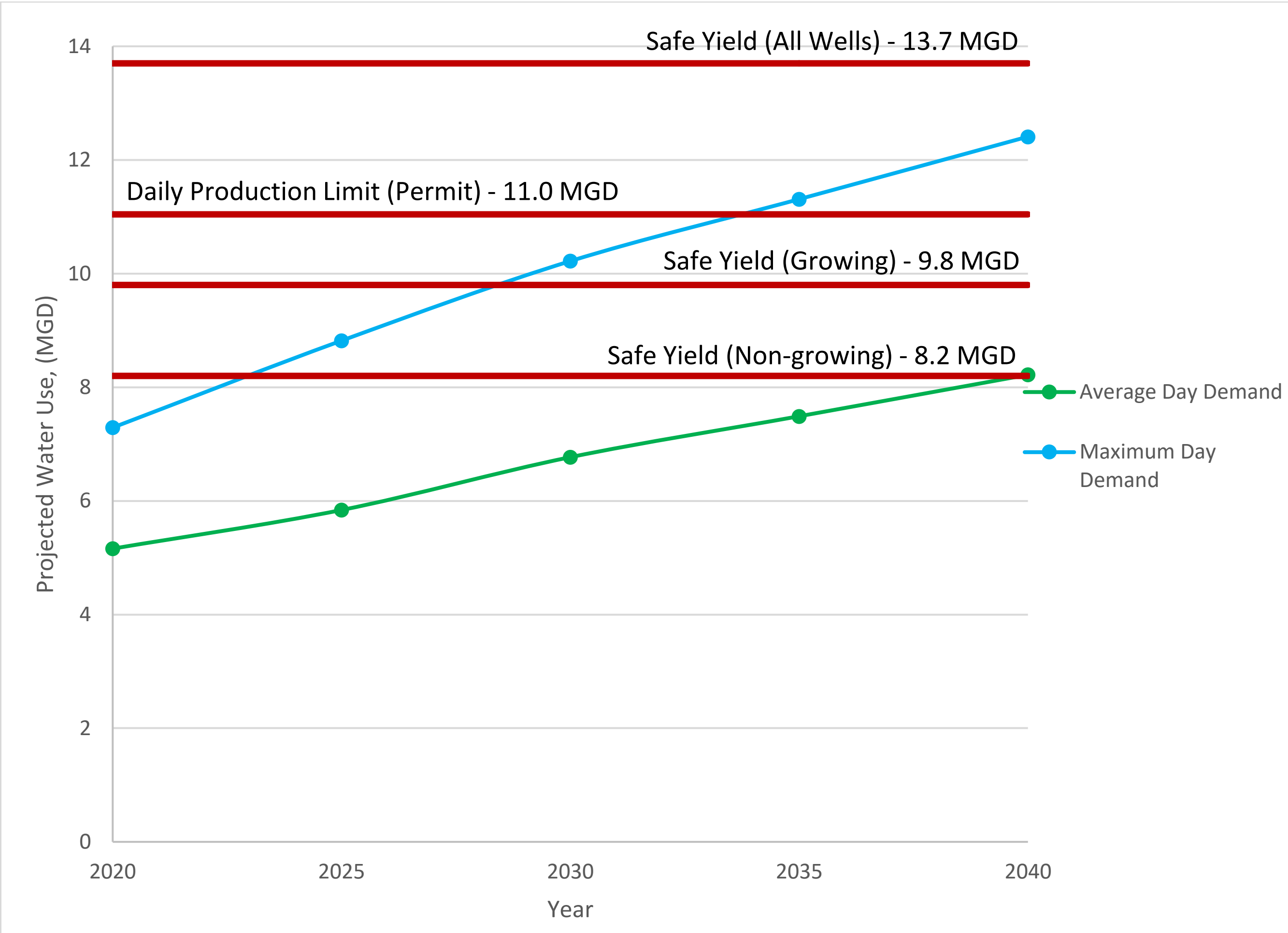


Figure ES-2 – Safe Yield vs. Projected Demands

Surface water is an additional potential drinking water source for the City. Aquifer Storage and Recovery (ASR) is a possible option which would allow seasonal water storage during wet times of the year and recovery and use during dry periods. Discussions with DNREC need to be initiated soon if the City is interested in pursuing this option, as the approval process can be lengthy.

Water supply facility inspections were conducted by WRA mechanical and electrical engineers for all active well houses and the Water Treatment Plant. Reports are included in the **Appendices**, and recommended improvements were summarized and included in the CIP.

0.3 Water Storage and Distribution

Recent water tank inspection reports performed by the City's tower maintenance consultant for the City's seven water towers were reviewed by WRA. Guidelines for future tower inspections, as well as a list of additional maintenance activities was provided. Calculations were also performed to compare theoretical water storage needs with the City's existing storage volume and indicated that the City has sufficient storage to meet demands through 2040.

The City's water distribution system consists of 233 miles of piping, with various sizes and materials. Evaluation of the distribution system was performed with the hydraulic model, which is discussed below.

0.4 Hydraulic Modeling

At the start of this effort, the City provided WRA with the latest version of their hydraulic water model. WRA updated the model with recently constructed pipeline projects, checked elevations and connections, adjusted well pump curves and well and tank water levels/elevations, added and distributed demands for all time steps (current through Build-Out), and calibrated the model based on recent hydrant flow data.

Following update of the hydraulic model, a series of simulations were performed to evaluate system operations such as pressures and pipeline velocities, available fire suppression flows and residual pressures, and system water age as an indicator of water quality. Recommended improvements were included in the proposed Capital Improvement Plan.

Modeling results indicate that under MDD the current distribution system, wells, and operational scheme can maintain pressures and velocities in the system until hydraulic Year 2035. In Year 2035, the addition of demands associated with Category 3 annexation lands results in a large enough increase to warrant additional water sources. Available fire flow within the older portions of the City is limited by allowable velocities, specifically in old small diameter cast iron lines. Replacement of these mains results in an increase in available fire flows.

In general, water age in the majority of the distribution system remains below 2 days throughout all hydraulic timesteps. Comparison of water quality complaints to current water age and existing piping materials seems to indicate a stronger correlation between brown water complaints and older cast iron mains than retention times in the system. Throughout the water quality modeling scenarios, at least half of the in-service tanks experience water ages greater than 5 days due to low tank cycling. Overall water age within the tanks decreases as demand increases in the system. The greatest reduction in water age within tanks is observed due to increased tank cycling and it is recommended that the City modify system controls to promote deeper tank cycling in their larger volume tanks. It is also possible that when resting wells for aquifer management purposes, the City coordinate these out of service wells with nearby higher age Tanks to cause increased draw down.

0.5 Capital Improvement Plan

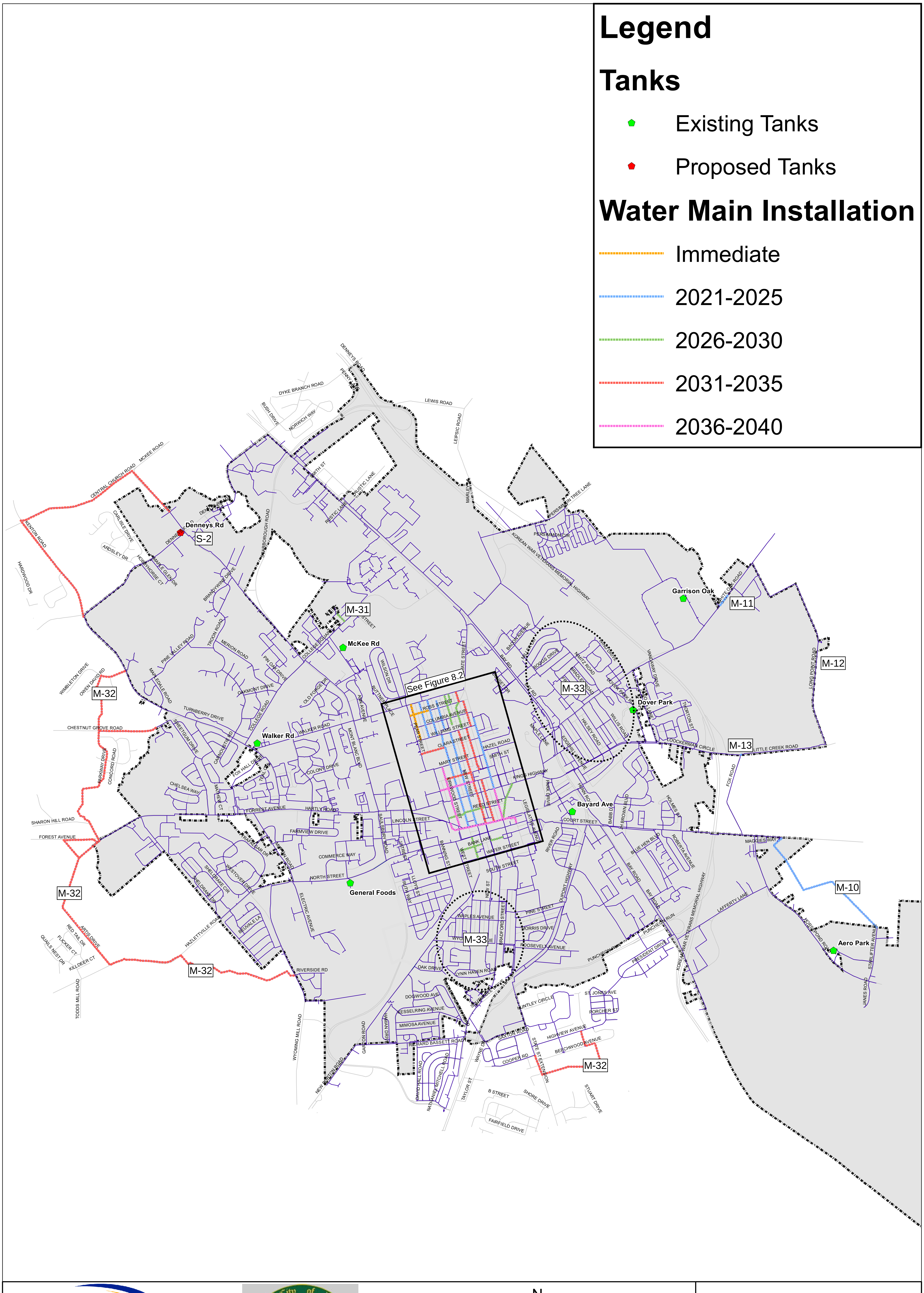
Recommended improvements to facilities or operations, studies, or evaluations shown to be needed by the hydraulic modeling results, water source review, and existing facility investigations are summarized in this Capital Improvement Plan (CIP). Projects have been given designations based on system type: RS for raw water supply, T for water treatment, M for distribution mains, S for storage tanks and O for operations. The proposed CIP is shown below in **Table ES-2** and illustrated in **Figure ES-3**.

Table ES-2 - City of Dover, DE Capital Improvement Plan Costs						
Project Number	Project Description	Project Cost				
		Immediate	2021-2025	2026-2030	2031-2035	2036-2040
	RAW WATER SUPPLY (RS)					
RS-1	Test Well/Development/Production Well				$ 200,000	$ 200,000
RS-2	General Wellhouse Maintenance		$ 45,500	$ 45,500	$ 45,500	$ 45,500
	WATER TREATMENT (T)					
T-1	Ventilation Improvements for electric equipment room	$ 25,000.00				
T-2	Eyewash / shower in hypochlorite room		$ 10,000.00			
T-3	Slope Backwash Tank floor to pump suction		$ 30,000.00			
T-4	Enhance Water Treatment Plant site security		$ 80,000.00			
	DISTRIBUTION MAINS (M)					
M-1	*940 LF, 8" DIP, Ross St*	*$ 199,271*				
M-2	*1600 LF, 8" DIP, N West St Alley West*	*$ 396,998*				
M-3	*3200 LF, 12" DIP, State St*		*$ 923,910*			
M-4	*1600 LF, 8" DIP, N West St Alley East*		*$ 322,920*			
M-5	*1600 LF, 8" DIP, Fairview Ave Alley West*		*$ 322,920*			
M-6	*1600 LF, 8" DIP, Fairview Ave Alley East*		*$ 322,920*			
M-7	*500 LF, 8" DIP, N Bradford St*				*$ 98,670*	
M-8	*4000 LF, 8" DIP, Queen St*		*$ 789,360*			
M-9	*4000 LF, 8" DIP, New St*		*$ 789,360*			
M-10	7000 LF, 12" DIP, S Little Creek Rd Loop to Starlifter Ave		$ 2,009,280			
M-11	600 LF, 10" DIP, White Oak Rd		$ 152,490			
M-12	20 LF, 16" DIP, Long Point Rd		$ 16,146			
M-13	80 LF, 16" DIP, North Little Creek Rd		$ 37,674			
M-14	*1400 LF, 8" DIP, Bradford St*				*$ 278,070*	
M-15	*1600 LF, 8" DIP, Kings HWY*			*$ 457,470*		
M-16	*2300 LF, 8" DIP, Reed St*			*$ 197,340*		
M-17	*1000 LF, 8" DIP, Queen St*			*$ 197,340*		
M-18	*2000 LF, 8" DIP, Bank Ln*			*$ 394,680*		
M-19	1300 LF, 8" DIP,Lakewood Pl Alley East			$ 260,130		
M-20	1200 LF, 8" DIP, Governors Bvld/N. Bradford St Alley West			$ 242,190		
M-21	1200 LF, 8" DIP, Bradford St Alley East				$ 242,190	
M-22	1000 LF, 8" DIP, Clara St				$ 197,340	
M-23	4000 LF, 8" DIP,Governors Ave				$ 789,360	
M-24	1600 LF, 8" DIP, Bradford St				$ 322,920	
M-25	1100 LF, 8" DIP, Cecil St				$ 224,250	
M-26	1500 LF, 8" DIP, Fulton St					$ 296,010
M-27	1300 LF, 8" DIP, State St					$ 260,130
M-28	2600 LF, 8" DIP, Kirkwood St					$ 520,260
M-29	3200 LF, 8" DIP, Loockerman St and Loockerman Pl					$ 636,870
M-30	300 LF, 8" DIP, Federal St					$ 62,790
M-31	540 LF, 8" DIP, College Rd			$ 114,816		
M-32	50,000 LF, 12" DIP, Southern and Western Annexation Lands				$ 7,176,000	$ 7,176,000
M-33	80,000 LF, Distribution main Cleaning and Lining		$ 3,737,500	$ 3,737,500	$ 3,737,500	$ 3,737,500
	STORAGE TANKS (S)					
S-1	Tank Maintenance Program		$ 500,000	$ 500,000	$ 500,000	$ 500,000
S-2	Denneys Road Tank (1.0 MG)				$ 3,000,000	
	OUTREACH (O)					
O-1	Community Outreach Evaluation		$ 20,000	$ 20,000	$ 20,000	$ 20,000
	TOTAL	**$ 621,269**	**$ 10,109,980**	**$ 6,166,966**	**$ 16,831,800**	**$ 13,455,060**

Notes:

1. Projects shown in *italics* are planned City projects scheduled for FY 2023 to FY 2026

PLANNING PERIOD TOTAL **$ 47,185,075**



Whitman, Requardt & Associates, LLP
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City of Dover, Delaware
Water System Master Plan

Figure ES-3
Capital Improvements Plan

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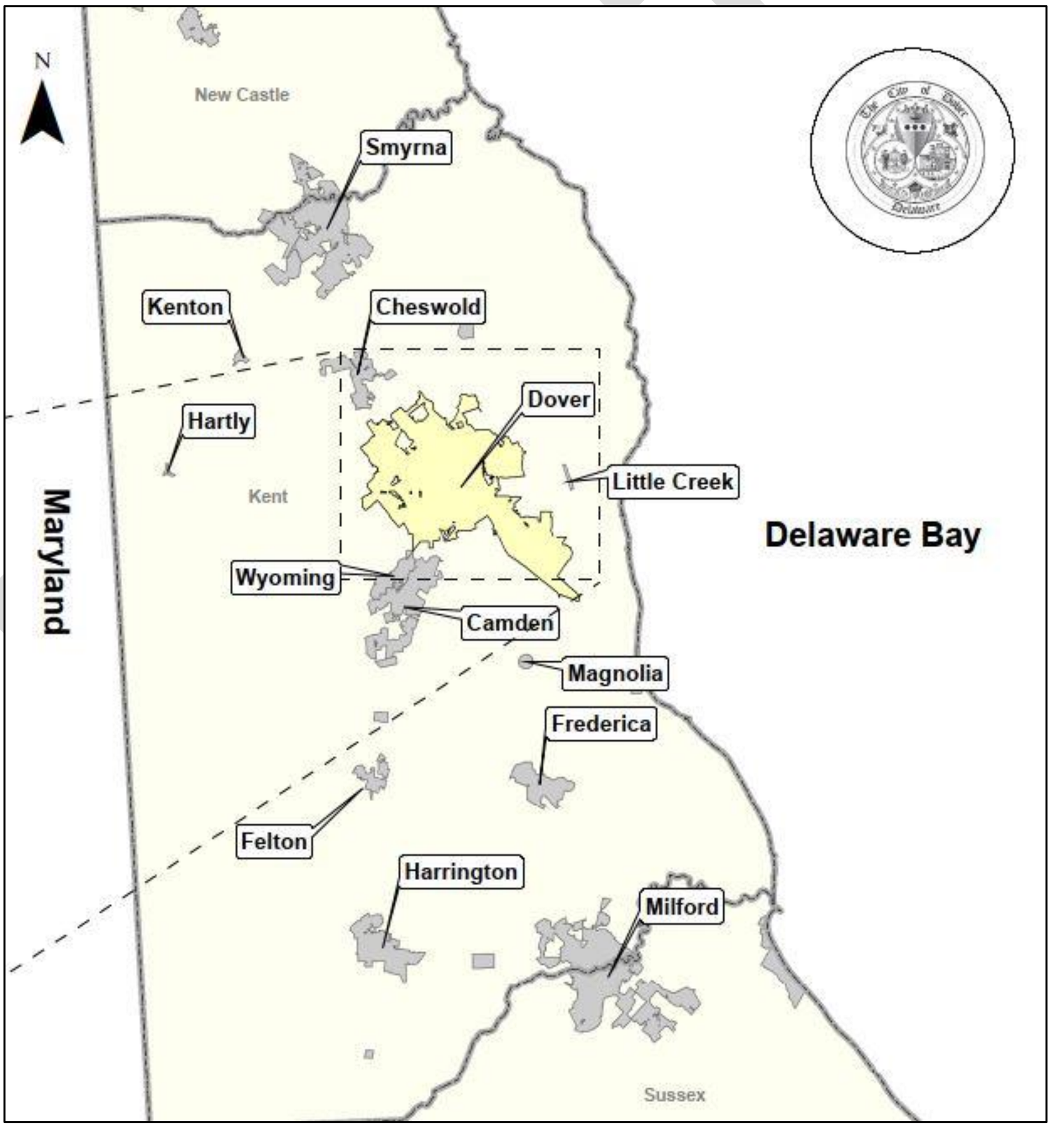
1 Introduction

The City of Dover (the City) is centrally located in Kent County, Delaware and is the state capital. In 2020, the City Department of Water and Wastewater provided water to approximately 11,125 residential users, and 1,370 commercial and industrial users (total of 12,500 accounts). It is anticipated that residential, commercial, and industrial growth will continue. Projections indicate a served population of 43,000 and an additional 5,216 acres of commercial and industrially zoned land will be annexed to the City's water service area by 2040. The system is currently fed by twenty one (21) wells (20 in service); fifteen (15) deep wells which pump directly into the distribution system and six (6) shallow wells which supply water to the City's 3 million gallon per day (MGD) water treatment plant. Seven (7) elevated water towers maintain system pressures and provide fire and emergency storage. The distribution system consists of approximately 233 miles of pipe comprised of a variety of materials, sizes, and ages.



Source: City of Dover, DE - 2019 Comprehensive Plan

Figure 1.1 – City of Dover, DE Location Map

In 2006, Whitman, Requardt and Associates, LLP (WRA) completed a Water Master Plan for the City which analyzed the City's water supply, storage, and distribution for a 20 year planning period through 2025 and provided recommended system improvements. WRA was retained by the City again to assemble an update to the City of Dover's Water Master Plan. This updated Plan incorporates a new 20-year projection for the City's population and water demand through 2040. Included is a complete re-evaluation of the water system which entails:

- A review and update of the projected water demands
- Review of available water from the Columbia, Piney Point and Cheswold aquifers including research for aquifer recharge
- Review of the City's existing elevated water tower inspection reports
- Inspection of the existing well facilities and water treatment plant
- Update to and calibration of the City's existing hydraulic water model to perform hydraulic analysis on the distribution system
- Hydraulic analysis of water age as an indicator of water quality to address concerns
- Evaluation of existing operating procedures including public outreach

Results of the water supply, storage, and distribution system evaluations are captured in the recommended Capital Improvement Plan (CIP). The CIP includes a recommended improvement implementation schedule and cost estimate.

1.1 Data Collection

The following is a list of the data and information that has been provided to WRA and utilized in the development of this plan:

- City of Dover, De – Maps of future annexation plans
- Fire hydrant flow testing data
- List of changes to the water system since the 2006 Master Plan
- City of Dover Comprehensive Plan
- Water allocation permits
- Well drawdown reports
- Pump test reports and curves
- Water purchase agreements
- Water quality reports
- Metered water consumption data
- Water production data
- City of Dover zoning maps
- Tank level data
- Pump operation tables
- Population projections

2 Water Demands

WRA first completed water demand projections for the City in 1985. These projections estimated the Year 2015 maximum day demand (MDD) to be 14.7 million gallons per day (MGD). Updated 20-year projections were completed for the 2006 Master Planning effort which resulted in a reduction of estimated maximum day demands to 13.72 MGD in Year 2025. As part of this update, WRA completed a new water demand analysis utilizing recent water production data, water meter consumption records, proposed developments, and proposed annexation land areas. The detailed water demand analysis and projections are included as the Master Plan Demand Projection Memorandum in **Appendix A**.

2.1 Historical Water Production

The City maintains detailed daily water production records from their groundwater wells. These records are more detailed than the totalized yearly water meter consumption data; therefore, production numbers have historically been utilized to establish the City's annual average day demand (ADD) and yearly maximum daily demand (MDD). These numbers are then analyzed to establish the average day to maximum day peaking factor (PF).

WRA received water production records from 2016 through the end of 2020. Calculations resulted in an annual average day production rate of 5.16 MGD and a maximum day production of 7.80 MGD. The average daily production to maximum day production peaking factor was then calculated using the following equation:

$$PF = \frac{Maximum\ Day\ Production}{Average\ Day\ Production}$$

The resulting PF is 1.51. This represents a reduction in the peaking factor from 1.7 which was utilized in previous modeling efforts. However, the data reviewed shows that yearly peaking factors for the most recent data sets range from 1.41 to 1.53. In addition, data from the 2006 Master planning effort was reviewed to establish water production trends. Comparing these data sets indicates that annual production rates have stayed relatively consistent while the yearly maximum day production rate has decreased (see **Figure 2.1**).

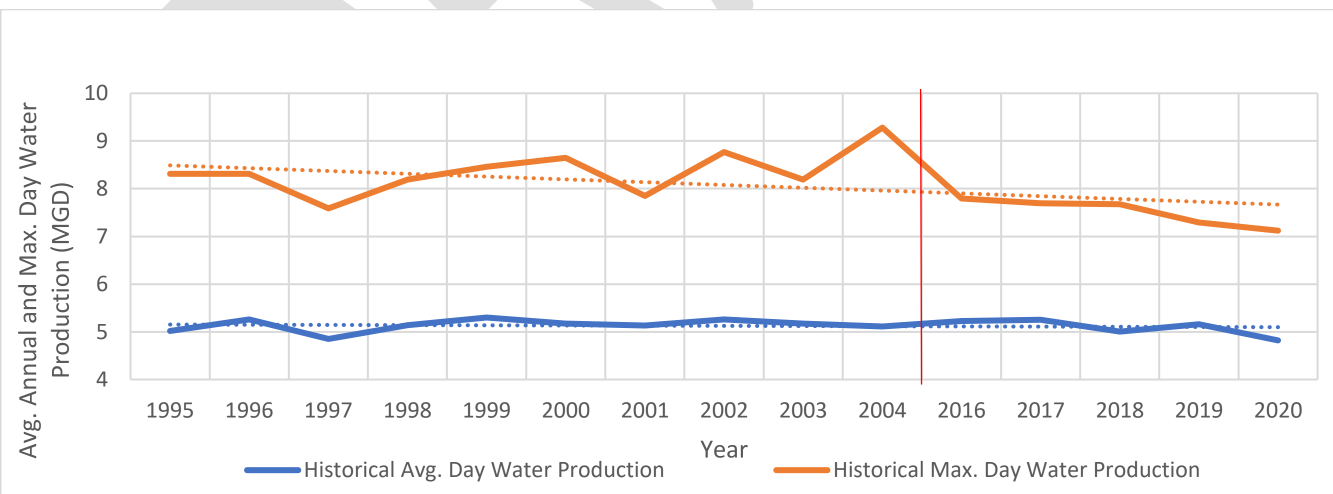


Figure 2.1 – Historical Water Production Trends

2.2 Water Demand Projection

WRA reviewed water meter records from 2018 to 2020 to calculate actual water consumption by zoning category. Based on the yearly meter reports, the total average day consumption for 2018, 2019, and 2020 is 4.56 MGD, 4.77 MGD, and 4.51 MGD, respectively. The largest portion of water consumed in Dover is from residential users followed by commercial (including office space) and industrial/manufacturing users. The remaining users make up less than 3% of the total water consumed in the City's service area.

To simplify water projection calculations, WRA merged the City designated zoning categories into three (3) types; residential, commercial, and industrial users. Merging categories resulted in a water use breakdown of approximately 45% residential consumption, 28% commercial consumption, and 27% industrial consumption. These percentages were then applied to water production numbers to account for any unaccounted for flows to ensure that the hydraulic modeling and improvement recommendations account for the full quantity of water needed to supply the system. This established a Current (Year 2019) average day water demand of 2.35 MGD for residential users, 1.45 MGD for commercial users and 1.37 MGD for industrial users.

Analysis of the 2020 data revealed differences in water production and consumption trends due to the Covid-19 pandemic as compared to the other yearly data sets. Therefore, while the data was included in the initial review, WRA did not utilize the 2020 data for demand projection calculations. In addition, the percentage of total water usage for 2020 attributed to residential accounts increased by approximately 13% as compared to previous years, which could be attributed to the related shift to work from home.

2.2.1 Projected Demands

Data available for use in calculating future system water demands included residential population projections from the City's 2019 Comprehensive Plan and the State of Delaware's 2020 Population Consortium, future land annexation areas from Maps 13-1: Potential Annexation Areas and 13-2: Potential Land Use for Annexation Areas found in the Comprehension Plan, and a list of 5 to 10 year residential and industrial developments provided by the City.

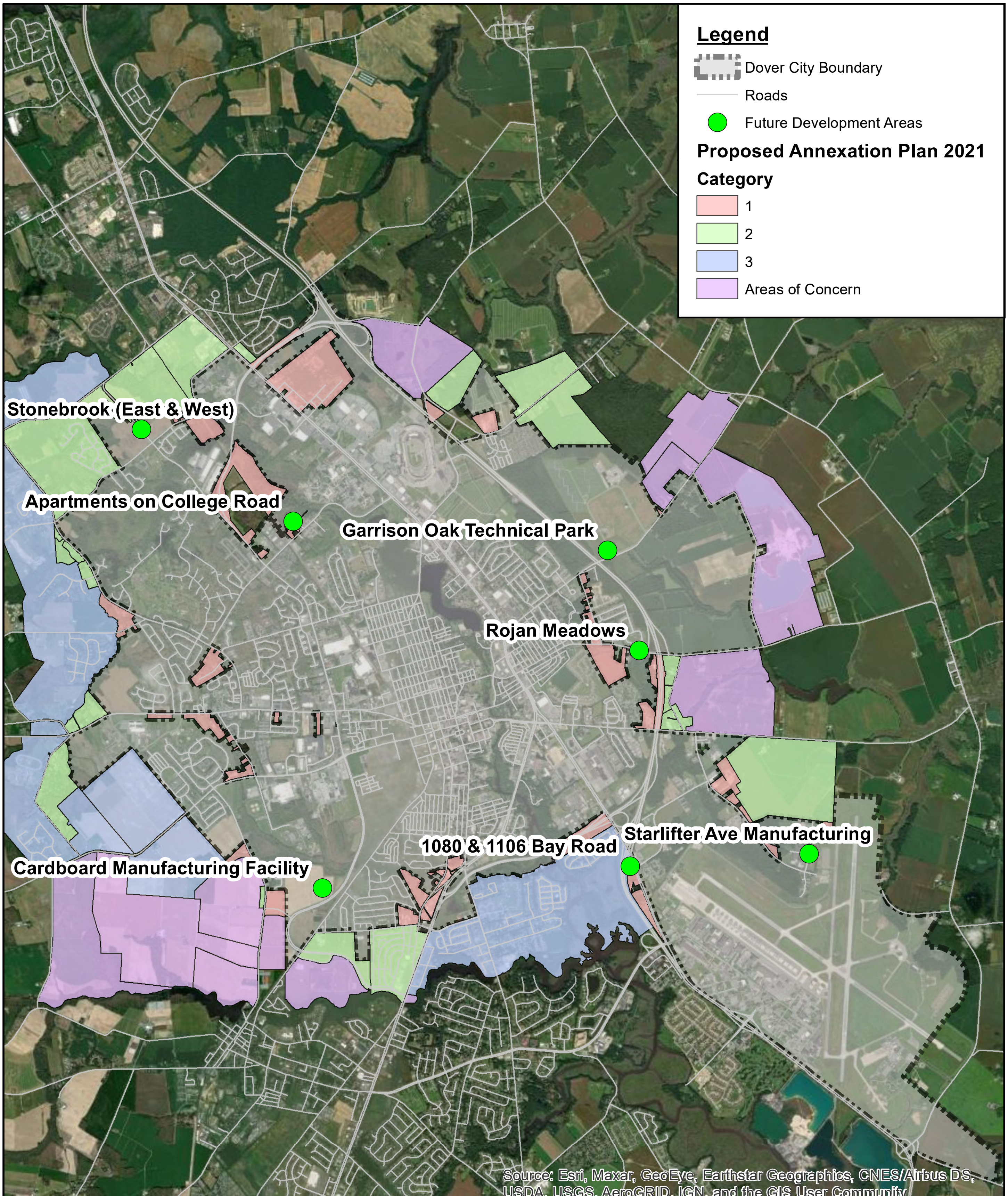
WRA calculated unit demands utilizing the current population and residential demand as well as current commercial and industrial demands and total acreage. A detailed explanation on the unit demand calculations can be found in **Appendix A**. These unit demands were then used to calculate future demands based on population projections and future annexed land areas. Land annexation areas are categorized as Category 1, 2, 3, and Areas of Concern. After discussions with the City, it was decided that Category 1 areas will be associated with 5-year projections (Year 2025), Category 2 areas will be associated with 10-year projections (Year 2030), and Category 3 areas will be split between 15- and 20-year projections (Year 2035 and 2040). Areas of concern were not considered as part of the study as the likelihood of these areas being annexed into the City's water service area are low.

Table 2.1 includes the list of provided developments and their associated zone types and estimated average day demands. Residential timesteps were assigned based on projected population growth and estimated time of construction. Industrial timesteps were assigned based on information provided by the City and estimated duration of construction. The approximate location of the proposed developments along with the potential land annexation areas can be found in **Figure 2.2**.

It was observed that none of the upcoming industrial developments are located within the proposed annexed land areas. This indicates that their demands would not be included in those calculated purely on estimated annexed areas. Therefore, WRA added the identified industrial development demand to the industrial water demand calculated through land annexation. Residential demands calculated for each development are assumed to be included in the City's overall projected population increase.

Table 2.1 – Future Development Demands and Hydraulic Timestep

Timestep	Development	Average Day Demand (gpd)	Zone	Description
2025	McKee Run Power Plant	-64,800	Industrial	Decommissioning of Power Plant
2025	Starlifter Ave. Manufacturing	3,900	Industrial	New Manufacturing User
2025	Cardboard Manufacturing Facility	7,502	Industrial	New Manufacturing User
2025	Garrison Oak Technical Park	45,014	Industrial	New Industrial Development
2025	Stonebrook East	39,111	Residential	255 Unit Apartment Development
2025	Stonebrook West	27,147	Residential	177 Unit Apartment Development
2030	Garrison Oak Technical Park	45,014	Industrial	New Industrial Development
2030	Rojan Meadows	24,387	Residential	159 Unit Apartment Development
2030	1080 & 1106 Bay Road	7,362	Residential	48 Unit Apartment Development
2030	Apartments on College Road	50,307	Residential	328 Unit Apartment Development



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1915 100 YEARS 2015

Figure 2.2
Land Annexation and Future Development

City of Dover, Delaware
Water System Master Plan

Using the provided growth information and unit demands calculated from the City's existing water consumption and production the updated projected maximum day water demand is 12.41 MGD in Year 2040. See **Table 2.2** and **Figure 2.3** for the projected water demands for each hydraulic timestep.

Table 2.2 – Projected Water Demands

Year	Residential Water Demand (MGD)	Commercial Water Demand (MGD)	Industrial Water Demand (MDG)	Total Average Day Demand (MGD)	Maximum Day Demand (MGD)
2019	2.35	1.45	1.37	5.16	7.79
2025	2.47	1.62	1.75	5.84	8.82
2030	2.55	1.67	2.55	6.77	10.22
2035	2.61	2.01	2.87	7.49	11.34
2040	2.68	2.35	3.19	8.22	12.41

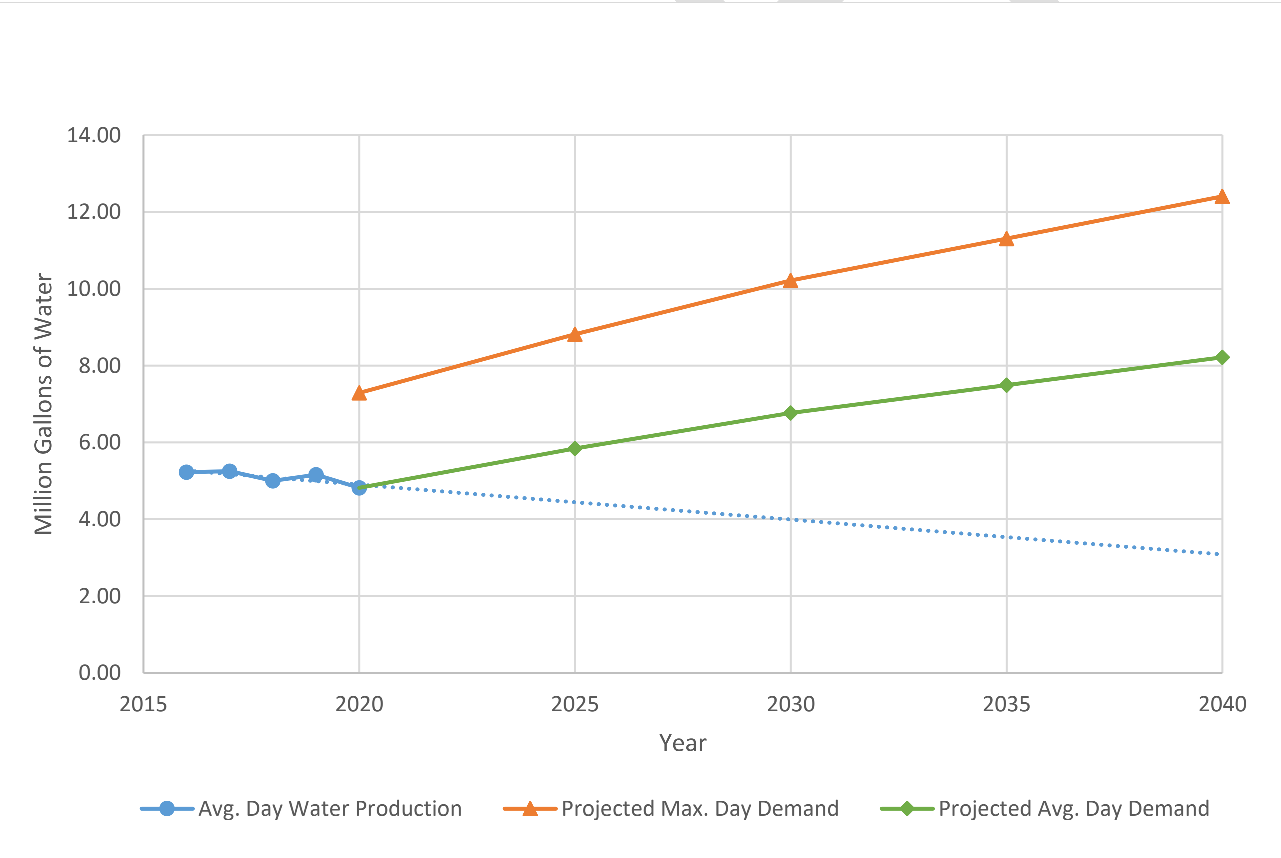


Figure 2.3 – Projected Water Demands

3 Water Supply

WRA assessed the City of Dover, Delaware groundwater supply based on information provided by the City and data published by the Delaware Geological Survey (DGS). This is a planning-level, desktop effort. In addition, in-person inspections were completed of the existing wellhouses, water treatment plant and associated equipment. Recommendations for maintenance and/or improvements based on the in-person inspections are included.

3.1 Hydrogeologic Setting

The City of Dover is within Kent County in central Delaware. **Figure 3.1** is a schematic hydrogeologic section of the aquifers in the region. Dover is in the Atlantic Coastal Plain Physiographic Province, according to DGS Report of Investigations No. 72, titled Geology and Extent of the Confined Aquifers of Kent County, Delaware, by Peter P. McLaughlin and Claudia C. Velez (2006). Layers of gravel, sand, silt, and clay underlie the region. The layers both thicken and dip at a low angle in a southeastern direction.

Groundwater is the sole source of water for Dover. Water-supply aquifers exist in the coarse-grained coastal plain geologic units that are comprised mainly of sand. The aquifers are bounded by fine-grained confining layers composed of silt and clay. The City of Dover uses the following aquifers (from shallowest to deepest): the Columbia Aquifer, the Cheswold Aquifer, and the Piney Point Aquifer.

The upper surface of the Columbia Aquifer is a water table on top of saturated sands. Therefore, the Columbia Aquifer is unconfined, though it is bounded underneath by a layer of silt and clay. The Columbia Aquifer is up to approximately 60 feet thick in the area.

The Cheswold Aquifer is a confined aquifer. It is approximately 50 feet thick in the Dover area. The top of the Cheswold Aquifer is approximately 75 feet below sea level.

The Piney Point Aquifer is also a confined aquifer. It is approximately 170 feet thick in Dover. The top of the Piney Point Aquifer is approximately 250 feet below sea level.

3.2 Water Production Wells

The City has twenty-one water production wells (twenty are currently in service), according to their application for renewal of the State water allocation permits dated September 19, 2018. **Figure 3.2** is a map of the wells. **Table 3.1** is a summary of available data about the wells.

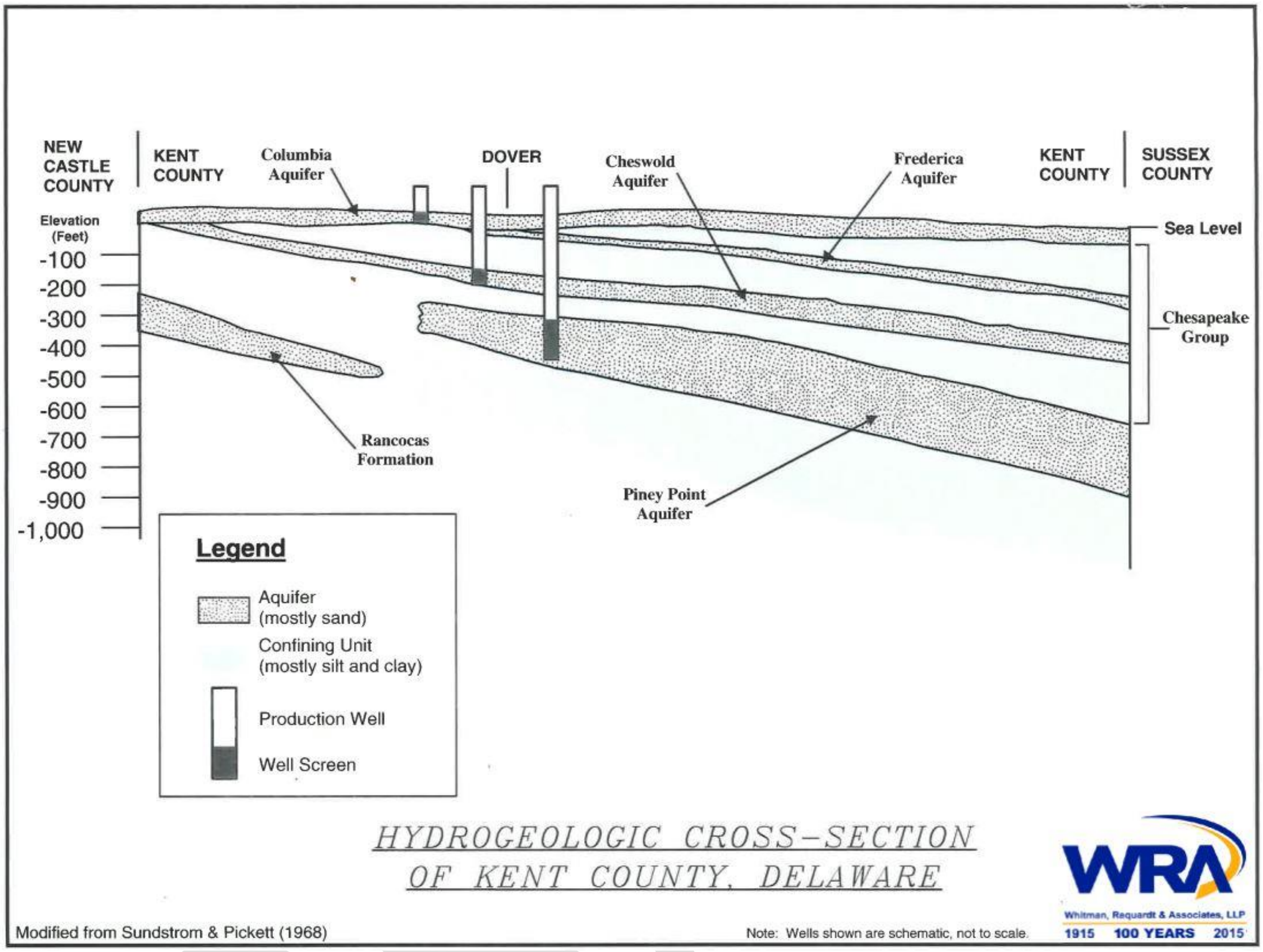
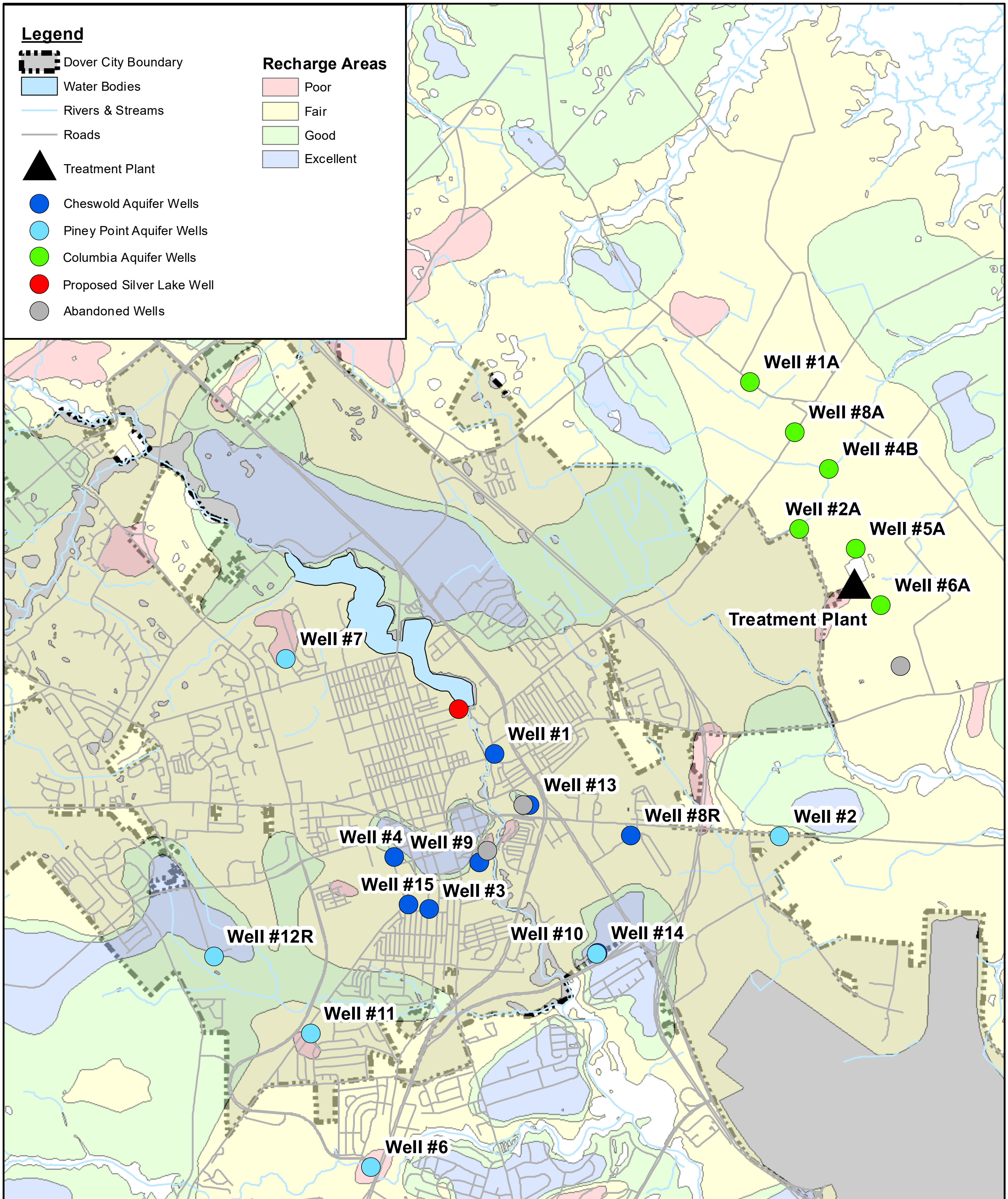


Figure 3.1 – Hydrogeologic Cross-Section of Kent County, DE



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The City of Dover Delaware

Figure 3.2
Well Locations

City of Dover, Delaware
Water System Master Plan

Table 3.1 - Water Production Wells

Aquifer	City Well No.	DNREC Well No.	Depth of Well (feet)	Diameter of Screen (inches)	Maximum Pumping Capacity (gpm)	Maximum Use (gpd)
Columbia	PW-1A	85025	60	16	500	720,000
	PW-2	59727	60	16	500	720,000
	PW-4B	85021	60	16	400	576,000
	PW-5	85022	60	16	500	720,000
	PW-6A	85023	60	16	500	720,000
	PW-8A	85020	60	16	300	432,000
Cheswold	1	10205	208	12	237	341,280
	3	10206	222	10	290	417,600
	4	10214	221	10	400	576,000
	5	*10207*	*X*	*X*	*400*	*576,000*
	8R	221103	225	10	350	504,000
	9	37893	222	12	585	842,000
	13	171720	230	10	250	360,000
	14	10365	221	12	160	230,000
	15	171719	250	10	500	720,000
Piney Point	2	31640	500	12	1,150	1,656,000
	6	10208	456	12	800	1,152,000
	7	10209	382	12	250	360,000
	10	10212	483	12	1,100	1,584,000
	11	10213	446	12	475	684,000
	12R	242962	410	12	1,000	1,440,000

The six Columbia Aquifer production wells have depths of approximately 60 feet, and screens with diameters of 16 inches. The wells are located off Long Point Road. Their maximum production rates are approximately 300 to 500 gallons per minute (gpm) per well. Water from these wells is treated by the City's water treatment plant prior to entering the distribution system. The treatment plant has recently undergone upgrades to enhance the facilities treatment capabilities. The upgrades are detailed later in this section.

The nine Cheswold Aquifer production wells have depths ranging from approximately 200 to 250 feet, and screens with diameters of 10 or 12 inches. Their maximum production rates are approximately 200 to 600 gpm per well. The City indicated that it will develop another Cheswold Aquifer production well at Silver Lake Park in about two years. Well 5 is currently out of service.

The six Piney Point Aquifer production wells have depths ranging from approximately 400 to 500 feet, and screens with diameters of 12 inches. Their maximum production rates are approximately 200 to 1,100 gpm per well. The most recently added Piney Point Aquifer well is at Schutte Park (Well 12R).

Water from the wells in the Cheswold and Piney Point Aquifers is dosed with chlorine and pumped directly into the distribution system. Fluoride treatment is administered at the Cheswold wells. Details on the deep well pumps and chemical delivery system are included later in this section.

3.3 Water Allocation Permits

The City of Dover has three water allocation permits from the Delaware Department of Natural Resources and Environmental Control (DNREC). Each permit is for one of the aquifers in use.

Columbia Aquifer - The permit for the Columbia Aquifer is designated 92-0002M1. Its withdrawal limit is a maximum of 3,000,000 gallons per 24 hours. The permit also requires monthly chloride sampling for a group of shallow monitoring wells, to assess saltwater intrusion into the Columbia Aquifer.

Cheswold Aquifer - The permit for the Cheswold Aquifer is designated 87-0018 RAM3. Its withdrawal limit is a maximum of 4,327,000 gallons per 24 hours. The permit limits pumping water levels in the aquifer to various depths ranging from 118 to 165 feet.

Piney Point Aquifer - The permit for the Piney Point Aquifer is designated 87-0018 BRM1. Its withdrawal limit is a maximum of 6,876,000 gallons per 24 hours. The permit limits pumping water levels in the aquifer to various depths ranging from 291 to 315 feet.

In addition to the withdrawal limit for each aquifer, the State water allocation permits limit the total City groundwater withdrawals from all three aquifers combined as follows: 11,043,000 gallons per 24-hours; 258,000,000 gallons per 30-days; and 2,252,000,000 gallons per year.

The Delaware River Basin Commission permits groundwater withdrawals by the City of Dover under Docket No. D-2001-43 CP. The total allocation is 438.24 million gallons per 30 days.

3.4 Water Use

In 2019 the City pumped approximately 5.2 million gallons per day (MGD) from the production wells. The Columbia Aquifer pumpage was 25% of the total pumpage, based on the reported maximum rates per well. The Cheswold Aquifer pumpage was 30% of the total, and the Piney Point Aquifer pumpage was 45%. (The percentages are estimated from the maximum pumping rates in the City's application for water allocation permits and may differ from the percentages in the most recent year.)

The future City average day demand for water will be approximately 5.8 MGD by the year 2025. (See **Appendix A** for a memorandum dated May 14, 2021 documents the water demand projections.) The estimated average day demand will be 6.8 MGD, 7.5 MGD, and 8.2 MGD in 2030, 2035, and 2040, respectively. The 2040 demand represents an increase of approximately 3 MGD (58%) over the current demand.

3.5 Groundwater Availability

WRA generally assessed future groundwater availability in the Dover area. As would be expected, the elevations of the potentiometric surfaces in the confined aquifers have dropped from their pre-development levels in response to decades of groundwater pumping from multiple users including the City of Dover.

The land surface elevation in Dover is about 30 feet above sea level. Over the last 10 years, the potentiometric surface in the Cheswold Aquifer has been an average of 5 feet above sea level in DGS monitoring well Jd-14-01 (**Figure 3.3**). This potentiometric surface remains about 80 feet above the top of the Cheswold Aquifer. Some of the remaining unused drawdown in the Cheswold Aquifer will need to be maintained to protect the aquifer.

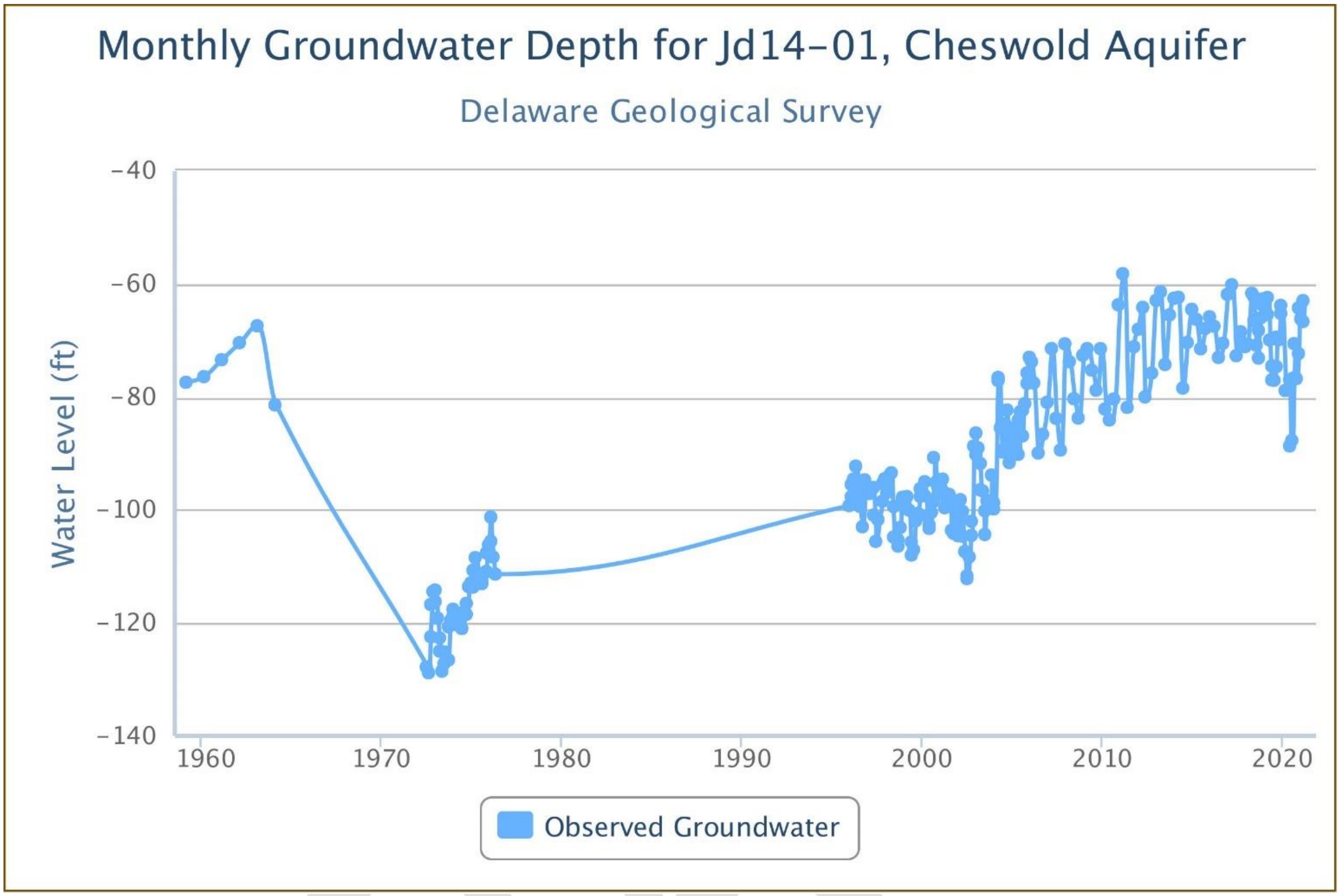


Figure 3.3 – Cheswold Aquifer: Monthly Groundwater Depth

The impact of long-term pumping has been relatively greater on the Piney Point Aquifer. Its pre-development potentiometric surface was above sea level. Over the last 10 years, the potentiometric surface in the Piney Point Aquifer has been an average of about 130 feet below sea level in DGS monitoring well Id 55-01 (**Figure 3.4**). This potentiometric surface remains 120 feet above the top of the aquifer. The current potentiometric surface represents historical use of a significant part of the available drawdown in the Piney Point Aquifer, and much of the remaining drawdown will need to remain undeveloped to protect it.

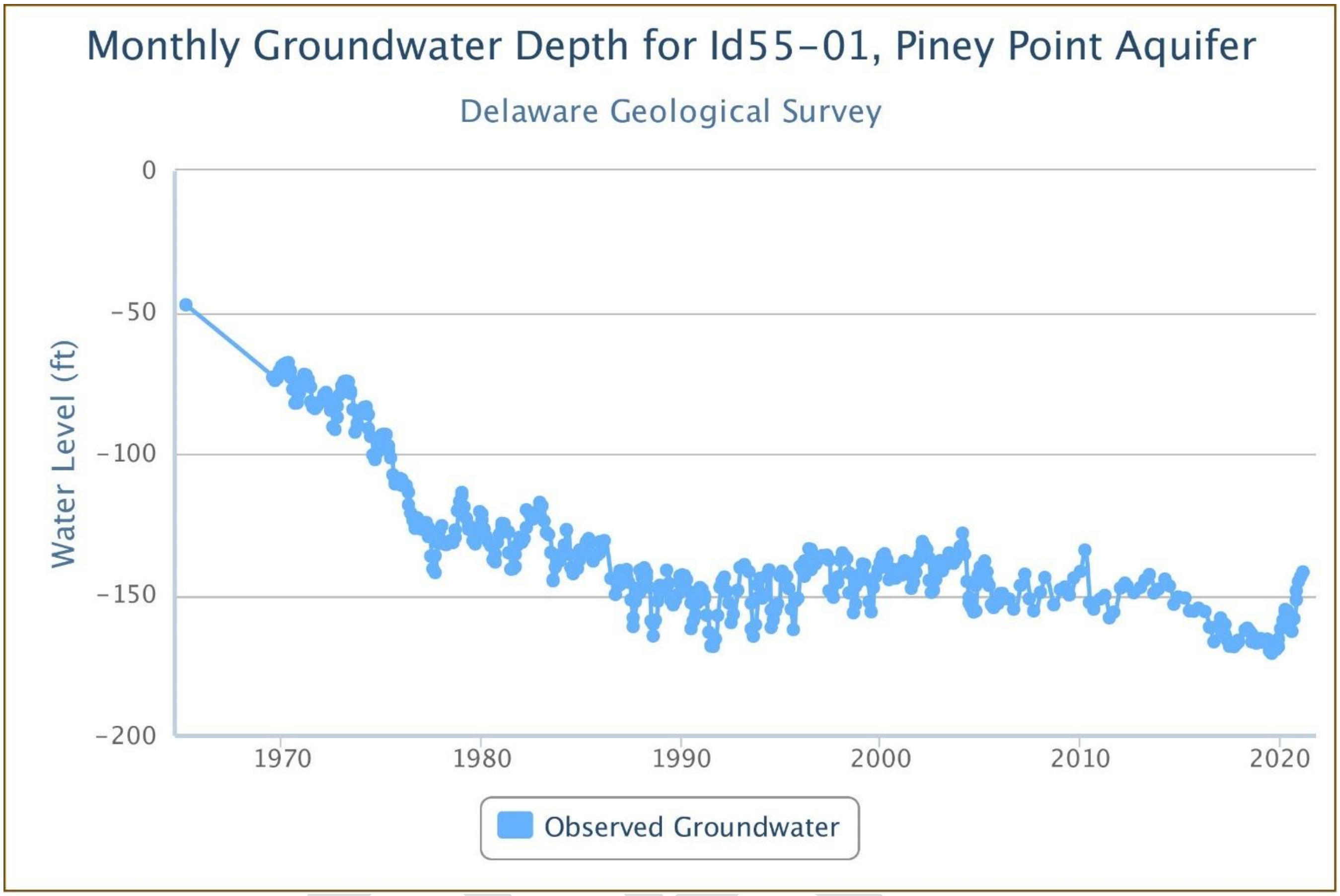


Figure 3.4 – Piney Point Aquifer: Monthly Groundwater Depth

3.6 Aquifer Management

In a July 1, 2020 memorandum, the City of Dover indicated that it plans to manage aquifer withdrawals to address its impact on the following issues related to the water supply: saltwater intrusion in the Columbia Aquifer due to over-pumping; protection of the Cheswold Aquifer; and depletion of the Piney Point Aquifer.

The City has indicated that it will continue to use the deep confined aquifer production wells throughout the year, but not as heavily in the winter months ("non-growing" season usage). They will continue to rest the two largest wells when possible.

Also, in accordance with this approach, the City would decrease use of the Columbia Aquifer from May to September. This is when the agricultural demand on the Columbia Formation is larger ("growing" season usage).

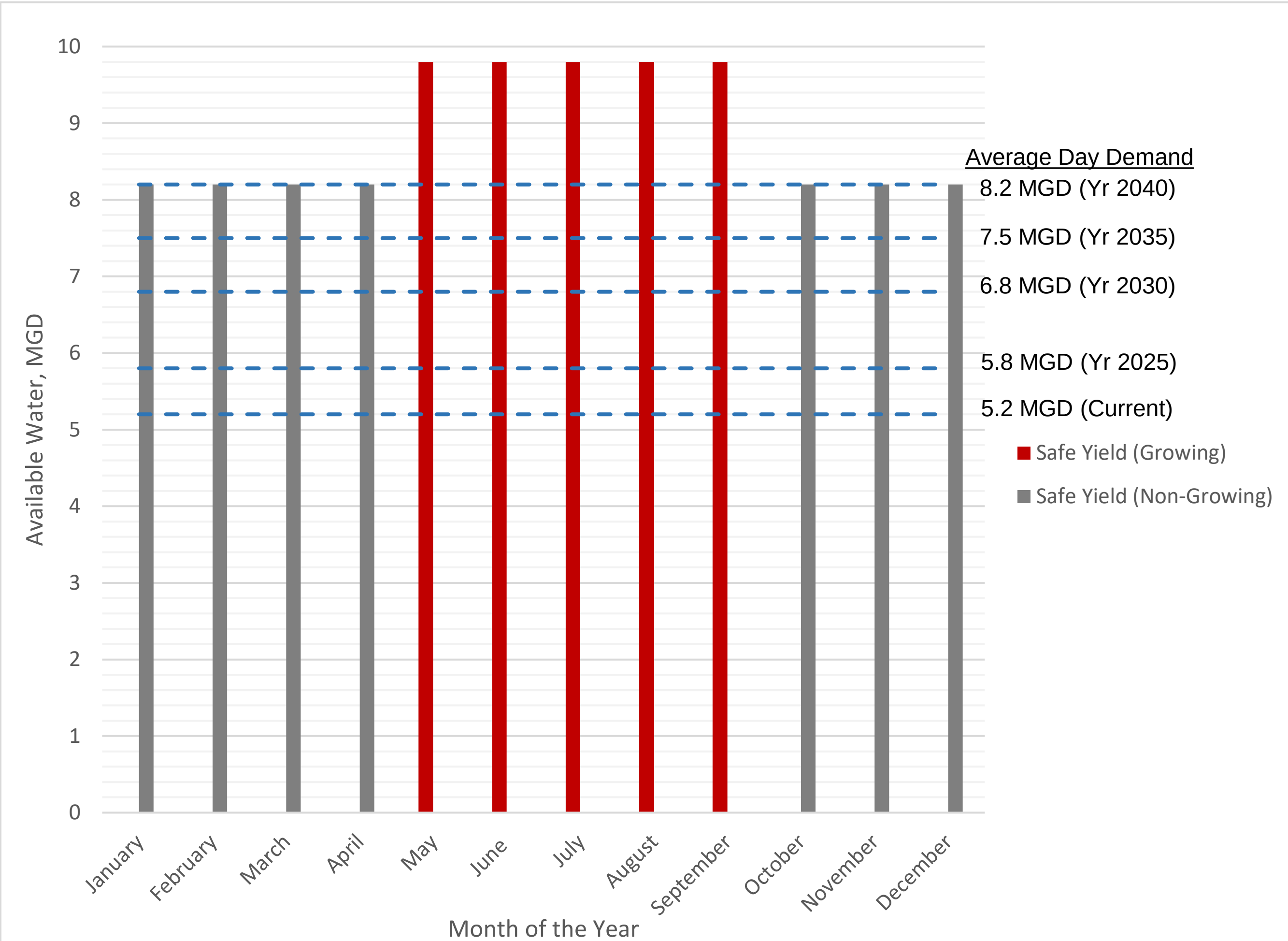


Figure 3.5 – Aquifer Management: Safe Yield Production

3.7 Safe Yield

The safe yield of a groundwater supply may be considered the yield available on a day when the largest-producing well is out of service. Assuming all the City wells could be used simultaneously, the safe yield would be 13.7 MGD with the largest well, No. 2 (1.7 MGD) out of service. Actual permit conditions such as aquifer pumping level limitations, or hydraulic conditions may limit what total rate of groundwater could be pumped on a given day.

The estimated safe yield of the Columbia Aquifer wells is only 3.2 MGD assuming one of the largest Columbia Aquifer wells (at 0.7 MGD) is out of service. The safe yield of the fifteen confined aquifer wells is 9.8 MGD, which assumes Well No. 2 is out of service.

To meet future average demands, WRA estimated future water sources based on equivalent wells. This assumes one well would be needed per additional 1 MGD developed. **Figures 3.5 and 3.6** assume the two largest confined aquifer wells are being rested in the non-growing season which means 8.2 MGD (Safe Yield Non-Growing) would be available. A new water production well is needed by year 2035. By 2040, another new well would be needed. The planned Silver Lake well would be in addition to these future wells.

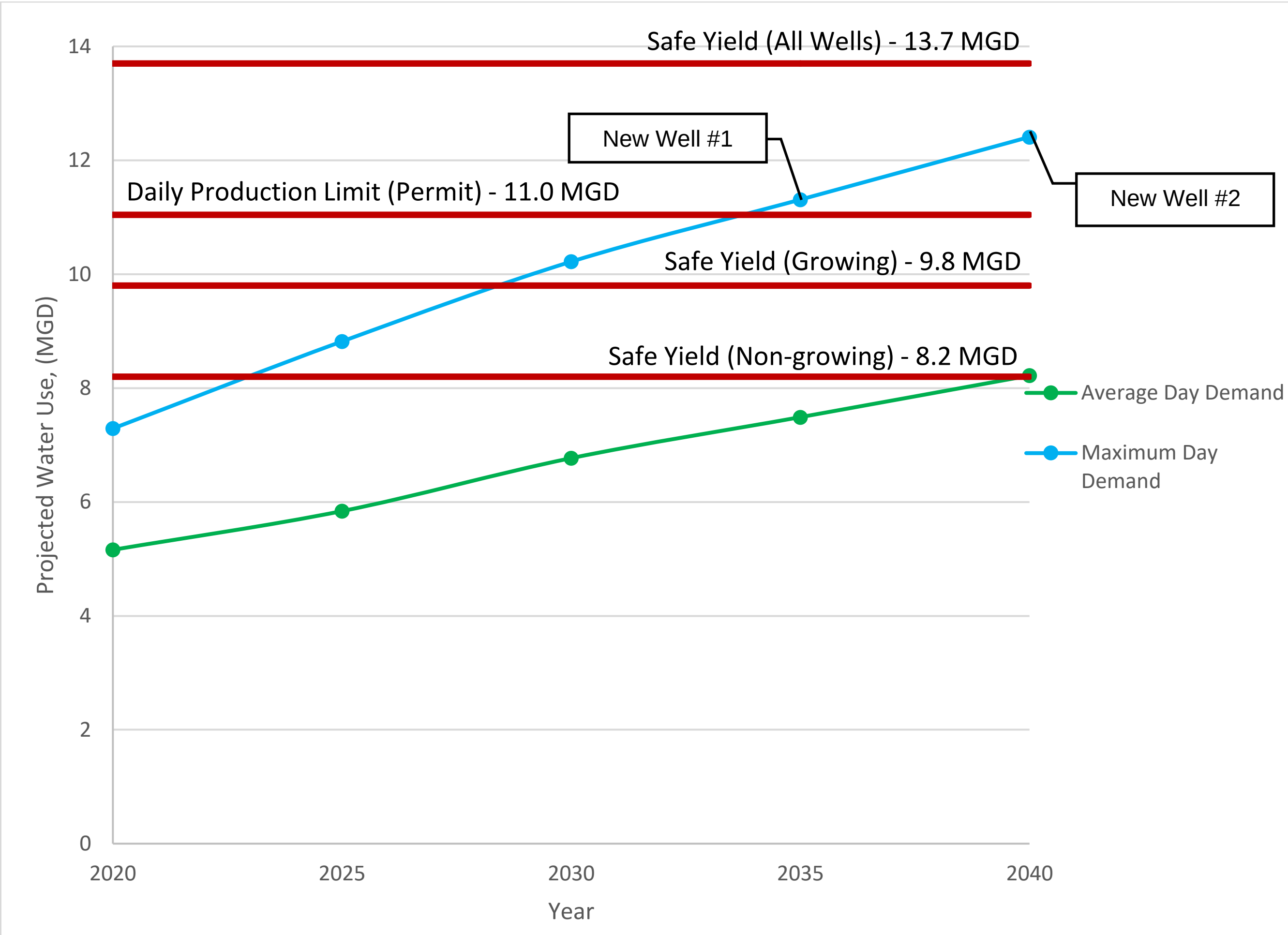


Figure 3.6 – Safe Yield vs. Projected Demands

3.8 Additional Water Sources

Theoretically the St. Jones River, which flows generally southeast through the Dover area, is a potential additional source of water for the City of Dover. Further southeast of Dover the river is surrounded by marshes and wetlands.

Figure 3.7 is a monthly streamflow graph for the St. Jones River at Dover from the Delaware Geological Survey. A representative order-of-magnitude minimum streamflow in the St. Jones River is 10 cubic feet per second (cfs), which is equivalent to about 6.5 MGD. A representative maximum streamflow is an order higher, about 65 MGD.

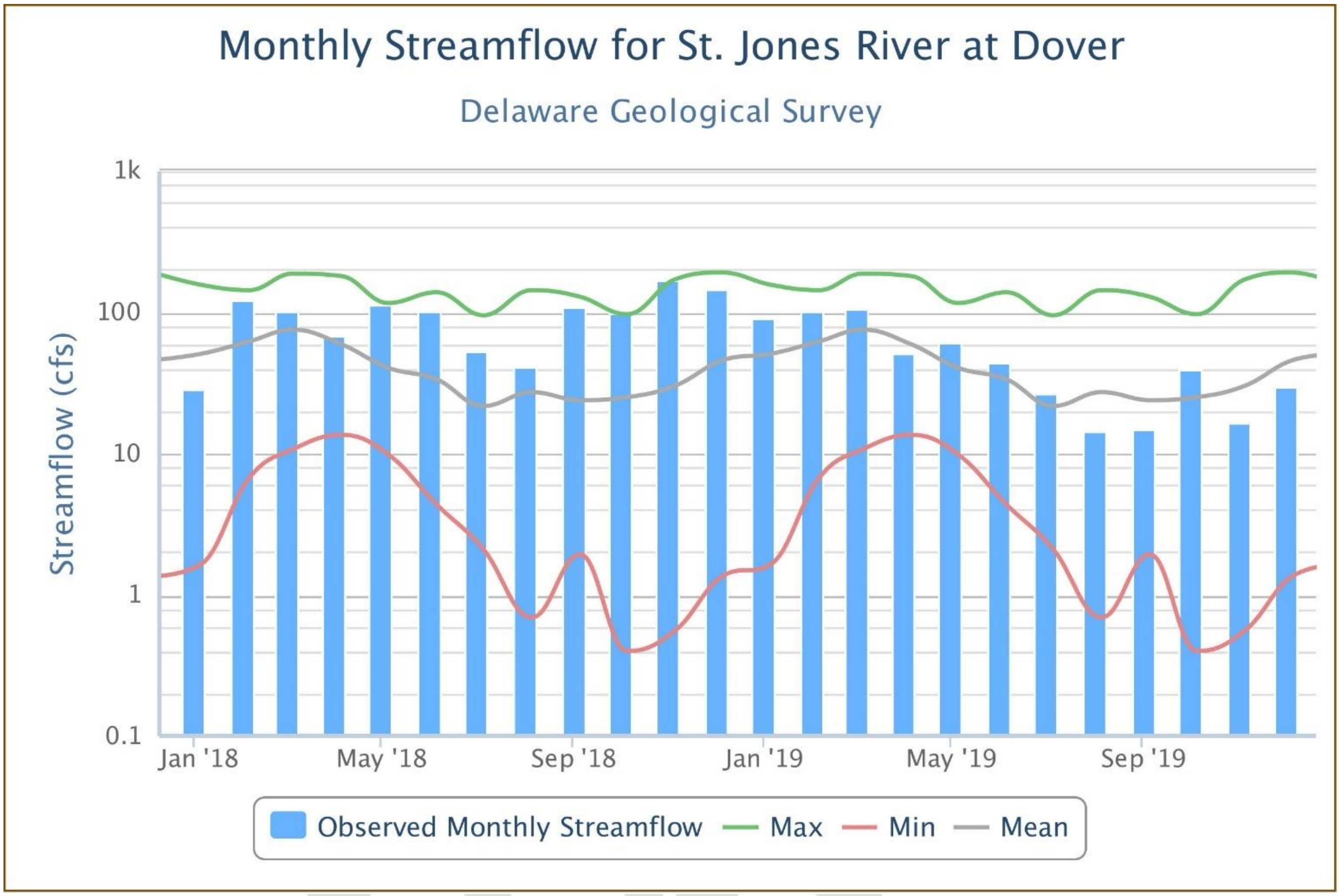


Figure 3.7 – St. Jones River Monthly Streamflow

Aquifer Storage and Recovery (ASR), in which water is injected underground during wet periods and recovered during dry periods, is also theoretically an option for the City. Surface water would be injected into a confined aquifer in the Dover area and be pumped out months later. To assess the feasibility of a surface water intake and ASR, extensive studies would be necessary including elements such as well drilling, aquifer testing, and groundwater modeling.

To withdraw water from a surface water body, the City of Dover would need to obtain a State water allocation permit from DNREC. The State limits withdrawals from surface waters based on factors including existing permitted withdrawals, water quality standards, protection of fish and wildlife, maintenance of adequate flows downstream, saltwater intrusion, and other ecological, recreational, aesthetic, and private benefits that depend on surface water flows.

Water withdrawal from a surface water source exceeding a daily average of 100,000 gpd in a 30-day period would also require a permit from the Delaware Basin Commission (DRBC). The DRBC requires assessment of the 100-year floodplain because pumps and related facilities may not be located within a 100-year floodway. Also, the City would be required to identify wetlands that may be impacted by a surface water source project.

Further, implementing seasonal water storage during the wet season and recovering it during the following dry season through ASR would involve the construction and testing of injection wells. To inject water into an aquifer, the City would need to obtain approval from DNREC for Class V injection wells, which are used to inject non-hazardous fluids underground. Site investigation and modeling of the injected water and its direction of movement in the aquifer are required as part of the injection well permitting process.

Lastly, ASR requires treatment of the surface water prior to injection to ensure no biological or chemical contamination is transferred to the aquifer and/or the water chemistry is compatible with that of the groundwater. To that end, surface water after sufficient treatment at a newly constructed water treatment plant, could also be discharged directly to the City's water distribution system to meet additional supply needs. This option would not provide for aquifer recovery but would eliminate the need for the development and operation of injection wells. Surface water treatment would still require a DNREC allocation permit and possible DRBC assessment. In addition, the City would need to assess the compatibility of the treated waters in the distribution system from different sources as mixing within the distribution system can lead to water quality or corrosion problems.

3.8.1 Water Supply Recommendations

Recommendations for additional water sources are:

(1) The City should add two additional confined aquifer wells; one by 2035 and one by 2040 based on the safe yield analysis. WRA also concurs with the City plan to add a confined aquifer well at Silver Lake Park.

(2) The City should initiate a discussion with DNREC concerning a water allocation permit for surface water withdrawal because, although technically feasible in concept, new withdrawal from surface water is subject to limits of the water resource in conjunction with downstream and ecological water users.

3.9 Facility Inspections

WRA completed on-site facility inspections of the City's deep well houses and the recently updated Water Treatment Plant (WTP) and associated shallow wells. Detailed reports for each facility are located in **Appendix B**. A summary of inspection results, discussion of well operations and recommended improvements are included below.

3.9.1 Deep Wells

Fourteen (14) of the City's twenty (20) operational wells draw water from deep, confined aquifers – the Cheswold and Piney Point. A condition assessment of these deep well facilities was performed on March 29, 2021. Recommendations resulting from the site visits are summarized below, and the full inspection reports are included in **Appendix B**.

3.9.1.1 Cheswold Wells

Table 3.2 – Cheswold Aquifer Wells Inspection Summary

Well Number / Location	Design Capacity	Recommended Improvements
1 – Jones Station	250 gpm @ 280' tdh	• Paint interior walls • Seal drums / day tanks, vent to outside • Replace metal door w/fiberglass • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures and incandescent lamps with LED
3 – Dover East	300 gpm *	• Seal drums / day tanks, vent to outside • Replace metal door w/fiberglass • Install GFCI receptacles and in-use receptacle covers • Replace incandescent lamps with LED

		• Evaluate ambient conditions for proper VFD operations
4 – West Water Street	240 gpm *	• Seal drums / day tanks, vent to outside • Replace metal door w/fiberglass • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures and incandescent lamps with LED • Replace motor starter in next 5 years
8R – Blue Hen Mall	400 gpm @ 250' tdh	• Paint interior walls • Seal drums / day tanks, vent to outside • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures and incandescent lamps with LED • Evaluate ambient conditions for proper VFD operations
9 – Kerbin Street	500 gpm @ 308' tdh	• Raise the floor elevation above flood plain • Replace mower-damaged vinyl siding • Pressure wash building exterior • Seal drums / day tanks, vent to outside • Replace metal door w/fiberglass • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures and incandescent lamps with LED • Evaluate ambient conditions for proper VFD operations • Replace 120/240v panelboard
13R – Bayard Avenue	350 gpm @ 270' tdh	• Paint interior walls • Seal drums / day tanks, vent to outside • Replace metal doors w/fiberglass • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures with LED equivalent • Evaluate ambient conditions for proper VFD operations
14 – Danner Farm	265 gpm	• Paint interior walls • Seal drums / day tanks, vent to outside • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures and incandescent lamps with LED • Replace VFD with newer model drive
15 – Dover Street Park	500 gpm @ 300' tdh	• Paint interior walls • Seal drums / day tanks, vent to outside • Replace metal doors w/fiberglass • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures with LED equivalent • Evaluate ambient conditions for proper VFD operations

*Estimated design flow and pressure not available

3.9.1.2 Piney Point Wells

Table 3.3 – Piney Point Aquifer Wells Inspection Summary

Well Number / Location	Design Capacity	Recommended Improvements
2 – Horsepond	900 gpm @ 500' tdh	• Paint interior piping • Install new magnetic flowmeter • Seal drums / day tanks, vent to outside • Replace metal doors w/fiberglass • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures with LED equivalent • Replace VFD with newer model drive
6 – Rodney Village	700 gpm @380' tdh	• Clean and paint interior walls • Pressure wash exterior • Seal drums / day tanks, vent to outside • Replace metal door w/fiberglass • Replace corroded ventilation fan • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures and incandescent lamps with LED • Replace VFD with newer model drive • Replace all corroded metallic conduits in chemical feed room with non-metallic
7 – McKee	200 gpm @ 430' tdh	• Paint interior piping • Install new pressure gauge • Seal drums / day tanks, vent to outside • Replace metal doors w/fiberglass • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures with LED
10 – Danner Farm	1000 gpm @420'tdh	• Clean and paint interior walls • Seal drums / day tanks, vent to outside • Replace metal doors w/fiberglass • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures and incandescent lamps with LED • Replace all corroded metallic boxes
11 – Crossgates	475 gpm @ 425' tdh	• Clean and paint door & bldg. trim and interior walls • Seal drums / day tanks, vent to outside • Replace metal doors w/fiberglass • Replace corroded ventilation fan • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures and incandescent lamps with LED • Replace LFMC at pump connector box

12R – Schutte Park	600 gpm @ 417' tdh	• Seal drums / day tanks, vent to outside • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures and exterior wall pack with LED equivalent • Provide conduit sleeve to protect LFMC installed through metal vent

3.9.2 Water Treatment Plant and Columbia Aquifer Wells

Six (6) wells draw from the shallow, unconfined Columbia aquifer, and send flow to the water treatment plant. A condition assessment of the shallow wells and WTP was performed on March 30, 2021. Results are summarized below, and the inspection reports are included in **Appendix B**.

Table 3.4 – Dover Water Treatment Plant / Columbia Aquifer Wells Inspection Summary

Facility Number / Location	Design Capacity	Recommended Improvements
Dover WTP	3.0 MGD	• Mechanical: - Ozone Room (electrical gear) HVAC improvements - Eyewash / shower in hypochlorite room - Backwash tank floor – slope to pump suction - Correct analyzer labels on influent, pre- and post-mixing - Enhance security; barbed wire, sliding gate with card access, CCTV at gate and building access, and lighting • Electrical: - Exit sign and emergency light repair and replacement - Replace fluorescent ceiling fixtures with LED equivalent - Replace incandescent lamps with LED lamps - Replace or repair pilot lamps in transfer switch - Install GFCI receptacles in Laboratory - Replace exterior flood lights with LED - Replace exterior light controls (photocell) - Replace SO cords to instruments at GAC tanks, and other boxes and raceways as needed - Replace all HID high and low-bay fixtures with LED, and include lowering devices for light fixtures in high bay - Review emergency generator installation for proper air flow; supplied with weather-tight enclosure but installed inside a building
PW1A – Chandelle	500 gpm	• Replace sump pumps • Paint piping • Install ladder safety grab bar • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures with LED equivalent

		• Replace all electrical equipment and relocate to above-ground • Replace all metallic raceway, supports, fittings and boxes in well pit with PVC
PW2A – Long Point	443 gpm @ 31 psi	• Replace sump pumps • Paint piping • Install ladder safety grab bar • Install in-use receptacle covers • Replace fluorescent fixtures with LED equivalent • Replace or protect fluorescent lamp fixtures in surface cabinet • Replace all metallic raceway, supports, fittings and boxes in well pit with PVC • Provide hole plugs for all unused knockouts in wireway
PW4A – Slaughter	400 gpm	• Paint interior walls and piping • Add corrosion resistant bird screen to louver • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures with LED equivalent
PW5A – Tarburton	365 gpm	• Replace sump pumps • Paint piping • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures with LED equivalent • Relocate electrical equipment to above-grade NEMA 3R cabinet
PW6A – Tilcon	368 gpm	• Replace sump pumps • Paint piping • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures with LED equivalent • Replace all corroded boxes and conduit in the well vault
PW8A – White Oak	300 gpm	• Paint the door • Install GFCI receptacles and in-use receptacle covers • Replace fluorescent fixtures with LED equivalent

4 Water Storage

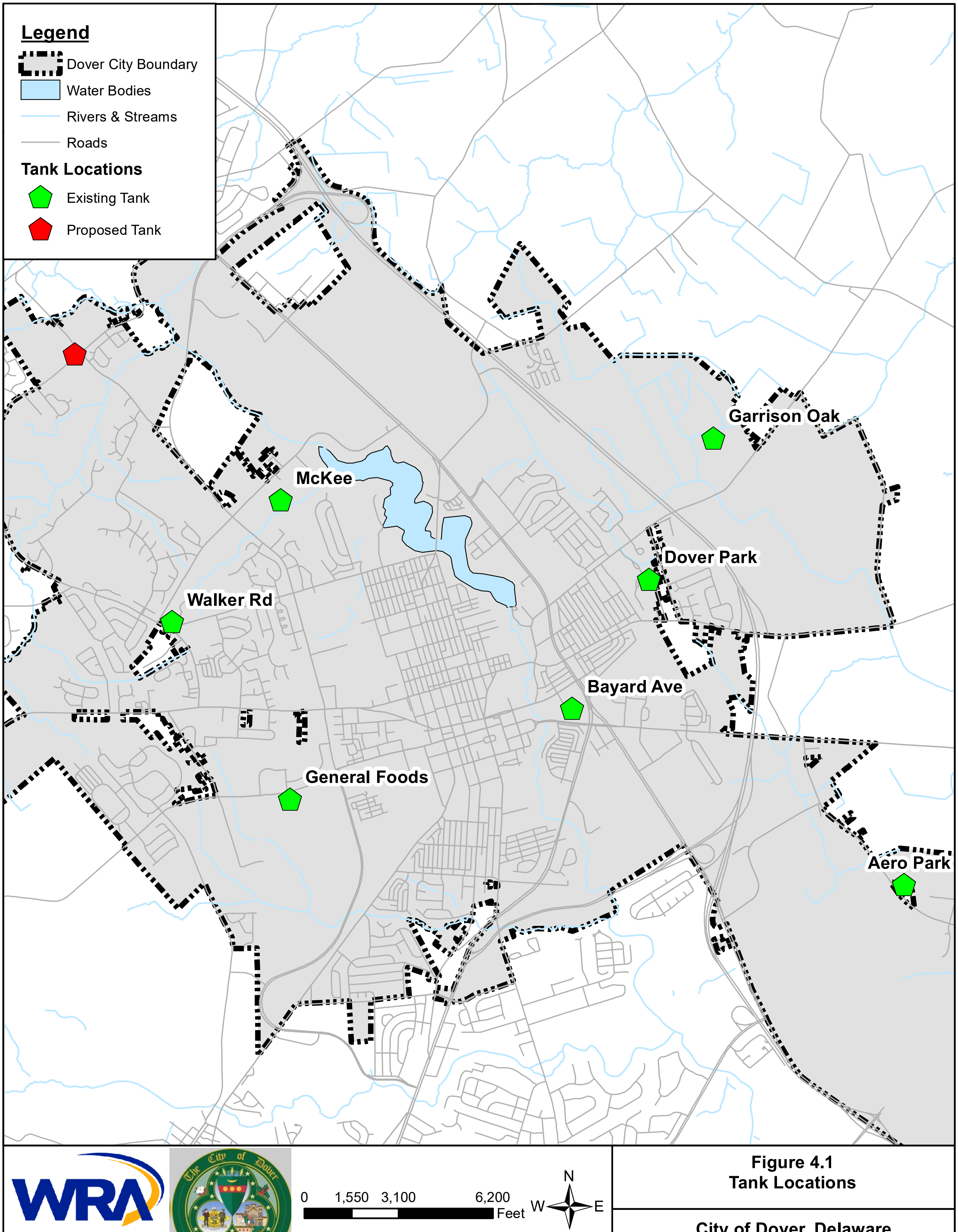
The City's existing elevated water towers were inspected by Corrosion Control Corp. in April of 2020. These inspection reports were provided to WRA for review. Based on these physical tank inspection results, WRA compiled a list of recommended improvements which are incorporated into the proposed CIP. In addition, WRA evaluated the required storage volume to serve the distribution system based on the updated water demand projects.

4.1 Existing Elevated Water Towers

Dover maintains seven (7) existing elevated water towers for a total storage capacity of 5.25 million gallons (MG). The first storage facility, the Bayard Avenue Tank, was constructed in 1955 with the most recent tower, the Garrison Oak Tank, constructed in 2016 to service a future technology park. **Table 4.1** provides a listing of the existing tanks, tank type, date constructed, and tank volume.

Table 4.1 – Existing Elevated Water Towers

Storage Tank	Type	Construction Date	Storage Volume (MG)
General Foods Tank	Legged	1963	0.25
Bayard Ave Tank	Legged	1955	0.25
McKee Road Tank	Legged	1974	1.0
Dover Park Tank	Fluted Column	1987	1.0
Walker Road Tank	Fluted Column	1987	1.0
Kent Co. Aeropark Tank	Legged	1993 Re-erect	0.25
Garrison Oak Tank	Composite	2016	1.5
		Total Current	**5.25**



Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

Figure 4.1
Tank Locations

City of Dover, Delaware
Water System Master Plan

4.2 Water Storage Requirements

WRA compared the storage capacity with the storage volume required to serve the distribution system. The total system storage required is typically calculated by the following formula which was utilized during the development of the 2006 Master Plan.

STORAGE VOLUME REQUIRED = EQUALIZATION + FIRE FLOW + EMERGENCY

Equalization	=	0.15 x Maximum Daily Demand (MDD)
Fire Flow	=	5,000 gpm for 4 hours (Commercial/multi-family) 1,200,000 gallons
Emergency	=	0.10 x MDD (to cover water main break, interruption in treatment/supply, etc.)

The above storage calculation in relation to projected demands are summarized below in **Table 4.2** and shown in **Figure 4.2**.

Table 4.2 – Water Storage Calculations

Scenario	MDD (MGD)	Equalization (MG)	Fire Flow (MG)	Emergency (MG)	Required Storage (MG)	Available Storage (MG)	Difference (MG)
2019	7.29	1.09	1.20	0.73	3.02	5.25	+ 2.23
2025	8.83	1.33	1.20	0.88	3.41	5.25	+ 1.85
2030	10.24	1.53	1.20	1.02	3.75	5.25	+ 1.50
2035	11.34	1.69	1.20	1.13	4.02	5.25	+ 1.22
2040	12.45	1.86	1.20	1.24	4.30	5.25	+ 0.95

1. Available storage volume may not all be at a usable hydraulic grade level.

Based on the storage calculations, the City has sufficient storage volume to provide for system demands and emergency flows through 2040. Of note, excessive storage volume can lead to high water retention times within the distribution system and low cycling rates within the tanks. High retention times or “Water Age” and minimal cycling/mixing in tanks can lead to water quality problems such as discolored water or order and taste problems. In systems with high organic content in the source water high water age can lead to the creation of disinfection by products.

The City currently has a new elevated water storage tank scheduled (FY23 start of construction) for Denneys Road in the northwest quadrant of the City. This tank will add 1.0 MG of storage for a total of 6.25 MG and is located near Category 1 – High Priority and Category 2 – Priority annexation areas in the 2019 Comprehensive Plan. Per the water storage calculations, additional storage volume in the system in not necessary; however, hydraulic water modeling was completed to evaluate if additional storage is required to balance pressures, provide fire storage volume, or to control the system. Results of that analysis are summarized in Section 6.0 – Hydraulic Modeling.

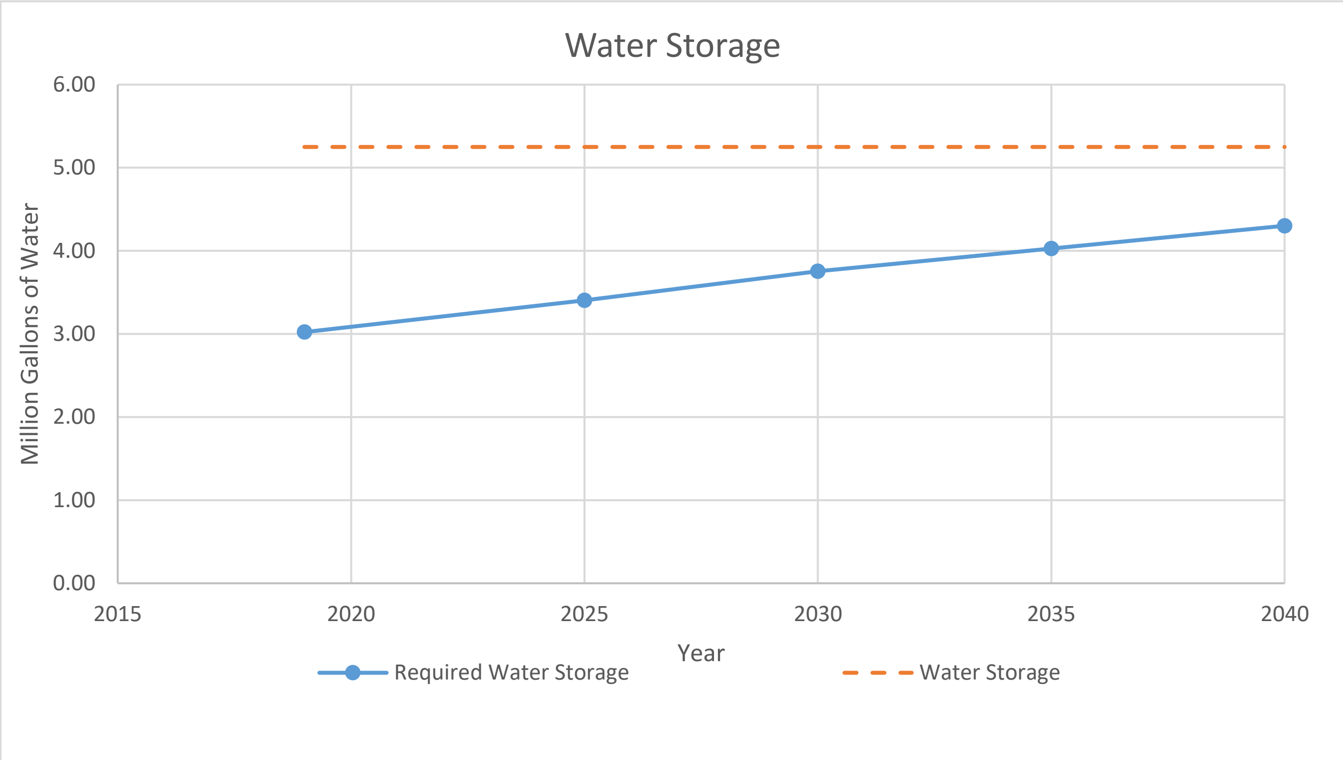


Figure 4.2 – Storage Requirements

4.3 Storage Facility Condition Assessments

Maintaining steel water storage towers is increasingly important in view of rising replacement costs. Relatively small outlays for scheduled inspections and subsequent maintenance can substantially delay major refurbishments or even eliminate the need to replace large capital investment in elevated water towers. A good, comprehensive maintenance program can extend the life of an existing water tower as well as that of a new water tower indefinitely.

Water towers are usually the primary water storage facility for a community, providing for safe drinking water, reliable pressure, and fire protection. To keep the water flowing it is important to make sure the tank is functioning properly. AWWA Manual M42 – "Manual of Water Supply Practices – Steel Water Storage Tanks" recommends that water tanks should be inspected, inside and outside, at least every three (3) to five (5) years. This time can vary due to prior quality of workmanship and the type of specified repairs and coating systems applied to the interior immersion surface and the specified coating system applied to the outside, either subjected to a mild (rural) or to a severe (industrial/seacoast) environment.

The inspection, evaluation and subsequent recommendations should adhere to the American Water Works Association (AWWA) steel tank standards noted below. Any and all recommended remedial work for the water tower structure must comply with the latest OSHA, state, and local regulations. In addition, the inspector should be qualified and have a working knowledge of inspection "methods and means".

- AWWA D100, "Standard for Welded Steel Tanks for Water Storage"
- AWWA D102, "Standard for Coating Steel Water Storage Tanks"

- AWWA D101 – 53 (R86) "Standard for Inspecting and Repairing Steel Water Tanks, Standpipes, Reservoirs, and Elevated Tanks for Water Storage"
- AWWA Manual M42 "Manual of Water Supply Practices – Steel Water Storage Tanks"

Important general areas of focus for the elevated water tower inspection procedure are listed below:

Washout: Should be performed by the Owner or a hired contractor prior to the water tower inspection. Without washouts, towers may accumulate large amounts of sediment and staining therefore prohibiting proper inspection on covered surfaces. See appropriate noted AWWA Standard.

Foundations: Sufficient information from visual observation and testing should be gathered to determine the structural integrity of concrete foundation. Concrete foundations tend to show a greater level of deterioration than any other structural component. See appropriate noted AWWA Standard.

Supporting Tower: Report detailed information on condition of sway rods, riser rods, tension, all connections thereof, bolts, welds, riser, etc. See appropriate noted AWWA Standard.

Container (roof, shell, bottom): Inspect interior and exterior to determine extent of metal loss and remaining thickness. See appropriate noted AWWA Standard.

Coating: The condition of the coating on the tank, inside and outside, should be effectively evaluated. To determine if a full removal of the existing system is prudent or overcoating is permissible, it is necessary to estimate the remaining effective life of the present coating systems. Factors to consider are the age of the coating, if available, the percent of rusting, peeling, total film thickness, and adhesion; inter-coat and to the steel substrate. If present coating system types are not known, tests should be performed to identify the present generic type. Existing coatings shall be tested for total lead percent and chromates to determine proper procedures to effectively treat and/or lawfully dispose of any hazardous waste as necessary. See appropriate noted AWWA Standard.

Vents: Tank venting is critical so air can exit and enter the tank at the same time water enters and exits the tank. This prevents a vacuum, which can cause detrimental structural damage. Tank venting should follow design guidelines set by AWWA D100, incorporating proper screening to prevent debris, birds, and other contaminants from entering the tank. The shroud (or cap) must cover the screen when viewing from the side, so wind driven rain does not enter the tank. The screen must be fully intact, and its mesh properly sized to comply with current established guidelines. Corrosion resistant material such as stainless steel or fiberglass should be used for screening, Screening, if attached correctly, should be flush above and below the openings in the vent frame. Also, the interior screen should include a designed frost-free pallet that moves freely with the flow of air. Older elevated tanks with floating access tubes will also include a screened venting system; this too must be inspected and maintained. Vent screens should be part of an annual inspection program. If distribution systems and pumping capacities are ever increased, the vent capacity should be reevaluated to ensure adequacy. See appropriate noted AWWA Standard.

Overflow Pipe: Tank overflow pipe needs to be properly screened and/or with a flap-gate arrangement over the end of the pipe to prevent unwanted contaminants from entering the tank, and unwanted animal intrusion. Most state standards recommend that overflow on elevated tanks be extended down the side of the tank to within 12 to 24 inches above grade and directed beyond the tank exterior perimeter to avoid damage to the tank grade or foundation. Most governing agencies require an air gap between the overflow piping and final drainage system in order to protect against backflow. Overflow pipe should not extend directly into storm sewers without an air gap. As permissible, and in lieu of an air gap, a rubber "duckbill" check valve may be installed at the end of the overflow pipe. Exterior overflow pipes are recommended over internal to prevent any ice buildup in cold weather which may become a problem. Exterior overflow pipes and brackets are easily accessible for maintenance, repair, and inspection. Overflow pipe should be part of an annual inspection program. If distribution systems and pumping capacities are ever increased, the overflow pipe capacity should be reevaluated to ensure adequacy. See appropriate noted AWWA Standard.

Manholes and Roof Openings: Inspector shall note structural condition and confirm that sizes and types of manholes comply with current OSHA safety regulations. A minimum of two (2) roof openings are required for personnel access and ventilation during maintenance and rehabilitation work on welded steel tanks. See appropriate noted AWWA Standard.

Ladders and Safety Devices: Inspector shall note structural condition of all ladders (inside “wet”, inside ”dry” and outside), platforms, handrails, and safety cables or climbing rails. Confirm that ladders comply with current OSHA safety regulations. See appropriate noted AWWA Standard.

Telecommunications: Inspector shall note the condition of telecommunications equipment installation mounted on the tank. Is the integrity of the coating system or tank structure compromised by the installation? Is there equipment present on the tank that should be removed? Is there equipment which can impede any required maintenance necessary on the tank? Is there faulty installation or damaged equipment which can permit water and dirt to enter the tank? It is important that any ancillary installations maintain the integrity of the tank.

Maintenance tank painting requiring exterior abrasive blasting will require that all telecommunications equipment be completely removed from the outside of the tank structure. Also, any equipment shelters on the ground, under or adjacent to the tank must be enclosed and secured from any possible abrasive damage. The City would have to get the carriers to strip all cables, etc. off tank, mount antennas on temporary pole, and reinstall on tank after painting completion.

Cathodic Protection: A cathodic protection system, if installed, should be evaluated, and properly maintained. The newer impressed-current systems with automatic controls and long-life anodes require less maintenance than the old manually controlled temporary anodes. Because of this, the impressed current system is more easily forgotten. These systems should be checked every year by the manufacture’s corrosion specialist technician.

Tower Security: Since 2001, water storage facilities have been designated as federally protected sites. The inspector should note the security measures in place at the tower location. Does site have fenced and locked enclosure? Are all roof manhole hatch covers locked? Is there a locked aluminum cover over the access ladder? Is pump house secured and locked? Is valve pit hatch cover locked? Is there closed circuit tv monitoring and/or intrusion switches? All security items in place should be listed.

4.3.1 Storage Inspection Report Summary

WRA reviewed tower inspection reports performed by Corrosion Control Corp. (CCC) in March of 2020. Several observations were noted on the tank inspection reports which should be included in the Tank repair schedule and are summarized in **Table 4.3**. The findings were considered in the development of the updated CIP. The inspection reports and full summary of observation and recommended improvements are included as **Appendix C**.

Table 4.3 – Summary of Tank Inspection Report Review	
Location	Inspection Report Summary
Dover Park Tank	- Photo document condition of failing grout - Provide condition of tower appurtenances (vent, overflow, ladders, safety climb, security)
Walker Road Tank	- Photo document condition of failing grout - Provide condition of tower appurtenances (vent, overflow, ladders, safety climb, security) - Provide assessment of how communications equipment may affect coating system - Check report of 55% topcoat failure. If this is correct, it should be addressed.
Garrison Oak Tank	- Photo document condition of failing grout - Provide condition of tower appurtenances (vent, overflow, ladders, safety climb, security) - Provide assessment of how communications equipment may affect coating system
McKee Road Tank	- Photo document condition of failing grout - Provide condition of tower appurtenances (vent, overflow, ladders, safety climb, security) - Provide assessment of how communications equipment may affect coating system - Determine source of water in valve pit, and address
Kent Co. Aeropark Tank	- Provide recommendation of schedule for tower refurbishment and what coatings should be applied - Determine whether interior shell ladder is needed - Provide condition of tower appurtenances (vent, overflow, ladders, safety climb, security) - Provide information on when tank was originally constructed - Confirm that ladders, manholes, roof openings, platforms and handrails meet current OSHA standards
Bayard Ave Tank	- Re-evaluate condition of concrete column piers - Evaluate the free-standing overflow pipe inside the bowl and lack of top supports - Provide assessment of how communications equipment may affect coating system - Provide condition of tower appurtenances (vent, overflow, ladders, safety climb, security) - Confirm that ladders, manholes, roof openings, platforms and handrails meet current OSHA standards
General Foods Tank	- Provide lead and chromate paint laboratory testing prior to refurbishing - Provide assessment of how communications equipment may affect coating system application. Since tower is recommended for refurbishment, cellular antennae and cables will have to be removed by the cellular companies, and equipment shelters will need to be protected - Provide condition of tower appurtenances (vent, overflow, ladders, safety climb, security) - Confirm that ladders, manholes, roof openings, platforms and handrails meet current OSHA standards

5 Water Distribution

The City of Dover maintains a Geographic Information System (GIS) database of the existing piping within the distribution system. The GIS mapping was utilized to create Dover's hydraulic water model which was provided to WRA for this study. Further discussion about the hydraulic model and pipe condition analysis is included in the hydraulic modeling section of this report (Section 6.0 – Hydraulic Modeling).

The distribution system is comprised of approximately 233 miles of piping which varies in size from 4-inch to 30-inch in diameter. Most of the piping (67%) is 8 inches in diameter or smaller. The oldest piping in the system (approximately 1 mile), located in the downtown area of the City, was installed in 1882 and is unlined cast iron pipe (UCIP). Most of the piping in the distribution system is either cast iron pipe (CIP) or ductile iron pipe (DIP) with a majority of the piping installed in the last 40 years being DIP. Other materials in the system include polyvinyl chloride pipe (PVC), high density polyethylene pipe (HDPE), galvanized steel pipe (GSP), and asbestos cement pipe (ACP). **Table 5.1** and **Figure 5.1** provide a statistical breakdown of the water distribution system components.

Table 5.1 – Existing Water Distribution System

Material	Length (mile)	% of System	Average Year of Installation
CIP	95	40.76	1964
DIP	121	52.01	1995
PVC	12	4.96	1996
HDPE	0.07	0.03	1997
GSP	1	0.48	1963
ACP	2	1.06	1960
Unknown	2	0.70	N/A
Total	**233**	**100**	

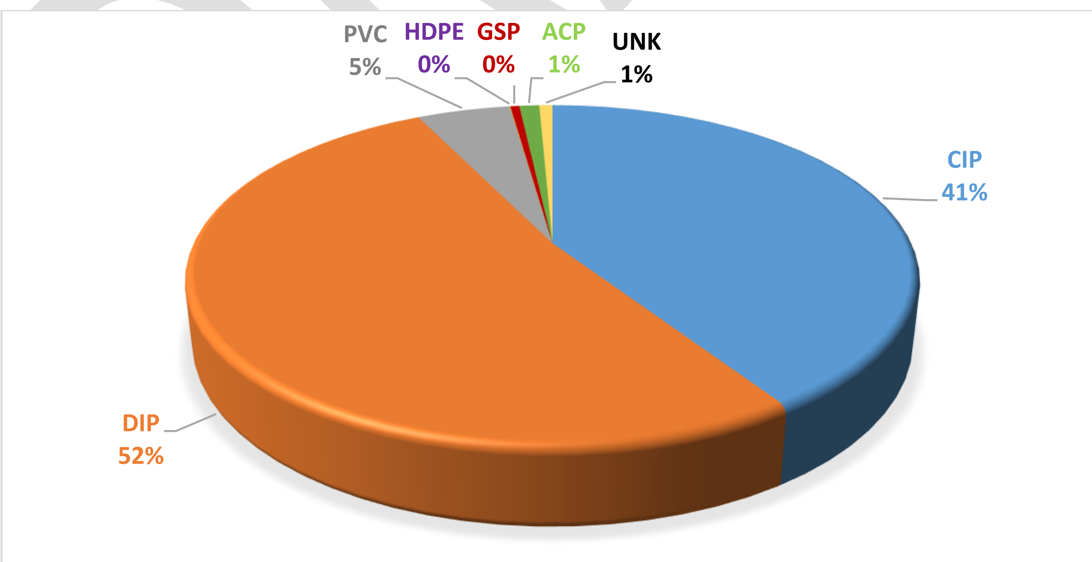
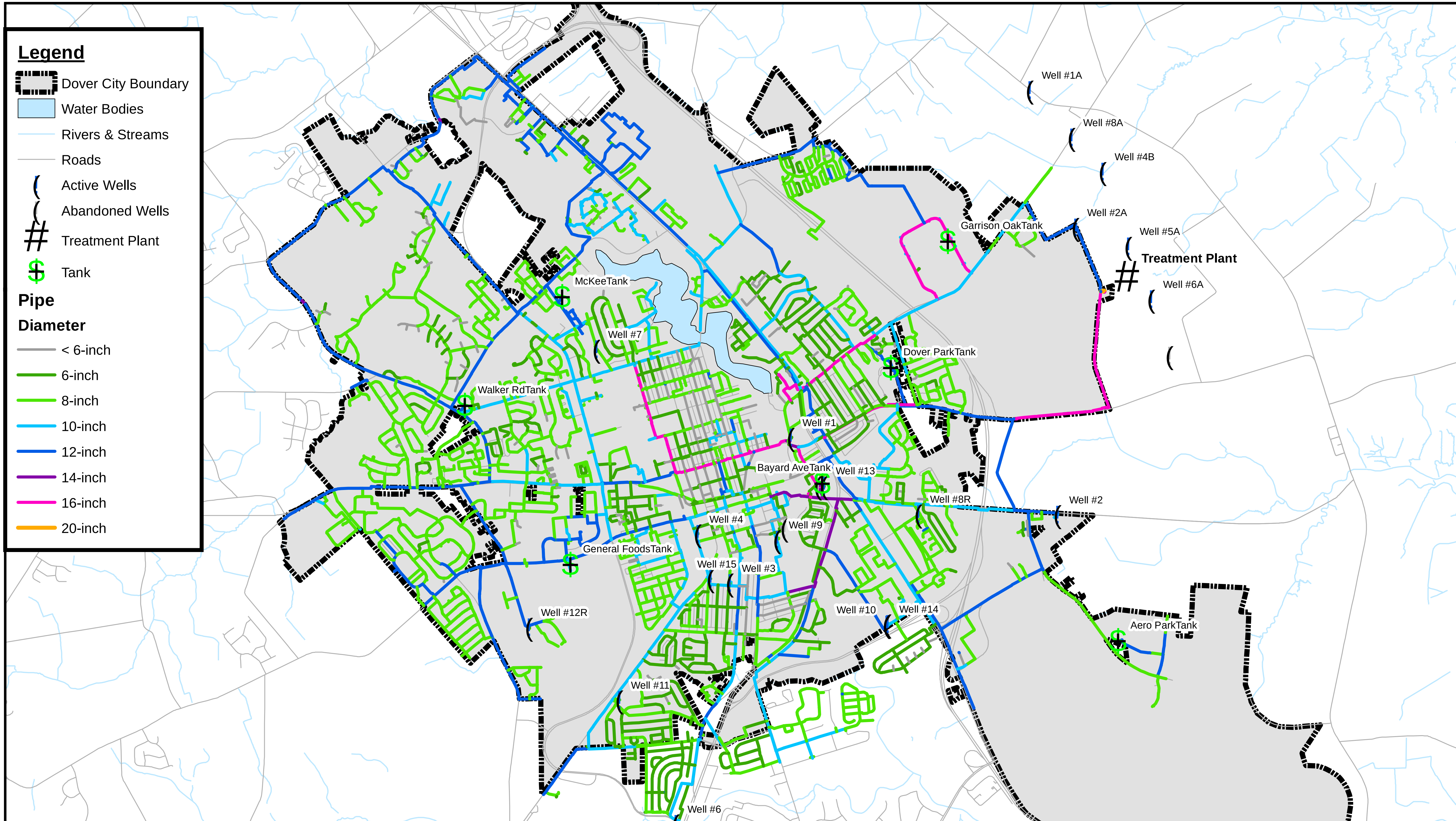


Figure 5.1 – Existing System Pipeline Material Distribution

The City's existing elevated storage tanks and deep wells (those that pump directly to the system) are distributed throughout the system while the City's water treatment plant is connected to the system in the northeast of the water service area. The shallow aquifer wells (Wells 1A though 8A) which pump to the treatment plant are located in this area as well. A map of the City's water distribution system including pipe materials and facility locations is included as **Figure 5.2**.

Evaluation of the distribution system was completed using the City's hydraulic model to identify deficiencies. Recommended system improvements, developed to remedy identified deficiencies, are outlined in Section 8.0 – Recommended Improvements.



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0 0.25 0.5 1 1.5 2
Miles

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Figure 5.2
Existing System Overview

6 Hydraulic Modeling

In 2006, WRA constructed and calibrated a hydraulic model of the City water distribution system for use in the master planning effort. Since then, the City has maintained and upgraded their hydraulic model for use. The City provided WRA with the current system model constructed in Innovyze InfoWater software which is a GIS based program. WRA reviewed and updated the provided model to assess the capabilities and limitations of the existing storage and distribution system, as well as to plan a logical and cost effective program of system improvements to meet existing and future demands.

Two types of analyses were utilized to examine the City of Dover's water distribution system: steady state (SS) analyses and extended period simulations (EPS). A steady state analysis is used to examine the system at an instantaneous moment. The operational settings are based on typical values provided by the City. Steady State analysis allows for evaluation of pressure and velocity in the system. An extended period simulation is used to evaluate operational settings and their time-related effects on water storage tanks and pumps supplying the system, movement of water through the system, as well as system reaction and recovery.

6.1 Water Model Update

The City provided WRA with the current version of their hydraulic water model. The model provided was created in the most recent version of InfoWater. WRA reviewed the model for piping configuration and input parameters, pump input parameters and operational controls, tank input and operations, water treatment plant output flows and pressures, and demand distribution. In addition, WRA utilized the various validation tools available within the InfoWater software to uncover duplicate pipes, nodes in close proximity that are not connected, orphan nodes, etc.

Observations from the provided model include the following:

1. Piping network was created using the City's GIS.
2. Pipe friction coefficients ranged from 110 to 150 which is typical for smooth wall new pipe in good condition. The model had not yet been calibrated; therefore, it was expected that these coefficients would be adjusted to system conditions during the calibration process.
3. Base demands are included which were distributed utilizing the 2018 metered consumption records.
4. A typical system diurnal curve was provided for extended period simulations.
5. The Monday pump operating rules were installed and operating during simulations.
6. All existing system Elevated Storage Tanks were included with an overflow elevation of approximately 166. WRA checked assigned elevations and diameters to confirm volumes against tank inspection reports.
7. The Water Treatment Plant was represented by a reservoir (all shallow wells) and pump. The pump curve is set to the high service pumps at the treatment plant.
8. All wells that directly connect to the system are represented by a pump and reservoir. The reservoir is set to the elevation of the groundwater at each well. All pumps were set to their design point flow and head gain.
9. The planned future well is included with anticipated flow and head conditions.
10. The model was able to function under both steady state and extended period simulations and produced pressure, velocity, and water age results with minimal to no errors.

WRA modifications to the model are as follows:

- Pump curves for well pumps which had undergone field testing were adjusted to current field conditions based on the provided well reports.
- Reservoir levels at groundwater wells were adjusted to reflect actual groundwater conditions recorded in the field during inspection and testing.

- A pipeline extending west of the Village of Cannon Mill on Hazlettville Road was removed from the model as it does not exist.
- Elevations were updated and assigned to all model nodes utilizing available aerial topology and the Elevation Extractor tool within the InfoWater software.
- "Current" or base demands were updated based on WRA's demand memo (**Appendix A**) and distributed to the nearest model node through GIS utilizing meter addresses found in the 2018 consumption information. Future demand distribution is detailed in Section 6.2.
- Pipeline improvements currently under construction (Ross St. Water Main and N. West St. Water Main) were added to the model under existing conditions.
- Pipeline C-factors were adjusted through model calibration efforts (See Section 6.3).

6.1.1 Validation Testing

Once updates to the model were completed a series of validation tests were conducted. These tests are available through the software and review the base model input for duplicate pipes, detached nodes, overlapping nodes in close proximity, and pipe split candidates. Results indicated that several duplicate pipes existed in the system. Duplicate pipes refer to model pipelines that are constructed during the GIS to model element conversion on top of one another. These pipes do not refer to parallel water lines that are currently in service in the downtown area of the City as shown in **Figure 6.1**. Identified duplicate pipes were removed from the model. The remainder of the tests did not indicate any other issues with the model.

Figure 6.1 – In Service Parallel Pipes

6.2 Demand Distribution

WRA utilized the City's existing meter location shapefile to accurately distribute demands throughout the model based on addresses of metered accounts. Actual metered consumption data were proportionally adjusted to meet the "Current" (Year 2019) demands as detailed in Section 2 - Water Demands. These adjusted demands were then associated via GIS to the nearest model nodes allowing for accurate location in the model. Spot checks of larger demands were completed to ensure that they were accurately located, and locations adjusted if necessary.

Future demands (Year 2025 through Year 2040) were distributed within the model based on address locations provided by the City and land annexation and use GIS files provided from planning and zoning. Piping connections from the new model nodes to the existing system were initially sized based on demands. Connection locations and looping were assumed based on review of the most reasonable connection location. Further review of connections and impacts to the distribution system were reviewed during the hydraulic modeling. **Figure 6.2** depicts added demands as compared to the existing distribution system through buildout (Year 2040).

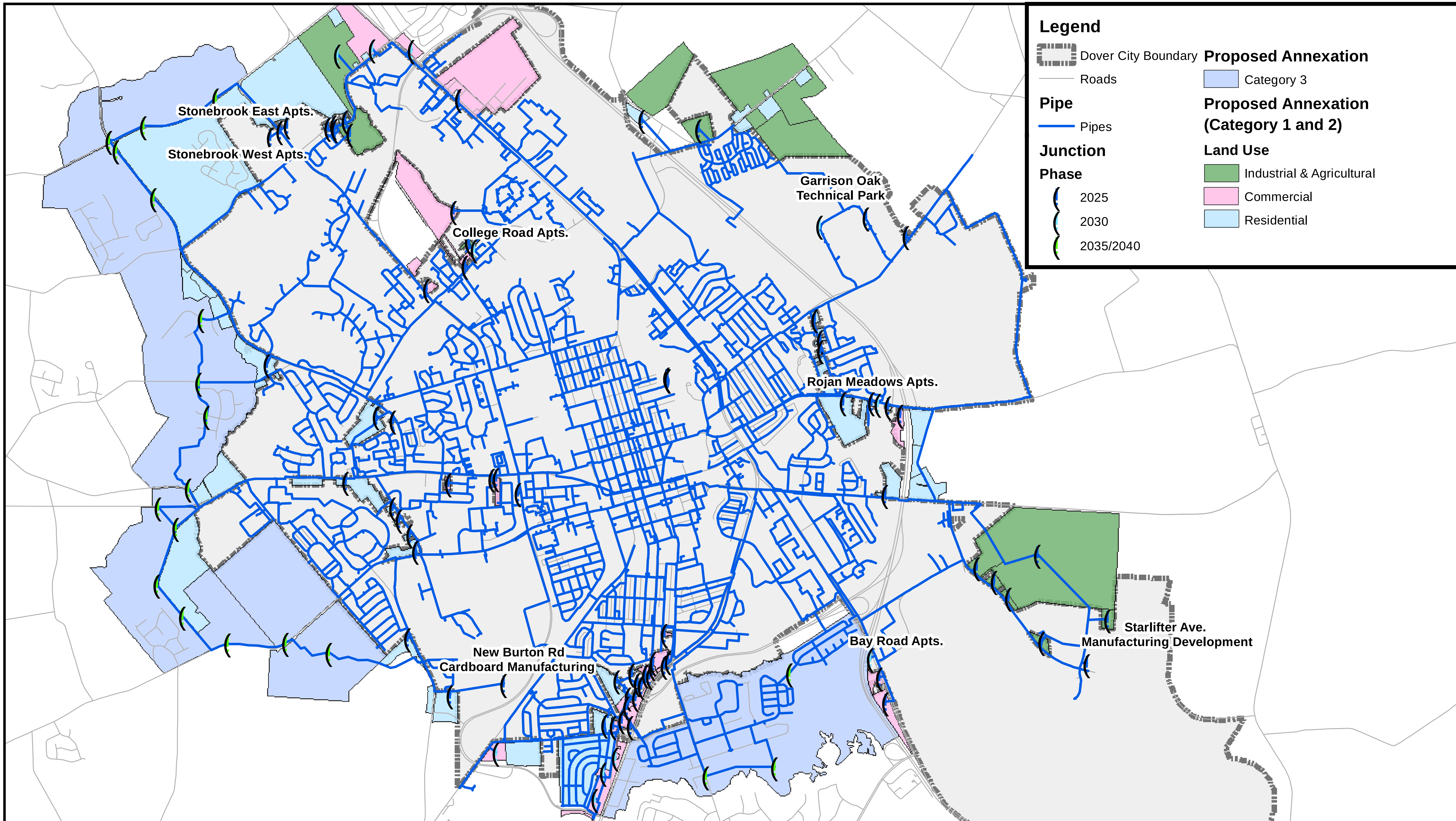

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Figure 6.2
Projected Demand Distribution

6.3 Model Calibration

Calibration of a hydraulic model should be completed following model construction/update to enable the model to provide results that represent actual system conditions. In order to calibrate the model, data from the operating distribution system needs to be collected and simulated. System pressures under normal and fire flow conditions are important tools in the calibration process. Calibration of the City of Dover hydraulic model was completed through numerous steady state analyses utilizing previous collected hydrant flow data and data collected as part of this analysis.

6.3.1 Hydrant Flow Tests

Hydrant flow tests are conducted by measuring the available flow from one hydrant, while monitoring its effect on other points in the system through pressure recorders placed on select hydrants. These hydrants are known as residual hydrants. Pressures are recorded for the residual hydrants under static conditions, before the flow hydrant is opened; and under residual conditions, while the flow hydrant is open and flowing steadily. The flow available from the flow hydrant is measured and recorded. This testing provides an indication of the available flow for fire suppression and allows pressures to be recorded in the system during such an event.

The City provided 4 years of hydrant flow data throughout the distribution system to provide testing points for model calibration. WRA reviewed the tests completed by the City and chose 18 hydrants based on the year of test completion and location within the system to provide distributed data points. An overall map showing the locations of the chosen test hydrants used in the model calibration is included in **Figure 6.4**. The hydrant flow information utilized in the calibration include results from hydrants 12, 107, 164G, 166, 195, 225, 546, 597, 719, 726, 1090, 1249, 1518, 1574, 1591, 1606, 1684, and 1702.

6.3.1.1 Unidirectional Flow Testing

In addition to the hydrant flow test data provided by the City, WRA identified locations of five (5) additional hydrant flow tests to capture additional system information and flow characteristics on a variety of pipe diameters, materials, and ages specifically for model calibration purposes. If a non-interrupted section of pipe is used for the flow test, and flow to the flow hydrant is unidirectional, the roughness factor (C-value) of the pipe can be calculated from the pressure loss between the hydrants, which gives an indication of the pipe interior condition. A schematic of the procedure is included as **Figure 6.3**.

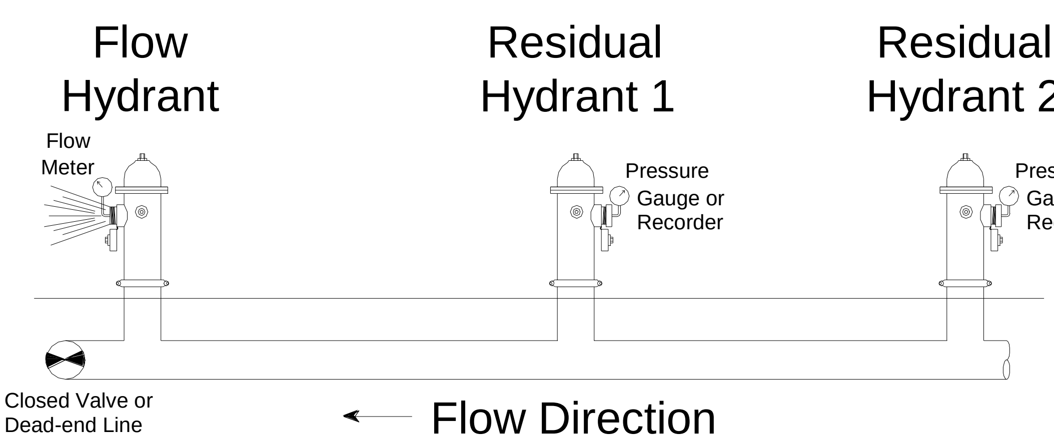

Figure 6.3 – Calibration Unidirectional Hydrant Flow Test Schematic

Four (4) out of five (5) suggested hydrant flow tests were completed by the City in April and May of 2021. The test that was not completed was due to coordination requirements, timing, and potential impacts to large costumers. Test location forms and recorded field information can be found in **Appendix D**. For each of the flow tests, pressures at the residual hydrants were monitored using pressure gauges. Flow was calculated using pitot pressure and the diameter of the orifice on the flow hydrant

Testing results show that available flow at hydrants during the additional unidirectional testing ranged from 932 gallons per minute (gpm) to 1,022 gpm. **Table 6.1** provides a summary of results from each location. As a result of the pressure and flow information collected from the flow tests an estimate of the pipe friction coefficients, or C-values was determined. The calculated C-values are also included in **Table 6.1**. Based on the calculated results, it was apparent that unidirectional flow was not achieved. Therefore, WRA utilized the collected pressure and flow data only and iteratively determined C-values in each testing area.

Table 6.1 - Hydrant Flow Test Results

Unidirect Test #	Location	Flow (gpm)	Pipe Diameter (in)	Pipe Length (ft) R1-R2	Hydrant #	Position	Hydrant Elevation	Static Pressure (psi)	Static HGL (ft)	Residual Pressure (psi)	Residual HGL (ft)	Change in HGL (ft)	Calculated C-value
1	College Rd	1,022	12	1188	302	Flow	51	42	N/A		N/A		
					301	Resid1	48	41	142.7	40	140.4		
					299	Resid2	43	45	147.0	41	137.7	2.7	**142**
2	--	--	--	--	--	Flow	--				N/A		
					--	Resid1	--	--	--	--	--		
					--	Resid2	--	--	--	--	--	--	--
3	Stoney Rd	1,022	8	1243	381	Flow	43.0	45	N/A		N/A		
					382	Resid1	44.0	45	148.0	42	141.0		
					384	Resid2	42.0	47	150.6	45	146.0	4.9	**305**
4	North Halsey Rd	1,022	6	914	573	Flow	33.9	50	N/A		N/A		
					572	Resid1	33.4	48	144.3	43	132.8		
					570	Resid2	32.6	50	148.1	49	145.8	13.0	**325**
5	Kesselring Ave	932	8	739	1150	Flow	28.0	55	N/A		N/A		
					1151	Resid1	30.0	50	145.5	46	136.3		
					1152	Resid2	32.0	52	152.1	46	138.3	2.0	**342**

The unidirectional flow procedure shown in this section and described in the unidirectional flow testing plan included in **Appendix D** is a particularly useful tool during calibration of a hydraulic model. While normal hydrant testing procedures should not be modified, the City should consider completing unidirectional flow testing throughout their system during the next model calibration effort.

6.3.2 Calibration Results

A steady state calibration analysis was completed to ensure model conditions are accurate to the real world distribution system. The hydraulic model calibration is considered adequate when pressures within the model are +/- 5 pounds per square inch (psi) from pressures observed in the field.

Detailed (continuous) SCADA data for pump output flow/pressure and tower levels was not available. Therefore, WRA utilized the available typical tank ranges and the average tank level at night (approximately midnight) provided and ran a 24-hr extended period simulation to estimate tank levels in each tank at 30 minute intervals throughout an average day. Tank levels for each steady state calibration scenario were then set in the model based on the time each hydrant test was completed to estimate system conditions. In addition, pump operations at the time of each test are unknown. Therefore, WRA allowed the pumps in the hydraulic model to turn on/off based on the assigned tank levels. The pump control scheme is explained in more detail under the model analysis summary discussion.

Due to the calibration assumptions, WRA was able to match most but not all of the static pressures within the model to the static pressures observed during the various hydrant tests. For those tests where a static pressure match could not be achieved, WRA focused on matching pressure losses to balance head loss due to internal pipe conditions. Due to the amount of assumptions that were utilized during the calibration effort as well as the variety of years, times, and techniques used in collecting the hydrant tests, WRA was not able to match all test locations. However, 94% of tests were matched to within 5 psi of residual pressure or pressure losses, therefore, the model was considered calibrated. A summary of all tests and model results is included in **Appendix D**. **Figure 6.4** shows pipe C-values in the model as a result of the calibration efforts. The calibration efforts resulted in C-values of 70-90 for older cast iron mains, 125-140 for ductile iron mains and 150 for PVC.

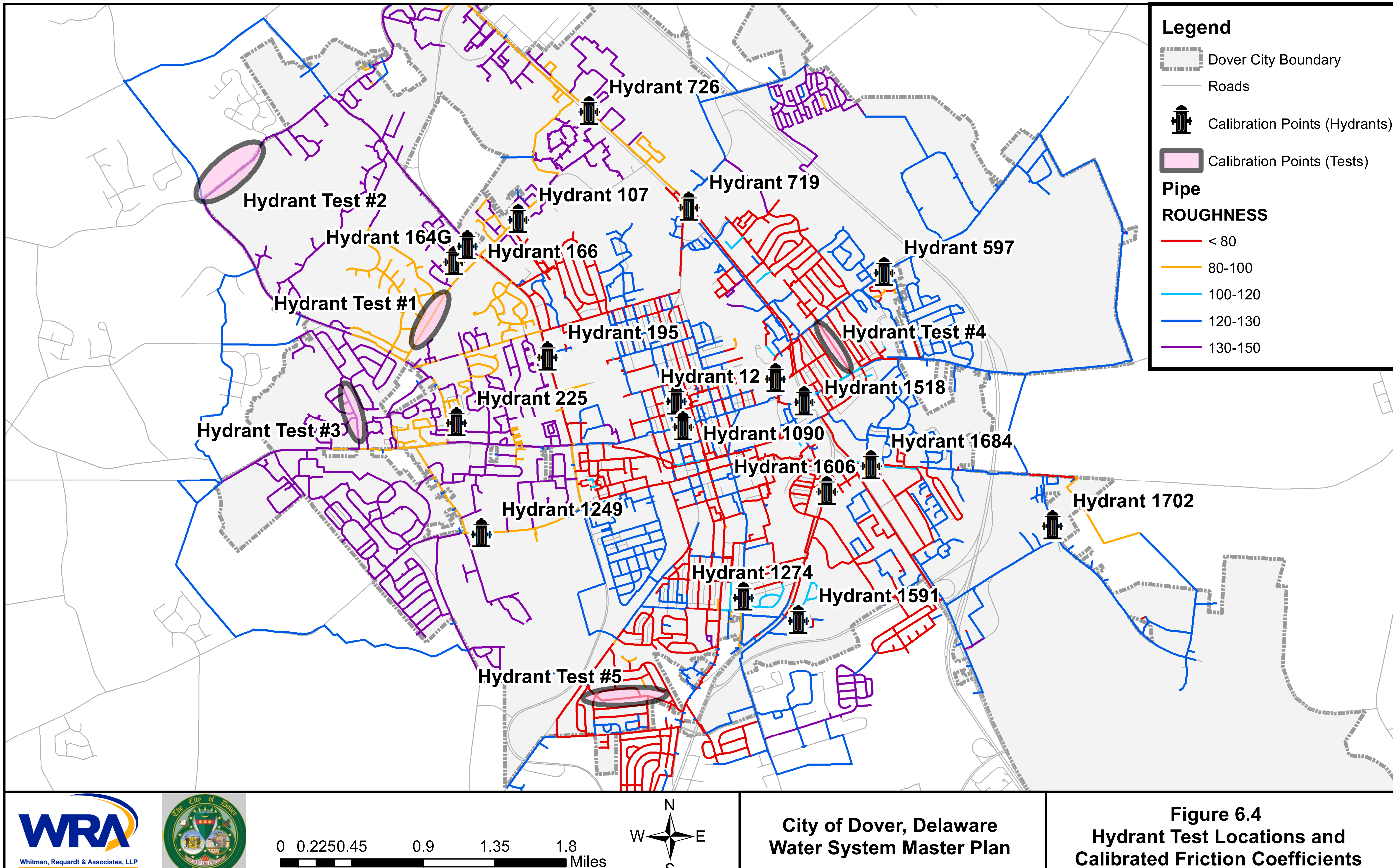

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Figure 6.4
Hydrant Test Locations and Calibrated Friction Coefficients

6.4 Model Analysis Summary

Utilizing the calibrated hydraulic model, the City of Dover water distribution system was simulated under various conditions. Scenarios were completed as both steady state and extended period simulations. The modeled scenarios evaluated system operations such as pressures and pipeline velocities, supply of fire flow and residual pressure and system water age as an indicator of water quality. Results were assessed based on a series of system minimum and maximum requirements which are summarized in the following section. The modeling scenarios utilized per timestep are as follows:

1. Maximum Day Demand Extended Period Simulation
2. Maximum Day Demand Steady State plus Fire Flow
3. Maximum Day Demand Extended Period Simulation plus Fire Flow
4. Water Age (Average Day Demand) Extended Period Simulation

WRA identified and evaluated system improvements as a function of projected demands over a 20 year planning period in 5-year increments. Five (5) hydraulic timesteps, "Current" or Year 2019, Year 2025, Year 2030, Year 2035, and Year 2040 or "Build-Out", were utilized resulting in a total of 20 modeling runs.

6.4.1 Model Assumptions

The following is a record of physical and operational assumptions utilized in the hydraulic model for analysis.

6.4.1.1 Physical Attribute Assumptions:

1. Pipeline replacement projects in the downtown Dover area to replace old small diameter cast iron mains scheduled to be constructed prior to FY 2025 are included in the Year 2025 in hydraulic timestep. Projects scheduled to be constructed after FY 2025 are included in the Year 2030 hydraulic timestep. Information on scheduled pipeline projects can be found in **Appendix E**.
2. Tank Levels for Steady State fire flow analysis were set to half (50%) full.
3. Initial Tank levels for EPS are based on available Tank SCADA data and are the average of the Tank's level at midnight (equivalent model start time of 0 hours).
4. New piping is assumed to be cement lined ductile iron with a C-value of 130.

6.4.1.2 System Operation Assumptions and Parameters:

1. Minimum allowable system pressures under maximum day conditions is 35 psi.
2. Maximum allowable velocity is 4 feet per second (ft/s).
3. Steady State Fire Flow tests will be conducted at 2,000 gallons per minute (gpm) with a minimum 20 psi residual pressure requirement. SS fire flow testing will occur at all new developments. SS fire flow testing locations are shown on model result figures located in the **Appendix F**.
4. Extended Period Simulation Fire Flow tests conducted in the downtown Dover area will be 5,000 gpm for 4 hours with a minimum residual pressure of 20 psi during peak demand (7:00 am to 11:00 am). Testing occurred at three nodes located in the Dover downtown area in the vicinity of planned water main replacement projects. Nodes were chosen based on location and diameter of water mains. Water Mains tested were 6-inch, 8-inch and 16-inch CIP. See **Figure 6.5** for test node locations.
5. Water age analysis will be for 10 days under Average Day Demand.
6. Maximum allowable water age in Tanks is 5 days (from 2018 Ten States Standards).
7. Detailed demand information is not available to create a specific diurnal curve for the City. Therefore, WRA assumed the curve utilized during the 2006 modeling effort was still applicable as the curve was developed based on conversations with the City operations staff at the time. The diurnal curve assigned for this modeling effort can be found in **Appendix E**.

8. Well pump rule controls are set to the City's Monday rule scheme. The City's daily pump operation rule schedule can be found in **Appendix E**. Due to the complicated daily nature of the City's operational scheme only the Monday conditions were modeled. Under normal operations, the system in controlled by levels in the General Foods Tank.
9. Based on conversations with City staff, the water treatment plant was set to operate daily from 7:00 am to 7:00 pm with a maximum output of 3.0 MGD.
10. The new groundwater well (Silver Lake Well) was assigned to be in service starting the Year 2025 timestep and is set to open and operates as needed.

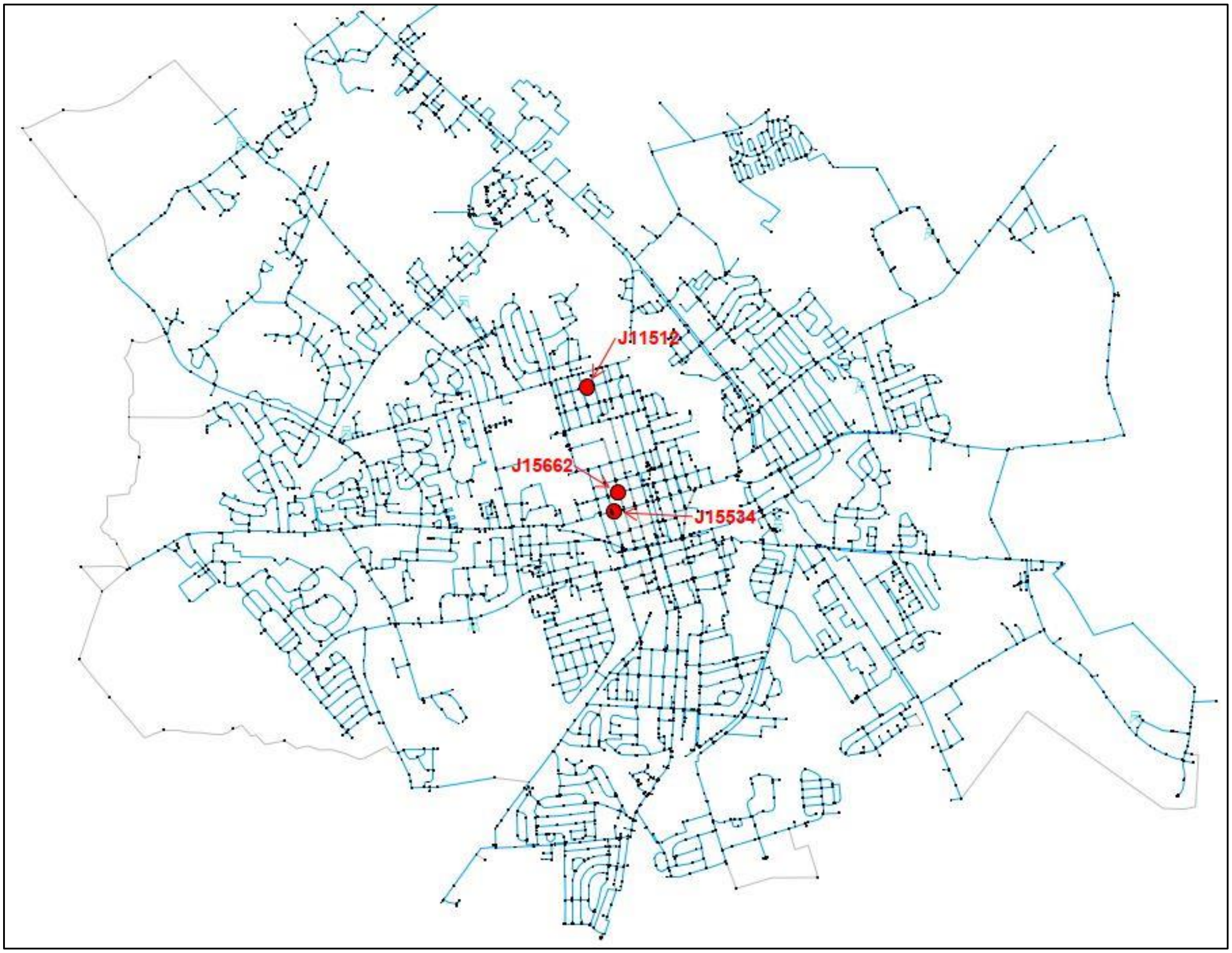


Figure 6.5 – EPS Fire Node Locations

6.4.2 Model Results

Results of the hydraulic model analysis are summarized in the following section. Model result data, figures and graphs can be found in **Appendix F**.

6.4.2.1 Year 2019 "Current"

Hydraulic analysis of the system under current conditions allows for optimization of the existing system in preparation for future expansion and development.

System Operations: Under existing conditions all pressures in the system remain above 35 psi with pressures ranging from 40 psi to 70 psi. The lowest pressures are located on the west side of the system which is the furthest from the City's water sources. The highest pressures in the system are observed downstream of pumped sources, and in the vicinity of Kentland Avenue, Governors Boulevard, Horsepond and Starlifter Roads, Long Point and N. Little Creek Roads and White Oak Road. Velocities in the system are below 4 ft/s in a majority of the system. Periodic instantaneous high velocities (< 6 ft/s) are observed in discharge lines from groundwater wells and tanks. However, the velocities are associated with pump on/off or initial tank draining. Therefore, no improvements are recommended. Additional areas of minor high velocities (4.2 ft/s to 5.5 ft/s) are observed at three locations in which a short reduction in the diameter of the water main exists. High velocities are observed in approximately 600 linear feet (lf) of 8-inch DIP on White Oak Road, 20 lf of 10-inch DIP on Long Point Road and 80 lf of 12-inch on N. Little Creek Road. Recommended improvements include:

- Upsize 600 lf of 8-inch DIP to 10-inch DIP along White Oak Road
- Upsize 20 lf of 10-inch DIP to 16-inch DIP along Long Point Road
- Upsize 80 lf of 12-inch DIP to 16-inch DIP along N. Little Creek Road

WRA reviewed pump operations and tank levels under maximum day demands. Results indicate that the General Foods Tank controls groundwater well operations. Cycling the small volume of the tower (0.25 MG) its full operating range results in very little level change in the other larger in service storage tanks. Levels in all Tanks remain above 60% full throughout the simulation. With the exception of the WTP, which operates on a timed schedule, operating pumps run continuously but are able to supply pressures and flows while maintaining tank levels.

Fire Flow: To test the existing system's fire flow capabilities, WRA spaced steady state fire flow testing nodes throughout the City. Results showed that the system was unable to supply 2,000 gpm at a 20 psi residual while maintaining velocities below 4 ft/s. Available flows were approximately 1,400 gpm. After review of the results, WRA determined that the 4 ft/s maximum velocity requirement was the limiting constraint. During fire flow events it is common in systems for velocities to increase to levels greater than typical maximum levels. Therefore, WRA retested the selected nodes allowing for a maximum velocity of 6 ft/s which is within typical operating ranges. Results indicate that greater flows were achieved at all locations.

EPS hydrant testing indicates that the existing downtown system is not able to maintain a fire flow of 5,000 gpm through the existing 6" and 8" mains. Pressures within the downtown area in the vicinity of these nodes drop below 20 psi (minimum pressure (-)10 psi) with velocities in the old CIP 4-inch and 6-inch mains increasing to 26 ft/s. The City is planning on completing a series of water main upgrades in this area. These projects will replace the existing cast iron small diameter lines with new 8-inch DIP increasing available fire flow in the area. Replacement projects scheduled to be completed prior to Year 2025 include:

- 3,200 lf of -inch pipeline replacement State St.
- 1,600 lf of 8-inch pipeline replacement along N. West St.
- 3,200 lf of 8-inch pipeline replacement along Fairview Ave.
- 500 lf of 8-inch pipeline replacement along N. Bradford St.
- 4,000 lf of 8-inch pipeline replacement along Queen St.

- 4,000 lf of 8-inch pipeline replacement along New St.

After discussions with the City, the scheduled year of the pipeline replacement along N. Bradford Street has been altered. While modeled under the Current timestep, this improvement will be included under Year 2035 in the proposed CIP.

6.4.2.2 Year 2025

Year 2025 hydraulic analysis was completed including recommended improvements from the previous hydraulic timestep. Anticipated new developments include the Starlifter Ave. Manufacturing facility, a cardboard manufacturing facility, the initial phase of the Garrison Oak Technical Park, the Stonebrook East and West apartments (432 units), and Category 1 annexed lands. The City also anticipates that a new groundwater well (Silver Lake Well) will be in operation. As mentioned in the Water Storage section of this report, the City has a new 1.0 MG elevated water tank scheduled for FY 2023 along Denneys Road. Per the water storage calculations, additional storage volume is not needed, however, WRA reviewed the need for this proposed tank for system operations and pressure maintenance. Construction of the tank was assumed to be in the vicinity of Denneys Road and McKee Rd.

System Operations: Model results indicate that the addition of the Denney's Road Tank during this timestep does not provide measurable benefits to the system. Results show that the system is able to maintain pressures above 35 psi even in the vicinity of additional developments in the northwest corner of the system without the addition of this Tank. No additional areas of velocities over 4 ft/s are observed. All new development areas were connected utilizing a 12-inch diameter main. Results show that groundwater pumps (including the proposed Silver Lake well) and tank storage are able to adequately supply the increase in system demands.

Fire Flow: Six (6) steady state fire flow tests were completed at the locations of the new developments and one downtown node. Fire flow testing was completed at the proposed Starlifter Avenue manufacturing area, Burton Rd cardboard manufacturing facility, Garrison Oak Technical Park, and Stonebrook East and West Apartments. Results indicate that at an allowable velocity of 6 ft/s, the distribution system can supply 2,000 gpm at a 20 psi residual pressure at all locations except for the downtown node and development along Starlifter Avenue.

Results indicate that a fire demand at the new manufacturing facility results in significant drainage of the Aero Park Tank and reduction of pressures below 20 psi along the existing dead end main in Starlifter Avenue. Flow and pressure deficiencies were also identified in this area under the 2006 Master Plan. To meet requirements, the 2006 Master Plan suggested looping approximately 5,500 lf of 12-inch main along the northwest edge of the Dover Air Force Base between S. Bay Road and Horsepond Road. Concerns about land availability and delays in development had stalled the project. Therefore, WRA reviewed alternative improvements. To meet fire flow requirements in this area approximately 7,000 lf of 12-inch DIP is required to loop the dead end line on Starlifter Avenue to S. Little Creek Road. Once in place, the system can supply fire flows to the new manufacturing development and maintain levels in the Aero Park Tank. As an additional benefit to this alignment, the proposed main bisects lands included under Category 2 – Priority annexation areas and can be used to supply this future development. In general, distribution supply requirements can be met along Starlifter Avenue by installing either improvement or both of the improvements discussed above. The 12-inch line connecting Starlifter to S. Little Creek Road is included in the CIP.

EPS hydrant testing indicates that the test completed on small diameter lines in the downtown area cannot maintain a fire demand of 5,000 gpm for 4 hrs while maintaining minimum pressures. However, replacement of mains in this area increases available flows and reduces velocities. It is recommended that the City continue their program of replacing small diameter cast iron mains in the downtown area. Replacement projects already scheduled to be completed prior to Year 2030 but after Year 2025 include:

- 1,400 lf of 8-inch replacement pipeline along N. Bradford St. (improvement included under Year 2035 improvements in the CIP)

- 1,600 lf of 8-inch pipeline replacement along Kings Highway
- 2,300 lf of 8-inch pipeline replacement along Reed St.
- 1,000 lf of 8-inch pipeline replacement along Queen St.
- 1,940 lf of 8-inch pipeline replacement along Bank Lane

Additional recommended pipeline replacement projects in the same downtown vicinity include:

- 1,300 lf of 8-inch pipeline replacement along Lakewood Place
- 1,200 lf of 8-inch pipeline replacement along Bank Lane

6.4.2.3 Year 2030

Year 2030 hydraulic analysis assumes improvements suggested in previous timesteps are complete and in service and includes the addition of annexed lands, the remainder of the Garrison Oak Technical Park, Rojan Meadows (159 unit apartment), 1080 and 1106 Bay Road (48 unit apartment), and the Apartments at College Road (328 unit apartment). All proposed developments were connected to the system using a 12-inch diameter pipeline.

System Operations: MDD analysis indicates that the distribution system is able to water demands. Pressures throughout the distribution system remain above 35 psi. No new areas of high velocity are observed. An overall decrease in tank levels is observed as compared to previous timesteps, however, all tanks remain above 55% full with the lowest levels observed in the General Foods and Aero Park Tanks. Since the Tanks are still cycling within a normal operating range and pressures are maintained throughout the system, no additional improvements are recommended.

Fire Flow: Steady State hydrant flow tests were competed at all new development areas and one node located in the downtown area of the City. Results show that 2,000 gpm at 20 psi residual is only able to be met at the Garrison Oak Technical Park when using 4 ft/s as a velocity constraint. At a constraint of 6 ft/s, the system can supply 2,000 gpm and maintain a residual pressure of 20 psi at all proposed developments with the exception of the Apartments at College Road. To meet hydrant demands, WRA recommends upsizing approximately 540 lf of 8-inch pipeline to 12-inch diameter line along College Rd. The system cannot supply 2,000 gpm at the downtown test location. An increase in available flow in this area is observed due to scheduled pipeline replacement projects. WRA recommends the City continue replacing the small undersized cast iron lines in this area to increase available flow during emergencies.

Downtown EPS fire flow results show that an increase in flow is available due to the pipeline replacement and upsize projects currently scheduled for completion. The remaining small diameter mains in the direct vicinity of the test nodes still see velocities of up to 32 ft/s. Residual pressures in the system remain above 20 psi with the exception of the hydrant test nodes. Increased draw down as compared to results from previous hydraulic timesteps is observed in the General Foods Tank, but the tank is able to recover.

Recommended improvements as a result of Year 2030 hydraulic analysis include:

- Upsize 540 lf of 8-inch watermain with 12-inch along College Road
- 2,800 lf of 8-inch pipeline replacement along Bradford St. (improvement included under Year 2035)
- 1,000 lf of 8-inch pipeline replacement along Clara St.
- 4,000 lf of 8-inch pipeline replacement along Governors Ave.
- 1,100 lf of 8-inch pipeline replacement along Cecil St.

6.4.2.4 Year 2035

Hydraulic analysis of Year 2035 included demands from 50% of the future annexed land areas located primarily along the western edge of the City's service area (Category 3 annexation areas). No water mains exist in this area to service these potential developments. Therefore, WRA assumed approximately 50,000 lf of 12-inch diameter transmission water mains with appropriate looping connections to the existing system is required to serve this area. Exact timing of development in these areas or if they will ever be developed is unknown. WRA recommends re-evaluating pipeline needs within these annexed lands if/when development occurs. The 50,000 lf of new pipeline will be evenly divided between 2035 and 2040 timesteps in the Capital Improvement Plan.

System Operations: Hydraulic analysis results show that a reduction in overall system pressure is observed due to the increase in demand as compared to previous timesteps. However, pressures remain above 35 psi throughout the system. The lowest pressures in the system are located in the southwest corner of the system and in areas of new development with pressures in the vicinity of water sources remaining above 50 psi. No new areas of high pipeline velocities are observed but an overall increase in maximum pipeline velocities is seen throughout the distribution system. It is noted that as compared to previous hydraulic timesteps all storage tanks in the system operate at lower levels with the General Foods Tank draining to 5 ft without recovery. In general, pressures and velocities are able to be met throughout the model scenario, however, the well pumps are running continuously at full capacity while maintaining lower water levels in the elevated tanks. WRA suggests additional water sources to increase the available flow in the system to meet projected max day demands. This result confirms the need for additional water sources by year 2035 as discussed in Section 3.0 – Water Supply. The need will also be highly dependent on the actual development of these additional long-term annexation lands.

In addition to the recommendation of a new water source, WRA reviewed changes in operational settings and/or the addition of the Denneys Road Tank to better maintain tank levels and pressures in the system. Based on results, WRA recommends the addition of the Denneys Road Tank to balance pressures on the west side of the distribution system and the removal of the General Foods Tank from service since levels in this tank cannot be maintained under the current operational scheme. Assuming a storage volume of 1.0 MG for Denneys Road, this change results in a total storage volume of 6.0 MG. MDD Results show that levels in all tanks under this scenario remain above 35%. Further analysis of tank cycling under this tank configuration is completed under the water age analysis portion of this report. The construction of and volume of the Denneys Road Tank will be highly dependent of actual development of the Category 3 lands. WRA recommends re-evaluating the need for and volume of the Denneys Road Tank as well as system operating requirements when the development schedule of these Category 3 areas is clearer.

Fire Flow: Steady State Fire flow availability was tested at 4 ft/s and 6 ft/s at multiple locations throughout the annexed land area. At all locations the system is able to provide 2,000 gpm at 20 PSI residual pressure. EPS fire flow analysis in the downtown Dover area shows that the system is able to supply 5,000 gpm for 4 hours at 20 psi residual throughout with the exception of the flow hydrant node. In addition, areas immediately adjacent to the test nodes experience high velocities, however, improvements have greatly increased available flows. WRA suggests the City continue their program to replace old undersized cast iron mains in the area to continue to increase available flows.

Recommended improvements include:

- 50,000 lf of new 12-inch DIP within the proposed long term annexed lands
- 1,500 lf of 8-inch pipeline replacement along Fulton St.
- 1,300 lf of 8-inch pipeline replacement along State St.
- 2,600 lf of 8-inch pipeline replacement along Kirkwood St.
- 3,000 lf of 8-inch pipeline replacement along Lockerman St. and Lockerman Plaza
- 300 lf of 8-inch pipeline replacement along Federal St.
- Construction of 1.0 MG (assumed volume) Denneys Road Tank
- New water source (1.0 MGD equivalent)

6.4.2.5 Year 2040

Year 2040 (Build-Out) analysis includes remaining demands from the future annexed land areas along the western edge of the City's service area (Category 3). No additional transmission lines other than those noted during Year 2035 are required. Modeling was completed assuming the construction of a 1.0 MG tank along Denneys Road and the decommissioning of the General Foods Tank. Pump controls were assumed to be based on the McKee and or Walker Road Tanks (current second tier control levels). WRA recommends further review of pump control levels if the Denneys Road Tank is in service.

System Operations: Under MDD, pressures below 35 psi (between 33 psi and 34 psi) are observed in the vicinity of the Cannon Mills Apartment Homes, Village of Westover Apartment Homes, off of Kenton Road just north of Forrest Avenue, and off of Kenton Road east of College Road. WRA reviewed various improvements to increase pressures in this area. The easiest way to increase pressures was observed when the existing well 12R was operationally allowed to pump at 100% capacity (currently setting in model is 90%). Similar to Year 2035, the additional demand results in increased draw down and operating levels of all tanks in the system indicating that additional water production is needed to maintain system pressures in conjunction with tank levels. Recommendations for additional water sources at system Build-Out are included in Section 3.0 – Water Supply. No additional areas of high velocities are observed.

Fire Flow: Fire flow during steady state was tested at the same locations as in Year 2035 hydraulic analysis as no water mains have been added to the system but demands throughout the annexation areas have increased. At 4 ft/s and 6 ft/s, all locations are able to achieve 2,000 gpm at 20 PSI residual pressure. Similar results during EPS analysis in downtown Dover to Year 2035 were recorded during 2040 analysis. No additional pipeline replacement projects are recommended.

Recommended Improvements as a result of Year 2040 modeling include:

- New water source (1.0 MGD equivalent)

6.4.3 Water Age Results

WRA completed a 10-day EPS under average day demand conditions to review water age as an indicator of water quality for each hydraulic time step. Water age result figures and elevated tank levels and ages are included in **Appendix F – Model Results.** Common water quality issues that occur in systems include development of odor, taste, and color (brown water) as well as the creation of disinfection by product (DBPs). DBPs are formed when free chlorine (chlorine residual) in the distribution system reacts with various elements in the water such as organic compounds.

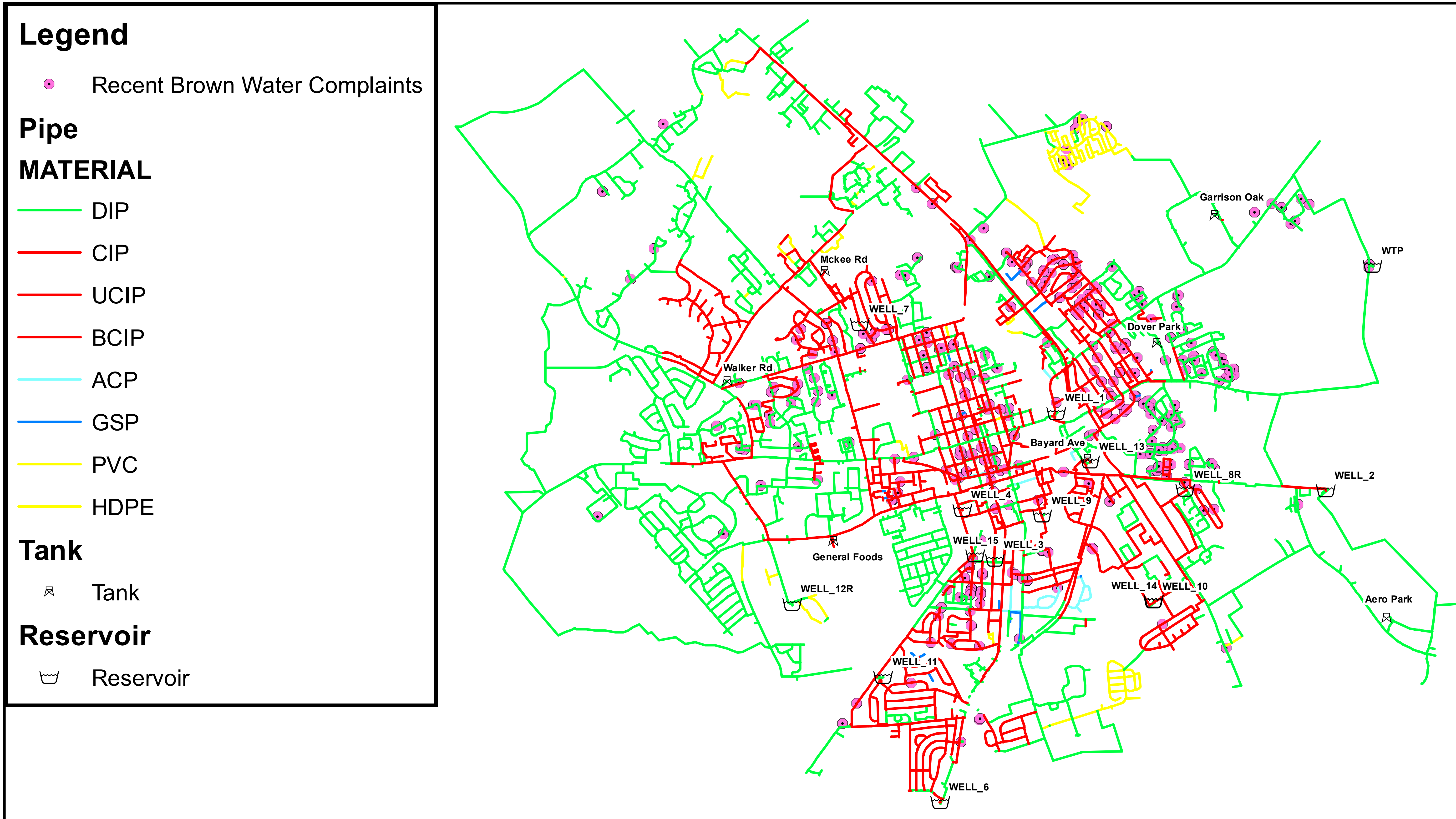
Water age, or the retention time of an element of water in the system, is used as a surrogate for more detailed, expensive, and often much more difficult water quality modeling, as water age is easy to calculate and is not dependent on variable chemical reactions. Results of water age analysis provide guidance for municipalities into areas of the system that could develop problems with water quality. These results do not necessarily indicate that there is a problem. Further study is required to establish specific water quality issues. Areas of high water age can be used in conjunction with anecdotal evidence such as customer complaints, and laboratory testing results to establish areas of concern. Changes in system operations or the addition of physical improvements to promote lower water age can be implemented to minimize the likelihood of water quality problems.

The City has experienced regular brown water issues throughout its distribution system. Reasons for water discoloration within the distribution system include the corrosion of old cast iron mains, chemical disinfection reactions or sediment build up. As described in Section 5 – Water Distribution, approximately 41% of the distribution system is comprised of unlined cast iron mains, the corrosion of which may be the reason for brown water. The City maintains a regular water main flushing program to mitigate the brown water problems and remove corrosion and sediment from the system. Despite these efforts, brown water complaints continue to be a problem.

Dover provided WRA with their log of water quality (brown water) complaints from customers which includes a list of complaints and associated addresses from 2002 to 2020. Prior to water age modeling, WRA imported the complaint locations into GIS and compared them to pipeline material type to see if a correlation exists. To simplify the comparison, only the past five (5) years of complaint data was utilized. In addition, complaints received during times of system flushing were removed. **Figure 6.6** shows piping in the existing system as compared to the filtered customer complaints.

Based on review of this figure, water quality complaints are concentrated in the areas of small diameter cast iron water mains in the downtown area and older communities on the east and south sides of the distribution system. Water main replacement and upsize recommendations included for the downtown area in the modeling results section above will result in the replacement of a majority of the undersized cast iron mains. The remaining cast iron lines in the older communities are 6-inch and above. Therefore, WRA recommends the City start a program to clean and line the old cast iron mains that are adequately sized (approximately 80,000 lf). As compared to replacement, cleaning and lining typically results in a slightly lower cost per linear foot and minimizes impacts to the community due to a reduction in open trench excavation.

Figure 6.6 also shows that areas of newer ductile iron and PVC mains in the east/northeast portion of the system have seen recent water quality complaints. These areas are located in a portion of the system that is most likely supplied water via the City's water treatment plant. It is possible that the differences in treatment at the WTP as compared to the deep wells or the actual water chemistry of the shallow Columbia Aquifer results in an increase in water quality problems within this zone of influence. The City recently completed upgrades to the WTP including the addition of Greensand+. Once the plant is operating consistently, the City should monitor complaints in this area of the distribution system to see if the change in treatment leads to a decrease or a change in location. The treatment plant operation could also have an impact on the quantity of cleaning and lining required as complaints within the older communities in this area could also decrease.



Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

City of Dover, Delaware
Water System Master Plan

Figure 6.6
Pipe Materials and
Water Quality Complaints

6.4.3.1 Water Age Modeling Results

Tank cycling graphs and results figures for average day demand water age analysis are located with all modeling results in **Appendix F**. Results of the City of Dover water age modeling are as follows:

Year 2019: Based on results of the 10 day extended period simulation, water age at individual nodes throughout a majority of the system was measured under 5 days. Pockets of water age between 5 and 7 days old were concentrated in the system at three general locations: north of College Rd, in the areas immediately east/northeast of Dover Park, and near the Garrison Oak Technical Park. Nodes with water older than 7 days were scattered throughout the system, as well as concentrated near the Aero Park Tank along Horsepond Road and Starlifter Avenue. All of these higher water age areas can be attributed to dead ends or branches of pipe with very low demand without looping which causes water to sit stagnant in the water lines. WRA recommends the City loop dead end lines to promote increased water movement whenever funds are available or in conjunction with other planned improvements or maintenance.

Water age in the Bayard Ave. Tank was less than 5 days old; the Garrison Oak Tank has water between 5 and 7 days old, and the remaining tanks – Aero Park, General Foods, Dover Park, Walker Rd, and McKee Rd – have water ages between 7 and 10 days old. Per the City's current control scheme, all deep well pump operations are controlled based on levels in the General Foods Tank. Due to its smaller volume (0.25 MG) cycling occurs quickly within this tower. To maintain levels in this tank, the well pumps continue to pump water which results in low cycling in the other larger tanks. Low cycling within tanks results in higher water retention times which typically results in the reduction of chlorine residuals and can lead to the formation of water quality issues. The 2018 Ten States Standards suggest tank turnover of 5 days or less. Increased cycling of tanks can often result from an increase in demands or a change in system operating procedures.

As Year 2019 results represent current system operating conditions, WRA compared the water age results to the filtered water quality complaint locations. **Figure 6.7** depicts water age results versus customer complaints. A majority of the recent water quality complaints are located within areas depicting water age as less than 2 days. Therefore, it looks as if the brown water concerns correspond greater to pipe age and material rather than the water retention time in the system. One area of concentrated complaints (the areas north/northeast of Dover Park) was observed to overlap with higher water ages (still below 10 days). Cleaning and lining of the pipes in this area has already been recommended which should prevent iron from leaching into the water due to prolonged contact time.

Year 2025: Water age modeling for timestep 2025 included improvements recommended under the water modeling results section. Water age in the 2025 system sees a vast improvement in the lines around the Aero Park Tank due to the proposed 7,000 lf loop from Starlifter Avenue to S. Little Creek Road and the new manufacturing development off Starlifter Ave. The areas near Dover Park and north of College Road are still experiencing pockets of water between 5 and 7 days old, however, as compared to current system results. Water older than 7 days was still found at isolated dead end locations throughout the system.

A slight increase in tank cycling is observed in all Tanks due to the increase in demands. Water age in the Bayard Ave Tank is still between 2 and 5 days old. The Aero Park and Dover Park Tanks have improved to between 5 and 7 days old, and General Foods, Walker Rd, and McKee Rd are all still more than 7 days old. However, water age in all tanks was reduced. As the City's water quality complaints seem to be tied to pipeline materials and the system already contains excess storage volume, no additional system improvements are recommended.

Legend

Recent Brown Water Complaints

Junction

Max. Water Age (hr)

- less than 48.00
- 48.00 ~ 124.00
- 124.00 ~ 168.00
- 168.00 ~ 240.00

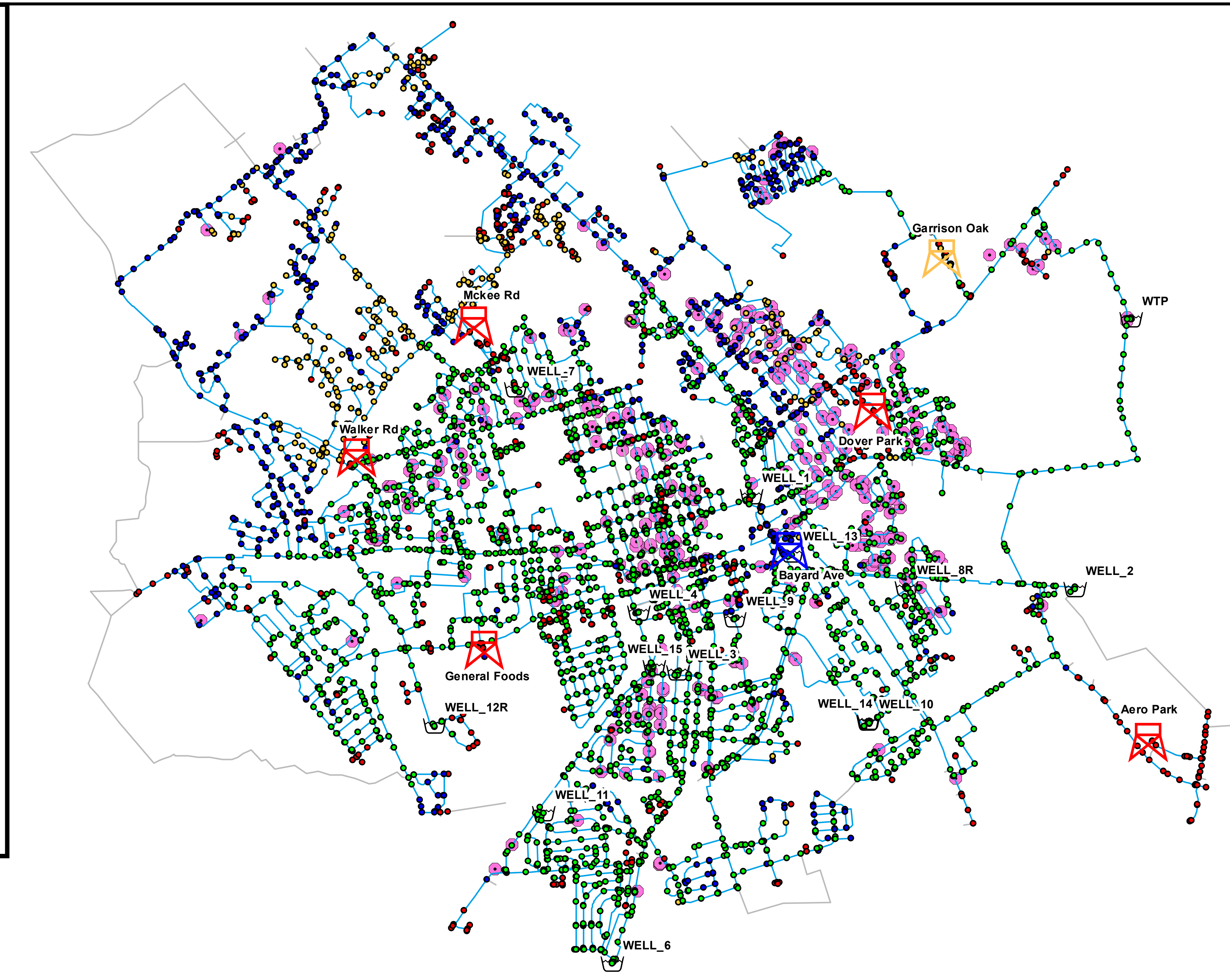
Tank

Max. Water Age (hr)

- less than 48.00
- 48.00 ~ 120.00
- 120.00 ~ 168.00
- 168.00 ~ 240.00

Reservoir

Reservoir



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0 0.25 0.5 1 1.5 2 Miles

N W E S

City of Dover, Delaware
Water System Master Plan

Figure 6.6
Water Age and
Water Quality Complaints

Year 2030: As compared to Year 2025, water age throughout the entire distribution system is observed to improve in the 2030 hydraulic timestep. The pockets of higher water age north of College Road between 5 and 7 days old have significantly diminished. The areas north/northeast of Dover Park and near the Garrison Oak Tank also experienced a reduction in water age. Water older than 7 days was still found at isolated dead end locations throughout the system.

Tank water age stayed consistent with 2025, with the exception of the Dover Park Tank. The Dover Park Tank saw an increase in water age, from between 5 and 7 days to between 7 and 10 days old. This is most likely associated with buildout of the Garrison Oak Technical Park and a resulting change is water flow patterns. As piping in the Dover Park area is included in the cleaning and lining recommendation, no additional improvements are recommended.

Year 2035: The 2035 timestep saw the addition of the Denneys Road Tank, and the removal of the General Foods Tank. This resulted in the areas north of College Road again experiencing water ages between 5 and 7 days old. The areas near Dover Park also saw an increase in water age. Nodes near the Aero Park Tank saw a significant decrease in water age due to new developments in the area.

Water in the new Denneys Road Tank, the Walker Road Tank, and the McKee Road Tank was between 7 and 10 days old. Water age in the Dover Park Tank again improved to between 5 and 7 days old. Water in the Garrison Oak Tank remained between 5 and 7 days old, and the Aero Park Tank water age improved to between 2 and 5 days old. With the General Foods Tank out of service, the system is operating utilizing controls based on the McKee Rd and Walker Rd Tanks. The City should evaluate the control levels and controlling tanks to provide for the greatest tank cycling when/if the Category 3 annexation areas are ever developed.

Year 2040: Water age throughout the entire system improved in the 2040 hydraulic timestep. The pockets north of College Road, the area north/northeast of Dover Park, and the area around the Garrison Oak Tank all experienced a reduction in water age, with pockets of water between 5 and 7 days old nearly disappearing. Water older than 7 days was still found at isolated locations throughout the system, but the system as a whole experience a reduction in water age.

Water in the Denneys Road Tank, the Walker Road Tank, and the McKee Road Tank remained between 7 and 10 days old. The Dover Park Tank water age remained between 5 and 7 days old. The Garrison Oak Tank water age improved, joining the Bayard Ave Tank and the Aero Park Tank at between 2 and 5 days old.

6.4.4 Hydraulic Modeling Conclusion

Under MDD the current distribution system, wells, and operational scheme can maintain pressures and velocities in the system until hydraulic Year 2035. In Year 2035, the addition of demands associated with Category 3 annexation lands results in a large enough increase to warrant additional water sources. Available fire flows within the older portions of the City are limited by allowable velocities, specifically in small diameter cast iron lines. Replacement of these mains results in an increase in available fire flows.

In general, water age in the majority of the distribution system remains below 2 days throughout all hydraulic timesteps. Comparison of water quality complaints to current water age and existing piping materials seems to indicate a stronger correlation between brown water complaints and older cast iron mains than retention time in the system. Throughout the water quality modeling scenarios, at least half of the in-service Tanks experienced water ages greater than 5 days due to low tank cycling. Overall water age within the Tanks decreases as demand increases in the system. Additional pipeline improvements which would increase water movement but add system volume are not recommended as storage volume in the system is already significantly oversized. The greatest reduction in water age within tanks is observed due to increased tank cycling and it is recommended that the City modify system controls to promote deeper tank cycling in their larger volume tanks. It is also possible that when resting wells for aquifer management purposes, as described in Section 3 – Water Supply, the City coordinate these out of service wells with higher age tanks to cause increased draw down.

7 Regulatory Review

Finished water quality and operation of the City of Dover's water production and treatment facilities are impacted by local, state, and federal regulations. The most significant of these is the Environmental Protection Agency (EPA) Safe Drinking Water Act (SDWA) of 1974, SDWA Amendments of 1986 and 1996 and subsequent "Rules" that apply to all public water systems (PWSs) in the United States. The Amendments to the SDWA have resulted in the promulgation of numerous "Rules" relating to new drinking water quality standards and treatment regulations to ensure that the drinking water is safe. Department of Health and Social Services (DHSS) Division of Public Health (DPH) in collaboration with the Department of Natural Resources and Environmental Control (DNREC) Division of Water regulates, oversees, and enforces compliance with the SDWA requirements.

7.1 Existing Regulations

The following describes the water regulations that have been finalized and are applicable to the City's water system:

7.1.1 National Primary Drinking Water Regulations (1986)

National Primary Drinking Water Regulations (NPDWRs or primary standards) are legally enforceable standards that apply to public water systems. Primary standards protect public health by limiting the levels of contaminants in drinking water. These primary standards include disinfectants, disinfection byproducts, inorganic chemicals, microorganisms, organic chemicals, and radionuclides. The City is required to monitor for these contaminants at various intervals based upon the specific contaminant and past history of compliance (longer monitoring intervals are allowed for certain contaminants if there is no history of non-compliance or non-detection).

7.1.2 National Secondary Drinking Water Regulations (1986)

National Secondary Drinking Water Regulations (NSDWRs or secondary standards) are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards, and maintaining values / concentrations below the SMCL should minimize the potential for customer complaints. Several secondary contaminants that could potentially be present in the City's groundwater supply include the following:

Chloride: The secondary maximum contaminant level (SMCL) for chloride is 250 mg/L at which concentration many people can detect a "salty" taste. Saltwater intrusion and up-coning typically result in increases in chloride concentrations.

Color: The SMCL for color is 15 color units (CU). Color can sometimes be experienced in ground water treatment systems during iron and manganese removal if treatment is not optimized.

Iron: The SMCL for iron is 0.30 mg/L. Concentrations of iron at or above 0.30 mg/L have potential to discolor drinking water and to stain laundry.

Manganese: The SMCL for manganese is 0.05 mg/L. Treatment techniques used for iron precipitation and removal are also typically effective for the removal of manganese. Similar to iron impacts, concentrations of manganese at or above 0.05 mg/L have potential to discolor drinking water and to stain laundry.

7.1.3 Total Coliform Rule (TCR) (1989) and Revised Total Coliform Rule (RTCR) (2013):

The TCR became effective in 1989, with the RTCR becoming effective in 2013. Collectively the rules set public health goals (MCLGs) and legal limits (MCLs) for the presence of total coliforms in drinking water. EPA selected total coliforms as a useful indicator of other pathogens since they are common inhabitants of ambient water and are impacted by water treatment in a manner similar to most bacterial pathogens and many viral enteric pathogens and are thus useful indicators of these pathogens. Total coliforms are used to determine the adequacy of water treatment and the integrity of the distribution system.

The TCR detailed the type and frequency of testing that systems must undertake to demonstrate compliance. The frequency and number of sample sites is proportional to the number of people served. Under the TCR, if any sample tests positive for total coliforms, the system must conduct additional tests as follows:

- Test that culture for presence of either fecal coliforms or E. coli
- Take one set of 3-4 repeat samples at sites located within 5 or fewer sampling sites adjacent to the location of routine positive samples within 24 hours
- Take at least 5 routine samples the next month of operation

The RTCR updated the requirements for repeat testing as outlined above under the TCR with the objective to improve public health protection. The RTCR was published in 2013 and there were minor corrections issued in 2014. The RTCR applies to all public water systems (except aircraft PWSs) and the compliance start date was April 1, 2016. In general, the RTCR retains the objectives and the basic monitoring requirements of the TCR along with the addition of new requirements as briefly summarized below:

- Establishes an E. coli maximum contaminant level goal (MCLG) of zero.
- Requires that all routine or repeat samples that test positive for total coliforms be tested for E. coli.
- Establishes requirements for PWSs to conduct assessments depending on monitoring results.
- Level 1 and Level 2 assessments are established in the RTCR, with the system required to submit a report documenting the corrective action.
- Assessments are triggered based on the number of positive total coliform results and E. coli results.

7.1.4 Lead and Copper Rule (1991; 2000 Minor Revision; 2007 Short Term Revisions):

The Lead and Copper Rule (LCR) was promulgated in 1991 following the 1986 lead ban and the resulting Lead Contamination Control Act of 1988 which amended the Safe Drinking Water Act (SDWA) to help control and remedy lead contamination in drinking water supplied at daycares and schools. Following the SDWA amendment, the LCR was conceived by the EPA, requiring public water systems (PWSs) to apply corrosion control treatment strategies to reduce corrosion of distribution systems and ultimately control lead and copper dissolution into drinking water.

The LCR established action levels (AL) of 0.015 mg/L for lead and 1.3 mg/L for copper based upon the 90th percentile level of tap water samples. If the AL is exceeded, other requirements are triggered that include water quality parameter monitoring, corrosion control treatment, source water monitoring/treatment, public education, and lead service line replacement. The monitoring is to be conducted every six months with number of sample sites proportional to system size. Frequency of monitoring can be reduced if certain criteria are met.

The original LCR has since undergone minor revisions in 2000, and short term revisions in 2007 to assist PWSs with clarifications to the rule and implementation practices. The 2000 revision included a requirement that systems on reduced monitoring must report to the state primacy agency (Office of Drinking Water) any changes in treatment or the addition of a new water source. The 2007 short term revisions modified the requirement to simply report a change in treatment or the addition of a new water source to a requirement for prior notice and approval from the state primacy agency. In addition, the 2007 short term revisions included several other changes to the LCR related to the definition of the monitoring and compliance periods, and public education information materials and distribution.

Future revisions to the LCR are currently being finalized. Additional discussion of these revisions is included in **Section 7.2.1.**

7.1.5 Radionuclides Rule (2000):

The Radionuclides Rule provides regulations for the following four contaminants and associated maximum contaminant levels (MCL):

- Beta/photon emitters: 4 mrem/yr
- Gross alpha particle (not including radon and uranium): 15 pCi/L
- Combined radium-226/228: 5 pCi/L
- Uranium: 30 ug/L

All systems must have completed the initial monitoring that included four consecutive quarters of monitoring. The Rule provides for reduced or increased monitoring depending upon measured concentrations.

Minor corrections to the Radionuclides Rule were published in 2004. This correction identified a detection limit for uranium.

7.1.6 Arsenic Rule (2001):

The Arsenic Rule was promulgated on January 22, 2001 and the new lowered maximum contaminant level (MCL) concentration of 10 ug/l became effective January 23, 2006. The new MCL replaced the previous standard which was 50 ug/l. For ground water systems, if the initial sample is less than the MCL, one sample is then to be collected every 3 years. Quarterly samples are required for systems with a sampling point result above the MCL until the system is consistently below the MCL.

7.1.7 Stage 1 Disinfectants and Disinfection Byproducts (D/DBP) Rule (1998):

The Stage 1 D/DBP Rule established more stringent requirements for Trihalomethanes and new requirements for five haloacetic acids and concentrations of disinfectants in drinking water. The maximum contaminant levels (MCLs) for the regulated disinfection byproducts under the Stage 1 D/DBP Rule are as follows:

Total Trihalomethanes (TTHM):	0.080 mg/L (based upon a running annual average of all quarterly measurements)
Five Haloacetic Acids (HAA5):	0.060 mg/L (based upon a running annual average of all quarterly measurements
Bromate (if using ozone):	0.010 mg/L
Chlorite (if using chlorine dioxide):	1.0 mg/L

In addition, EPA established a maximum residual disinfectant level (MRDL) for chlorine dioxide of 0.8 mg/L.

Under the Stage 1 D/DBP Rule, the required number of compliance sampling sites was dependent upon the population served. The Stage 1 D/DBP Rule required that running annual average (RAA) DBPs not exceed 80 µg/L for TTHMs and 60 µg/L for HAA5.

7.1.8 Stage 2 Disinfectants and Disinfection Byproducts (D/DBP) Rule (2006):

The Stage 2 Disinfectants/Disinfection By-Products Rule (Stage 2 D/DBPR) was promulgated on January 4, 2006. This rule provides for the selection of new additional sampling sites for rule compliance monitoring and requires that compliance be based upon a Locational Running Annual Average of quarterly results. LRAA is defined as the running annual average concentration for each sample site location. Although the MCLs of the Stage 1 D/DBPR have remained the same, the LRAA requirement can result in some locations being in compliance and others not. Therefore, the Stage 2 D/DBP Rule requires that systems must comply with MCLs of 0.080 mg/l for TTHM and 0.060 mg/l for HAA5 as a locational running annual average (LRAA, average of previous 4 quarterly TTHM and HAA5 sample results) for each individual sampling site.

In addition to the above referenced LRAA for 4 previous quarterly results, systems must comply with rule requirements to determine compliance with the operational evaluation levels. The operational evaluation level (OEL) for any monitoring location is exceeded when the sum of the two previous quarters' concentrations plus twice the current quarter's result, divided by 4 to determine an average, exceeds the MCL (0.080 mg/l for TTHM and 0.060 mg/l for HAA5). If the operational evaluation level is exceeded, an operational evaluation must be conducted, and a written report submitted to the State and made available to the public upon request.

Typical strategies for compliance can include maximizing the use of the highest quality wells, implementing aeration in water storage tanks, and reducing water retention time within the distribution system via a flushing program.

7.1.9 Ground Water Rule (2006):

The Ground Water Rule was promulgated on November 8, 2006 with the objective to reduce illness by microbial contamination in public ground water systems. The basic provisions of the Ground Water Rule (GWR) include:

- System Sanitary Surveys conducted by State
- Hydrogeologic Sensitivity assessments for undisinfected systems
- Source water microbial monitoring by systems that do not disinfect and have "issues"
- Corrective Actions by any System with significant "issues"
- Compliance monitoring for systems which disinfect to ensure 4-log (99.99%) inactivation or removal of viruses

7.2 Possible Future Regulations

The following drinking water regulations have been identified as pending or possible future regulations that may impact the City of Dover water system in terms of testing and monitoring.

7.2.1 Lead and Copper Rule Revisions

After the Flint Water Crisis developed in 2014, the nation's need for heightened regulations governing lead in drinking water was emphasized. Since the LCR implementation, large drinking water systems with action level exceedances (ALEs) for lead have decreased by over 90 percent, however lead contamination is still prevalent in some communities across the Nation. To address concerns about the future of lead contamination, the National Drinking Water Advisory Council (NDWAC) – a Federal Advisory Committee to the EPA – provided a list of LCR long term revision recommendations to the EPA in December 2015. The list includes:

- Require PWSs to enact proactive lead service line replacement (LSLR) programs instead of waiting for a lead service line (LSL) to have an ALE.

- Establish stronger public education between PWSs and customers by updating Consumer Confidence Reports (CCRs) to increase information provided to the public.
- Strengthen CCT if new scientific information warrants a change
- Establish a health-based, household action level for lead concentrations in tap water
- Modify requirements for monitoring, inform public health agency when household action levels are exceeded, assess CCT effectiveness
- Implement system-specific water quality parameters for the respective CCT strategy being employed at the PWS, and to increase WQP monitoring
- Separate water quality parameters to analyze copper and lead specifically. Establish new regulations governing water that is corrosive to copper and implement compliance and enforcement techniques.

By March 2016, the American Water Works Association (AWWA) had voted to unanimously support the NDWAC recommendations.

By October 2016, the EPA issued a Lead and Copper Rule Revisions White Paper. Included within the White Paper document are the above-mentioned recommendations from the NDWAC, as well as proposed revisions by the EPA.

On June 10, 2021, the EPA signed a final rule to extend the effective date of the Lead and Copper Rule (LCR) Revisions to December 16, 2021. This action allows the agency to continue gathering valuable input from communities that have been impacted by lead and to seek feedback from national water associations, Tribes and Tribal communities, and EPA's state co-regulators. It also extends the revised LCR's compliance deadline to October 16, 2024 to ensure that drinking water systems and primacy states continue to have the full three years provided by the Safe Drinking Water Act to take actions needed for regulatory compliance.

EPA's new Lead and Copper Rule better protects children and communities from the risks of lead exposure by better protecting children at schools and childcare facilities and getting the lead out of our nation's drinking water. Improvements under the new rule include:

- Using science-based testing protocols to find more sources of lead in drinking water.
- Establishing a trigger level to jumpstart mitigation earlier and in more communities.
- Driving more and complete lead service line replacements – utilities must develop lead service line inventories, regardless of ownership.
- For the first time, requiring testing in schools and childcare facilities.
- Requiring water systems to identify and make public the locations of lead service lines

7.2.2 Per- and Polyfluoroalkyl Substances (PFAS)

PFAS, or per- and polyfluoroalkyl substances, are persistent synthetic compounds used in a variety of industrial and consumer product applications including non-stick cookware and firefighting foams. The presence of PFAS compounds in source water and drinking water is of increasing public concern due to their widespread use, environmental persistence, and possible adverse health effects. The USEPA issued its PFAS Action Plan in February 2019 and continues to collect data and prepare to work toward issuing a regulation for these substances.

Currently DNREC is investigating PFAS at two areas in Kent County, Delaware. One area is at Chestnut Grove Road and Fire School Road in Dover. The other area includes five sites at Dover Air Force Base. The reports of PFAS occurrence are not necessarily reports of drinking water contamination. However, it would be prudent for the City of Dover to include monitoring for PFAS when sampling groundwater extracted from the City of Dover production wells at Long Point Road, which are in the unconfined Columbia Aquifer. In general, unconfined aquifers are relatively more vulnerable to contamination originating at the land surface.

8 Capital Improvement Plan

Recommended improvements to facilities or operations, studies, or evaluations shown to be needed by the hydraulic modeling results, water source review, and existing facility investigations are summarized in this Capital Improvement Plan (CIP) using the following improvement categories:

- Immediate: address as soon as possible (Year 2020)
- 5-Year: address by Year 2025
- 10-Year: address by Year 2030
- 15-Year: address by Year 2035
- Comprehensive: address by Year 2040 (Build-Out)

In addition to the list of CIP projects, estimates of probable construction costs and a distribution of those costs over the 20-year planning period are included.

The capital improvement projects presented below are an outline of potential projects as seen by the current model using current growth and development projections, as well as current system operational priorities. As the projections and priorities change, the water system improvement projects and their timing will change as well, so this plan will need to be revisited and updated on a regular basis.

8.1 Summary of Recommended Improvements and Evaluations

Based on system analysis the following projects have been identified. Projects have been given designations based on system type: RS for raw water supply, T for water treatment, M for distribution mains, and S for storage tanks. In addition, a discussion of operational improvements (O) focusing on public outreach have also been included. Numerical order of the projects included in the list below do not reflect importance or prioritization of projects. Locations of all system projects can be found in **Figure 8.1** and **Figure 8.2**.

8.1.1 Recommended Improvements

Recommended system improvements for raw water supply, the water treatment plant, distribution system and elevated storage tanks, and water system operations are summarized herein and corresponding **Table 8.1**.

8.1.1.1 Raw Water Supply (RS)

RS-1: Test Well/Development/Production Wells – Based on the City's desired operational scheme, existing permit limits, and projected demands, WRA estimates two (2) new wells with an average capacity of 1 MGD each (or other equivalent water sources) will be required to supply the City through buildout. WRA estimates that one (1) well will be required by 2035 and one (1) well by 2040.

RS-2: General Wellhouse Maintenance – A program to perform routine maintenance on the well facilities as outlined in the facility inspection reports. Maintenance items include replacement of corroded doors, painting, upgrades to fixtures, installation of GFCI receptacles, etc.

8.1.1.2 Water Treatment Plant (T)

T-1: Ventilation Improvements – Ventilation improvements in the electrical room due to presence of high temperatures around equipment.

T-2: Eyewash / Shower in hypochlorite room – Project to include an eyewash/shower in the hypochlorite room. Eyewash/shower is required due to chemical exposure risk.

T-3: Slope Backwash tank floor – Project to increase drainage in the Backwash tank room.

T-4: Enhance site security – Installation of secure gate and card reader, barbed wire, etc. to protect the Water Treatment Plant and minimize trespassing risk.

8.1.1.3 Distribution Mains (M)

M-1 through M-2: 2,540 LF of in-progress 8-inch Water Main Replacement - The project includes the replacement and upsizing of approximately 2,540 LF of old small diameter cast iron pipe in downtown Dover. 4-inch and 6-inch CI main will be replaced with 8-inch DI line on Ross Street and N. West Street from the alley west. These projects are currently under construction.

M-3 through M9: 16,500 LF of 8-inch and 12-inch Water Main Replacement in Downtown Dover – City scheduled projects to continue replacement of old small diameter cast iron water mains in downtown Dover. Modeling indicates that replacement and upsizing of the water mains results in an increase in available flow. This project includes upsizing of mains along State Street, N. West Street from the alley east, Fairview Avenue, N. Bradford Street, Queen Street and New Street.

M-10: 7,000 LF of new 12-inch Water Main looping– Project includes looping dead end lines from Starlifter Avenue to S. Little Creek Road to maintain levels in the Aero Park Tank.

M-11: 600 LF of 10-inch Water Main Replacement, White Oak Road– Project upsizes approximately 600 lf of 8-inch pipe to 10-inch pipe along White Oak Road to reduce velocities.

M-12: 20 LF of 16-inch Water Main Replacement, WTP – Project upsizes approximately 20 lf of 10-inch pipe to 16-inch south of the water treatment plant to reduce velocities.

M-13: 80 LF of 16-inch Water Main Replacement, N. Little Creek Rd. – Replacement of approximately 80 lf of 12-inc main with 16- pipe along N. Little Creek Road prior to Fox Rd. Project reduces system velocities.

M-14 through M-18: 7,700 LF of 8-inch Water Main Replacement in Downtown Dover – City scheduled projects to continue replacement of old small diameter cast iron water mains in downtown Dover. Modeling indicates that replacement and upsizing of the water mains results in an increase in available flow. This project includes upsizing of mains along Bradford Street, Kings Highway, Reed Street, Queen Street and Bank Lane.

M-19 through M-30: 20,300 LF of 8-inch Water Main Replacement in Downtown Dover – These projects include upsizing additional old 4-inch and 6-inch cast iron mains in downtown Dover. Modeling indicates that replacement and upsizing of the water mains results in an increase in available flow.

M-31: Upsize of 540 LF of 8-inch water main to 12-inch, College Road – Project includes upsizing 540 lf of 8-inch pipeline to new 12-ingh DIP due to fire flow requirements for the proposed Apartments at College Road.

M-32: 50,000 LF of new 12-inch Water Main, Western Annexation Lands – Possible transmission main expansions to supply future annexed land areas along the western edge of the City water service area.

M-33: 80,000 LF Distribution main Rehabilitation – Cleaning and lining of small diameter (6-inch) cast iron distribution lines in the eastern portion of the distribution system. The project is included due to high concentrations of customer water quality complains in these areas. Lines are considered adequately sized.

8.1.1.4 Storage Tanks (S)

S-1: Tank Maintenance Program – Continuation of the City's Tank inspection, repair, and painting program

S-2: 1.0 MG Denneys Road Elevated Water Tank – Construction of a 1.0 MG elevated water Tank along Denney's Road.

8.1.1.5 Outreach (O)

O-1: Public Outreach - The City of Dover has a current Public Outreach program to inform the public of various activities relating to the water system. The City deals with periodic brown water complaints, so this is a concern that needs to be specifically addressed. The current outreach program includes:

- Notification of upcoming flushing operations via website, print, TV, social media, e-newsletter
- Notification of upcoming Water Construction Projects via website, handouts, social media, e-newsletter
- Distribution of Consumer Confidence Report (CCR) via print, website, social media, e-newsletter

Public Outreach programs conducted by other local water providers in the region were researched, and recommendations for enhancing the current program by including multiple ways to reach various audiences include the following:

General:

- Provide a robust and up to date web site that includes information such as
  - Who We Are: Mission, Vision, Values, if applicable; department directory, with contacts for various aspects of the water/wastewater operations.
  - What We Do: Information about everyday system operations; major upcoming projects; other system work such as flushing programs and PM activities that impact customers; water quality information including annual Consumer Confidence Reports
  - Real-time mapping that includes locations of planned work, flushing operations, emergency work, etc., and that customers can navigate to find out what impacts them directly. Include project status, City contact, current schedule, estimated start and completion dates.
    - Link to current City mapping, such as https://doverde.maps.arcgis.com/home/index.html
  - Upcoming events including public meetings, special events, outreach events like visits to schools or community groups
  - Customer feedback link
  - News and press releases
  - Links to groups such as AWWA and the Water Environment Federation (WEF), where the public can find other general information and resources. Also check www.csawwa.org for more local resources and suggestions for outreach programs and activities.
- Establish Facebook page that can include the various items above, or link to the website.
  - Update Facebook page with notices, etc., that are shared to other audiences
- Consider using Twitter to send out notices and updates
- Establish relationships with community groups, HOAs, schools so that they feel empowered to reach out to the City with questions and feedback
  - Attend meetings, events, fairs, festivals
- Consider visits to schools to educate students about the water/wastewater system and its importance in everyday life
  - Provide opportunities for tours of City facilities
- Establish customer “subscription” to e-newsletters, informational news releases, etc., allowing them to select which information to receive
- Include updates and CCR with customer bills

Flushing Operations:

- Provide press releases to media outlets, detailing plans and timing for the flushing program and providing contact information (phone, e mail, links to web site or Facebook page) for the public’s use. Include “why” flushing is done, possible impacts like brown water, and what a customer should do if they observe brown water
- Post copies of the press releases on the web site under a header such as “What We Do”

- Provide real time mapping on the web site that includes locations for upcoming flushing work
- Post road-side signs several days prior to flushing in the areas that will be impacted
- Establish contacts with community groups, HOAs, etc., with contacts who can forward information to their constituents, and provide them with notice of upcoming flushing operations to share with their audiences
- Include information in e-newsletters

Upcoming construction projects:

- Provide press releases to media outlets, detailing plans and timing for the construction and providing contact information (phone, e mail, links to web site or Facebook page) for the public's use
- Post copies of the press releases on the web site under a header such as "What We Do"
- Provide real time mapping on the web site that includes locations for upcoming construction projects, including projects in the planning or design phases
- Establish contacts with community groups, HOAs, etc., with contacts who can forward information to their constituents, and channel questions/feedback to the city
- Include information in e-newsletters

Limited funding has been included in the CIP to pursue selected programs.

8.1.2 Recommended Evaluations

8.1.2.1 Water Quality

Additional system evaluations to optimize system performance and reduce the potential for the development of water quality problems are provided in the list below.

- Perform a water quality analysis to see if the different water sources (Cheswold / Piney Point / Columbia aquifers) could create water quality issues when mixed in the distribution system.
- Continue to monitor brown water complaints and compare historic trends to current complaints once the upgraded Water Treatment Plant is fully operational.
- Study tank mixing to see if it would provide a cost-effective method for improving water age and chlorine residual.
- Promote water movement by looping dead end water mains when funds are available or as part of other improvements or maintenance.

8.1.2.2 SCADA

The City water SCADA system was originally based on the Autocon Microcat RTU product line. This unit has gone through several iterations of ownership and has been an obsolete product for quite some time. The migration path to upgrade the Microcat RTU was to use the Intra-Link LC series of controllers by US Filter. The Intra-Link was developed as an updated controller to the Microcat using the same proprietary communications protocol in order to be a straight-forward replacement. This product line also has gone through several series of ownerships from US Filter to Siemens and finally to Evoqua.

The City is currently upgrading the Microcat controller in the SCADA system to the LC controller. The City has been using their own personnel to perform these upgrades, and to date, about half of the facilities have been upgraded. Based on our recent research on the LC series, it is no longer a current product line supported by Evoqua. No new owner of the product is known, nor is it clear if there are any plans for it to be continued to be manufactured. WRA was able to find two vendors in the US that are able to provide these products, but through our discussions we were discouraged by both of the vendors for its continued use. It is unclear as to the long-term viability of the LC products in the future, even as spare parts to replace existing units.

The software used to interface and program the LC controllers is based on the Windows 7 operating system. The Windows 7 operating system is also obsolete and is no longer supported by Microsoft. Software upgrades and security patches are no longer available for Windows 7. Maintaining any computer running on the Windows 7 operating system exposes a significant cybersecurity vulnerability. Connecting this computer to the City's network should not be permitted. Moving forward, any programming environment would need to be hosted on a computer with an up-to-date operating system running a virtual Windows 7 shell to run the programming software. This arrangement could also be a cybersecurity risk to the City if the computer is connected to the City's network.

The communications for the SCADA System are based on GE/MDS iNet series radios operating on the unlicensed 900 MHz frequency spectrum that is open to access from the public domain. These radios communicate locally to the RTUs using a direct serial link. The radios have a number of security features built into them that can reduce the risk of outside, unauthorized access to the system. Although these radios are inherently secure due to the spread-spectrum frequency hopping pattern and the proprietary data encapsulation, there are still risks that can be mitigated through enabling elective security features and disabling remote administrative tools. Other vulnerabilities such as public interference from third-party transmitters is harder to mitigate. It is unknown if the radios have been set up with these elective security features which would more effectively manage these risks.

SCADA Recommendations:

The operations of the water system are dependent on the SCADA system. Water Treatment Plant staff must be able to remotely monitor and control the wells and tanks in the system from the Water Treatment Plant. Based on our evaluations of the existing SCADA system, we recommend that the City perform some immediate actions to assess the SCADA system's ability to provide uninterrupted secure and reliable remote monitoring and control of the water facilities. We recommend the following:

- Conduct an evaluation of the current inventory of LC controllers for requirements to continue the transition from the Microcat to LC products.
- Verify the supply chain and product life cycle of the Intra-Link LC product line. The City should have conversations with representatives of the current owner of the product line that provide a written guarantee of product life cycle and support for the hardware and software.
- Temporarily stop the upgrade at the remote facilities until an accurate inventory and lifecycle assessment of LC products is completed. Since the system is currently running, the products may be needed in the short-term to replace failed or damaged product to keep the system operational.
- If the LC product lifecycle cannot be guaranteed by the manufacture, the City should plan on a comprehensive SCADA upgrade project for the controllers, communications and WTP HMI interface software. WRA's recommendation for the upgrade path is to select a PLC based system that uses an open-architecture that can be readily supported by local system integrators and uses an open published communications protocol such as DNP3 over Ethernet that would allow for easier planed upgrades in the future. The upgrade should also consider migrating to a Private IP based wireless network.
- Complete a thorough cybersecurity assessment and evaluation to identify cyber risks and cyber vulnerabilities as they relate to the Operational Technology (OT) of the SCADA System. This cybersecurity assessment should review the connected hardware, software, network architecture, remote access and the followed/enforced practices, policies, and procedures for cybersecurity of the OT system. An OT cybersecurity focus should be the availability of the SCADA system as an operational asset. A significant portion of the cybersecurity assessment should include the supply of in-house stocked spares, factory available spare parts and trained personnel to keep the system running.
- Review of the setup of the radios to evaluate if the elective cybersecurity features have been enabled. We recommend enabling features such as authentication, approved access point and remote

site white-listing and AES-128 encryption. Other vulnerabilities such as allowing remote login and remote management of services for the RTU radios should be eliminated.

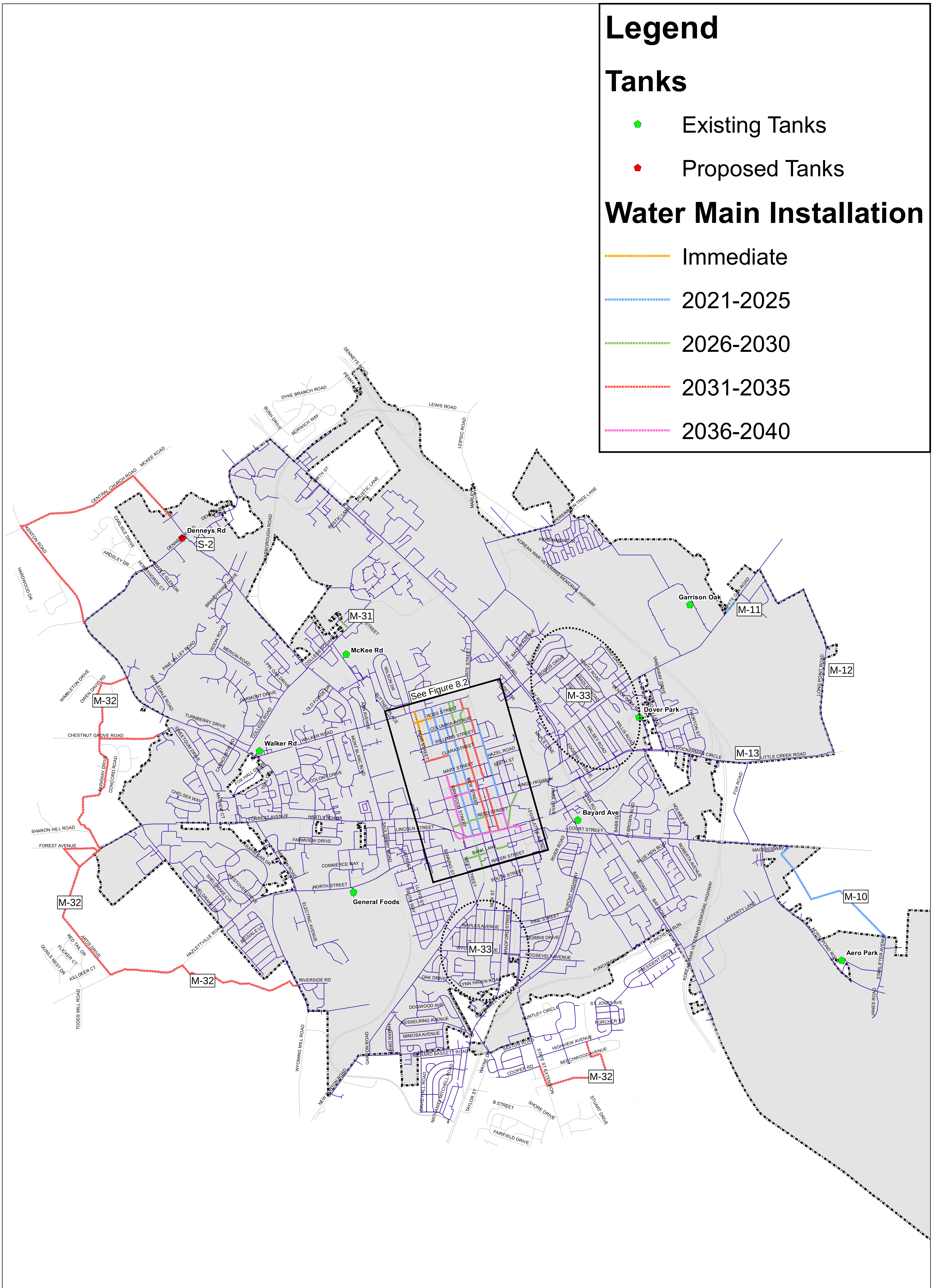
- The City should evaluate the long-term man-power resources required for continued in-house support of the SCADA system. The City should immediately start the process of succession planning for SCADA system personnel. Required personnel at a minimum includes a SCADA System/OT Administrator to manage the overall asset including training programs, maintenance, cybersecurity policies and technicians skilled in programming, trouble shooting, repair of the controllers, networking, and communication systems.

Table 8.1 - City of Dover, Delaware Capital Improvements Plan						
Number	Name	Description	Quantity	Reason	Modeled	Timestep
M-1*	Ross St Water Main	Replace 940' of 6" CIP with 8" DIP on Ross St from Pear St to the alley east of Carrol St	940	Replace Small Diameter CIP	Yes	Immediate
M-2*	N West St Alley West Water Main	Replace 1600' of 4"-6" CIP with 8" DIP in the alley west of West Street from William St to Walker Rd	1600	Replace Small Diameter CIP	Yes	Immediate
RS-1	Raw Water Supply	Test Well/Development/Production Well - 2 Wells				Immediate
T-1	Water Treatment	Ventilation improvements for electric room		High temperatures around equipment		Immediate
M-33	Distribution main cleaning	80,000 LF of cleaning and lining distribution mains throughout the distribution system				Ongoing
O-1	Operations	Community Outreach Evaluation				Ongoing
RS-1	Raw Water Supply	Test Well/Development/Production Well				Ongoing
RS-2	Raw Water Supply	General Wellhouse Maintenance				Ongoing
S-1	Tank Maintenance	Tank inspections, painting, and repairs				Ongoing
M-3*	State St Water Main	Replace 3200' of 4" CIP with 12" DIP on State St from Division St to Pennsylvania Ave	3200	Replace Small Diameter CIP	Yes	2023
M-4*	N West St Alley East Water Main	Replace 1600' of 4"-6" CIP with 8" DIP in the alley east of West Street from William St to Walker Rd	1600	Replace Small Diameter CIP	Yes	2024
M-5*	Fairview Ave Alley East Water Main	Replace 1300' of 4"-6" CIP with 8" DIP in the alley east of Fairview Ave from William St to Walker Rd	1300	Replace Small Diameter CIP	Yes	2024
M-6*	Fairview Ave Alley West Water Main	Replace 1600' of 4"-6" CIP with 8" DIP in the alley west of Fairview Ave from William St to Walker Rd	1600	Replace Small Diameter CIP	Yes	2024
M-8*	Queen St Water Main	Replace 4000' of 4" CIP with 8" DIP in Queen St from William St to Loockerman St	4000	Replace Small Diameter CIP	Yes	2025
M-9*	New St Water Main	Replace 4000' of 4" CIP with 8" DIP in New St from William St to Loockerman St	4000	Replace Small Diameter CIP	Yes	2025
M-10	Starlifter Ave Water Main Loop	Install 7000' of 12" DIP from S Little Creek Rd to Starlifter Ave	7000	Install a loop in the system to support new industrial developments and the Aero Park water tower	Yes	2025
M-11	White Oak Rd Water Main Bottlenecks	Replace a total of 600' of 8" pipe with 10" DIP at two locations on White oak Rd	600	Fix bottleneck in the distribution system causing water to flow faster than 4 ft/s	No	2025
M-12	Long Point Rd Water Main Bottleneck	Replace 20' of 10" DIP with 16" DIP directly adjacent (south) to the WTP	20	Fix bottleneck in the distribution system causing water to flow faster than 4 ft/s	No	2025
M-13	North Little Creek Rd Water Main Bottleneck	Replace 80' of 12" DIP with 16" DIP on N Little Creek Rd immediately before it splits with Fox Rd	80	Fix bottleneck in the distribution system causing water to flow faster than 4 ft/s	No	2025
T-1	Water Treatment	Ventilation improvements for electric room				2025
T-2	Water Treatment	Eyewash/shower in hypochlorite room				2025
T-3	Water Treatment	Slope backwash tank floor to pump suction				2025
T-4	Water Treatment	Enhance water treatment plant security				2025
M-15*	Kings Hwy Water Main	Replace 1600' of 4"-12" CIP with 8" DIP form Division St to Loockerman St	1600	Replace Small Diameter CIP	Yes	2026
M-16*	Reed St Water Main	Replace 2300' of 4"-6" CIP with 8" DIP on Reed St from Water St to State St	2300	Replace Small Diameter CIP	Yes	2026

M-17*	Queen Street Water Main - 2	Replace 1000' of 6" CIP with 8" DIP on Queen St from North St to Water St	1000	Replace Small Diameter CIP	Yes	2026
M-18*	Bank Ln Water Main	Replace 1940' of 4"-6" CIP with 8" DIP on Bank Ln from West St to The Green	2000	Replace Small Diameter CIP	Yes	2026
M-19	Lakewood Pl Alley East Water Main	Replace 1300' of 4"-8" CIP and GSP with 8" DIP on Lakewook Pl alley east from Walker Rd to William St	1300	Replace Small Diameter CIP, and galvanized steel pipe	No	2030
M-20	Governors Bvld/N Bradford St Alley West Water Main	Replace 1200' of 4" CIP with 8" DIP on Governors Bvld and N Bradford St alley West from Ross St to William St	1200	Replace Small Diameter CIP	No	2030
M-31	College Rd Apartments Water Main	Replace 540' of existing 8" DIP with 12" DIP on Rita Wilma Rd	540	Upsize existing main to meet fire flow demands for a new development	No	2030
S-2*	Denneys Road Tank	Install a 1 million gallon tank on Denneys Road				2035
M-7*	N. Bradford St Water Main	Replace 500' of 4" CIP with 8" DIP in N. Bradford St from Walker St to Ross St.	500	Replace Small Diameter CIP	Yes	2035
M-21	Bradford St Alley East Water Main	Replace 1200' of 4" CIP on Bradford St alley east from Ross St to William St	1200	Replace Small Diameter CIP	No	2035
M-14*	Bradford St Water Main	Replace 1400' of 4"-6" CIP with 8" DIP on Bradford St from Division St to Loockerman St	1400	Replace Small Diameter CIP	Yes	2035
M-22	Clara St Water Main	Replace 1000' of 6" CIP with 8" DIP on Clara St from Pear St to Queen St	1000	Replace Small Diameter CIP	No	2035
M-23	Governors Ave Water Main	Replace 4000' of 4" CIP with 8" DIP on Governors Ave from William St to Loockerman St	4000	Replace Small Diameter CIP	No	2035
M-24	Bradford St Water Main	Replace 1600' of 4" CIP with 8" DIP on Bradford St from William St to Cecil St	1600	Replace Small Diameter CIP	No	2035
M-25	Cecil St Water Main	Replace 1100' of 6" CIP with 8" DIP on Cecil from Kirkwood St to Governors Ave	1100	Replace Small Diameter CIP	No	2035
M-32	Water Main Addition to Support Annexed Lands	Install 50,000' of 12" DIP along the southern and western limits of the distribution boundary to support serve future annexation lands	50,000	Install infrastructure for City annexations	Yes	2035
M-26	Fulton St Water Main	Replace 1500' of 6" CIP with 8" DIP on Fulton St from West St to Governors Ave	1500	Replace Small Diameter CIP	No	2040
M-27	State St Water Main	Replace 1300' of 6" CIP with 8" DIP on State St from Division St to Lockerman St	1300	Replace Small Diameter CIP	No	2040
M-28	Kirkwood St Water Main	Replace 2600' of 4"-6" CIP wit 8" DIP on Kirkwood St from Mary St to Forest St	2600	Replace Small Diameter CIP	No	2040
M-29	Loockerman St and Loockerman Plaza Water Main	Replace 3000' of 4"-6" CIP with 8" DIP on Loockerman St and Loockerman Pl from Federal St to West St	3200	Replace Small Diameter CIP	No	2040
M-30	Federal St Water Main	Replace 300' of 4" CIP with 8" DIP on Federal St From Loockerman Plaza to E North St	300	Replace Small Diameter CIP	No	2040

* Planned City projects scheduled between FY 2023 - FY 2026

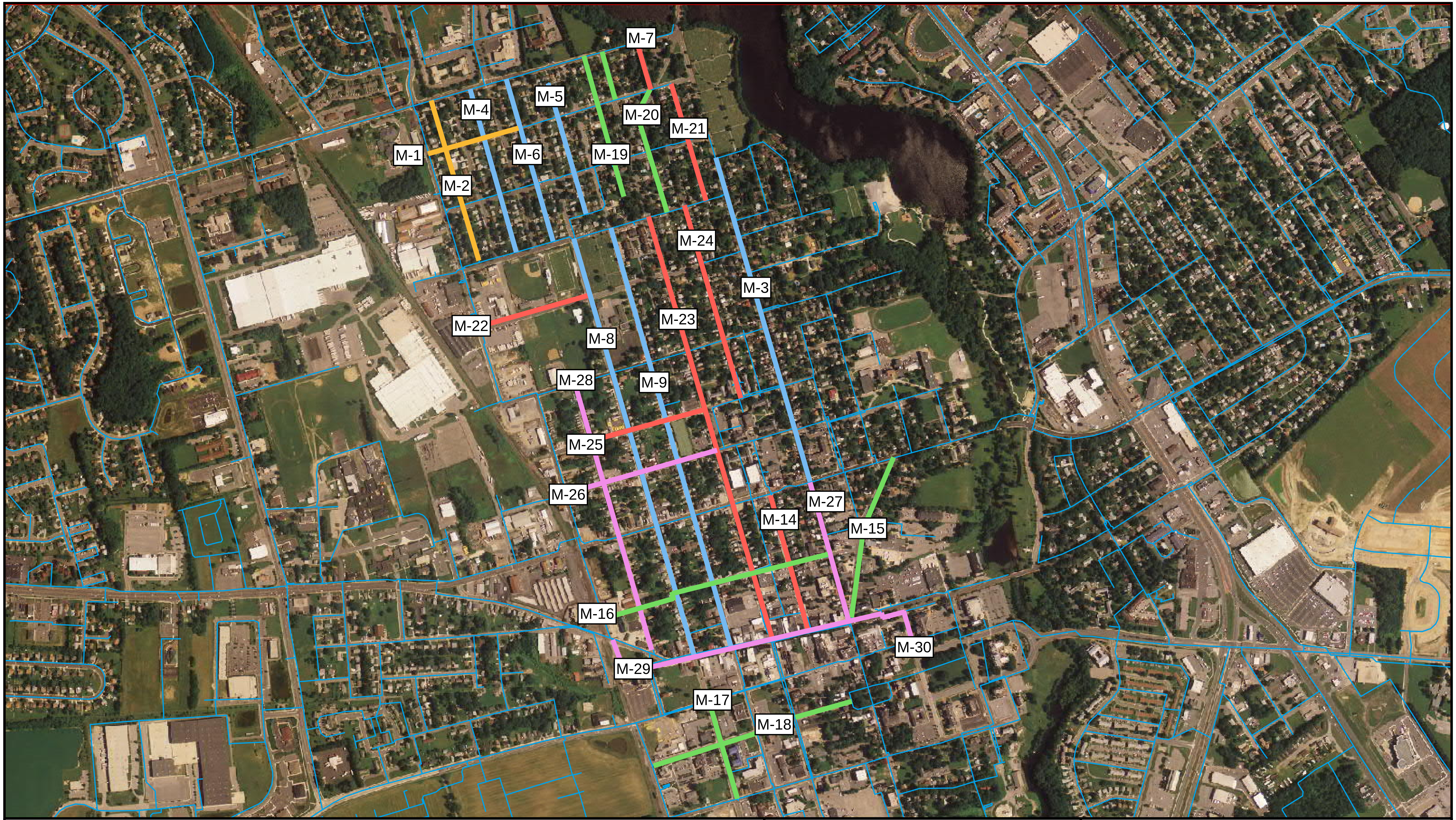
Legend	
(yellow)	Immediate
(purple)	Ongoing
(light blue)	2021-2025
(light green)	2026-2030
(red)	2031-2035
(pink)	2036-2040



Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

City of Dover, Delaware
Water System Master Plan

Figure 8.1
Capital Improvements Plan



Whitman, Requardt & Associates, LLP 1915 100 YEARS 2015

0 0.05 0.1 0.2 0.3 0.4 Miles

City of Dover, Delaware
Water System Master Plan

Figure 8.2
Downtown Dover
Water Main Improvements

8.2 Project Cost Estimates

An estimation of cost was completed for all identified projects. Costs were estimated based on the following assumptions.

- **New Water Main / Replacement:** New water mains include all new proposed piping and piping to be upsized. New water main construction assumes open cut installation within roadways (no private easements). Price per linear foot includes pipe materials, trenching, backfilling, paving, seeding and sodding and replacement of valves and other appurtenances, and was based on Ductile Iron Pipe. Note that in the current economic climate, PVC and DIP prices are fluctuating rapidly. PVC may offer some benefits in terms of cost and corrosion resistance, but that will need to be analyzed during design, bidding and award. For purposes of cost estimating it is also assumed new fire hydrants will be installed at five hundred-foot intervals.

- **Clean and Line:** Unlined cast iron piping will be cleaned and lined using cement. Price per linear foot includes medium cleaning of the water main, temporary water service, replacement of all valves and lining of the interior of the pipe.

- **Lump Sum:** Lump sum cost estimates are based on engineering judgement and past studies of similar scope and are utilized for specific facility improvements and general maintenance programs.

Unit costs utilized for this construction cost estimate are included in **Table 8.2**. All construction costs will be in 2021 dollars and have not been escalated to time of construction. A 15% contingency and a 30% increase in costs have been added to all construction cost estimates to account for associated planning and engineering costs. Estimated costs are included in the Capital Improvement Plan tables included in Section 8.3.

Table 8.2 – Unit costs

Item	Price	Unit
6-inch	$ 90.00	LF
8-inch	$ 120.00	LF
10-inch	$ 150.00	LF
12-inch	$ 180.00	LF
16-inch	$ 240.00	LF
Fire Hydrant and Assembly	$ 6,000.00	ea
Rehabilitation (clean and line 4" through 14", includes excavation costs)	$ 125.00	LF

8.3 Capital Improvement Plan

Total cumulative construction costs for recommended water projects through the Year 2040 planning period is approximately $47 million. Projects have been prioritized into Immediate (Year 2020), 5-Year, 10-Year, 15-year and Comprehensive (Year 2040 Build-Out) categories based on hydraulic modeling results as well as discussions with the City regarding projected timing of development. **Table 8.3** includes estimated construction costs which are distributed by year of implementation.

Table 8.3 - City of Dover, DE Capital Improvement Plan Costs

Project Number	Project Description	Project Cost				
		Immediate	2021-2025	2026-2030	2031-2035	2036-2040
	RAW WATER SUPPLY (RS)					
RS-1	Test Well/Development/Production Well				$ 200,000	$ 200,000
RS-2	General Wellhouse Maintenance		$ 45,500	$ 45,500	$ 45,500	$ 45,500
	WATER TREATMENT (T)					
T-1	Ventilation Improvements for electric equipment room	$ 25,000.00				
T-2	Eyewash / shower in hypochlorite room		$ 10,000.00			
T-3	Slope Backwash Tank floor to pump suction		$ 30,000.00			
T-4	Enhance Water Treatment Plant site security		$ 80,000.00			
	DISTRIBUTION MAINS (M)					
M-1	*940 LF, 8" DIP, Ross St*	*$ 199,271*				
M-2	*1600 LF, 8" DIP, N West St Alley West*	*$ 396,998*				
M-3	*3200 LF, 12" DIP, State St*		*$ 923,910*			
M-4	*1600 LF, 8" DIP, N West St Alley East*		*$ 322,920*			
M-5	*1600 LF, 8" DIP, Fairview Ave Alley West*		*$ 322,920*			
M-6	*1600 LF, 8" DIP, Fairview Ave Alley East*		*$ 322,920*			
M-7	*500 LF, 8" DIP, N Bradford St*				*$ 98,670*	
M-8	*4000 LF, 8" DIP, Queen St*		*$ 789,360*			
M-9	*4000 LF, 8" DIP, New St*		*$ 789,360*			
M-10	7000 LF, 12" DIP, S Little Creek Rd Loop to Starlifter Ave		$ 2,009,280			
M-11	600 LF, 10" DIP, White Oak Rd		$ 152,490			
M-12	20 LF, 16" DIP, Long Point Rd		$ 16,146			
M-13	80 LF, 16" DIP, North Little Creek Rd		$ 37,674			
M-14	*1400 LF, 8" DIP, Bradford St*				*$ 278,070*	
M-15	*1600 LF, 8" DIP, Kings HWY*			*$ 457,470*		
M-16	*2300 LF, 8" DIP, Reed St*			*$ 197,340*		
M-17	*1000 LF, 8" DIP, Queen St*			*$ 197,340*		
M-18	*2000 LF, 8" DIP, Bank Ln*			*$ 394,680*		
M-19	1300 LF, 8" DIP,Lakewood Pl Alley East			$ 260,130		
M-20	1200 LF, 8" DIP, Governors Blvd./N. Bradford St Alley West			$ 242,190		
M-21	1200 LF, 8" DIP, Bradford St Alley East				$ 242,190	
M-22	1000 LF, 8" DIP, Clara St				$ 197,340	
M-23	4000 LF, 8" DIP,Governors Ave				$ 789,360	
M-24	1600 LF, 8" DIP, Bradford St				$ 322,920	
M-25	1100 LF, 8" DIP, Cecil St				$ 224,250	
M-26	1500 LF, 8" DIP, Fulton St					$ 296,010
M-27	1300 LF, 8" DIP, State St					$ 260,130
M-28	2600 LF, 8" DIP, Kirkwood St					$ 520,260
M-29	3200 LF, 8" DIP, Loockerman St and Loockerman Pl					$ 636,870
M-30	300 LF, 8" DIP, Federal St					$ 62,790
M-31	540 LF, 8" DIP, College Rd			$ 114,816		
M-32	50,000 LF, 12" DIP, Southern and Western Annexation Lands				$ 7,176,000	$ 7,176,000
M-33	80,000 LF, Distribution main Cleaning and Lining		$ 3,737,500	$ 3,737,500	$ 3,737,500	$ 3,737,500
	STORAGE TANKS (S)					
S-1	Tank Maintenance Program		$ 500,000	$ 500,000	$ 500,000	$ 500,000
S-2	Denneys Road Tank (1.0 MG)				$ 3,000,000	
	OUTREACH (O)					
O-1	Community Outreach Evaluation		$ 20,000	$ 20,000	$ 20,000	$ 20,000
	TOTAL	**$ 621,269**	**$ 10,109,980**	**$ 6,166,966**	**$ 16,831,800**	**$ 13,455,060**

Notes:

1. Projects shown in *italics* are planned City projects scheduled for FY 2023 to FY 2026

PLANNING PERIOD TOTAL **$ 47,185,075**

Appendix A
Demand Memorandum

MEMORANDUM

Date: 5/14/2020

To: City of Dover, DE
From: WRA
Subject: Master Plan Demand Projection

CC: File

Work Order Number: 14466.000
Contract Number: Contract number
Project: City of Dover, DE - Update to the Water Master Plan

Redline Markups are reflective of new data received May 24th, 2021.

The City of Dover, Delaware (the City) has retained Whitman, Requardt & Associates, LLP (WRA) to assemble an update to the City of Dover Water Master Plan. This updated Plan includes a 20-year projection for the City's population and water demand. The demand analysis is a critical element in updating the Water Master Plan, as it sets the basis for the hydraulic analysis of the distribution system, and the supply and storage needs. This memo will provide the following information:

- Summary of existing water supply agreements
- Historical water production, consumption, and determination of water-use patterns
- Build-out flow projections and growth pattern assumptions
- Review of City annexation plans
- Water storage calculations

Water Supply Agreements

In addition to providing water to City residents and businesses, The City of Dover has several supply agreements with Tidewater Utilities, Inc. (Tidewater). The City is contracted to provide a minimum of 1,250,000 gallons per month to the Carlisle Village Development, with a 20% surcharge on water supply exceeding 2,500,000 gallons per month. The City is also contracted to provide an estimated 800,000-1,200,000 gallons of water per month to the Lakeland Service Area for fire protection. *Table 1* below provides a summary of the City's metered supply of Tidewater Utilities along with their average monthly demands.

Table 1 – Tidewater Utilities Metered Connections Demands

Development	Purpose	Average Daily Demand (gal)
Carlisle Village	Residential	52,754
Lakeland Service Area	Fire Protection	20,695
Bush Manor via Wilmington College	Residential	22,329

The water used by these communities is included in the City billing records and will be accounted for in the current and projected water use.

Current Water Production and Consumption

The City provided WRA with the below listed water demand and production data:

- Monthly water production data from each well (2016-2020)
- Daily water production data from each well (2018-2020)
- Yearly water meter consumption for each meter and connection (2018-2020)
- Maximum Day Production (2016-2020)

Water Production

Using the provided daily and monthly water production data from the City's wells, the annual average daily production was calculated and the maximum day production was assessed. A maximum day peaking factor (PF) was calculated by dividing the maximum day production by the average annual daily production. Results are included in *Table 2*.

Table 2 - Water Production

Year	Annual Average Daily Production (MGD)	Maximum Daily Production (MDG)	Maximum Day Factor
2016	5.23	7.80	1.49
2017	5.25	7.70	1.47
2018	5.01	7.67	1.53
2019	5.16	7.29	1.41
2020[1]	4.82	7.12	1.47
Overview	*Avg. 5.16*[2]	*Max 7.80*[3]	*Comb. 1.51*[4]

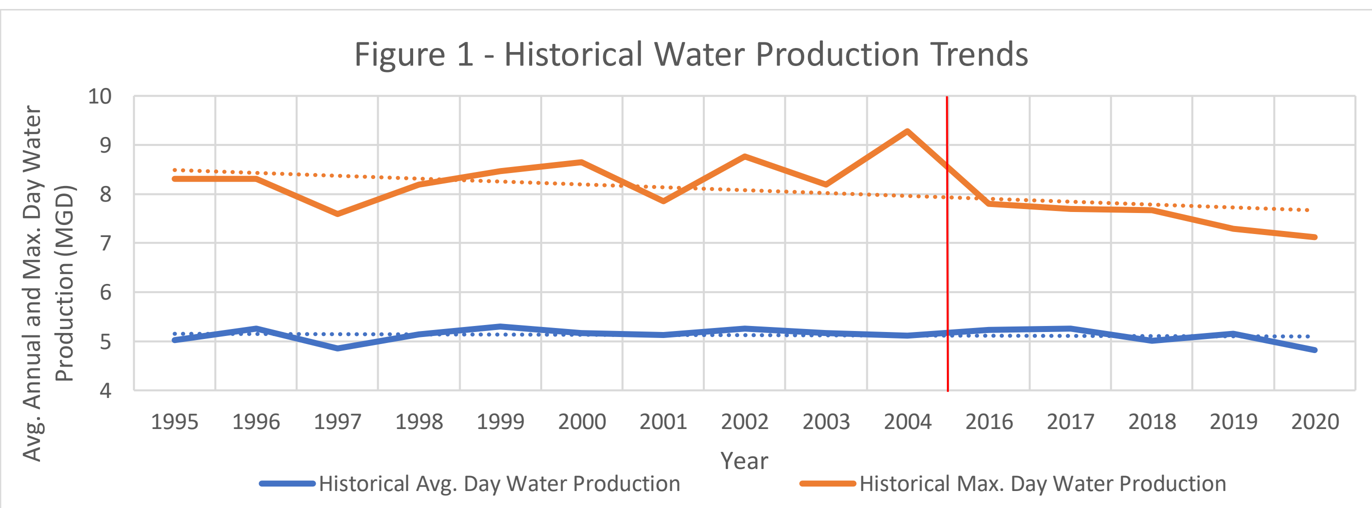
1. Data from Year 2020 not used for Overview calculations as 2020 water usage/production do not match typical yearly patterns due to effects of COVID-19 pandemic.
2. Average of Year 2016 through 2019 Annual Average Daily Production
3. Overall maximum day production from the years analyzed.
4. Combined Maximum Day Factor determined from Overall Max. Day / avg of Annual Average Day

Year 2020 production data was reviewed, however, due to changes in daily water use attributed to the COVID-19 pandemic (i.e. more people working from home, reduction in manufacturing, etc.) the data was not utilized for calculations or demand projections. In general, water production numbers for 2020 were lower than previous historical water production numbers. *Table 3* includes additional historical production numbers over a 10 year time period that were analyzed as part of the City's 2006 Master Planning effort. *Figure 1* depicts yearly average production over this time period as well as trends in average and max day production. Overall, the annual average day water production in the City over the last 25 years has remained fairly consistent. The calculated maximum day peaking factor based on recent data is 1.51 as compared to the 1.7 peaking factor calculated for the 2006 Master Planning effort. As indicated in *Figure 1*, maximum day production has decreased. This can be a result of more accurate metering, reduction in system losses or the effect of water saving measures.

Table 3 – Historical Water Production

Year	Annual Average Daily Production (MGD)	Maximum Daily Production (MGD)	Maximum Day Factor
1995	5.02	N/A[1]	N/A
1996	5.26	8.31	1.58
1997	4.85	7.59	1.56
1998	5.14	8.19	1.59
1999	5.30	8.46	1.60
2000	5.17	8.65	1.67
2001	5.13	7.85	1.53
2002	5.26	8.77	1.67
2003	5.17	8.19	1.59
2004	5.11	9.28[6]	1.82
2016	5.23	7.80	1.49
2017	5.25	7.70	1.47
2018	5.01	7.67	1.53
2019	5.16	7.29	1.41
2020[2]	4.82	7.12	1.47
Overview	***5.12[3]***	***8.77[4]***	***1.72[5]***

1. Data for full fiscal year not provided, accurate maximum daily demand unable to be determined.
2. Data from Year 2020 not used for Overview calculations as 2020 water usage/production do not match typical yearly patterns due to effects of COVID-19 pandemic.
3. Average of Year 1995 through 2019 Annual Average Daily Production
4. Overall maximum day production from the years analyzed.
5. Combined Maximum Day Factor determined from Overall Max. Day / avg of Annual Average Day
6. The 9.28 value was omitted because it was seen to be an anomaly



1. Max. Day data unavailable for 1995.

Water Consumption

WRA reviewed the City's yearly water meter records from 2018 to 2020 to calculate actual water demand and the percent water consumption by zoning type. Based on the yearly meter reports, the total average day consumption for 2018, 2019 and 2020 is 4.48 million gallons per day (MGD), 4.72 MGD, and 2.77 MGD, respectively. The City classifies their water meter types by 9 main categories. *Table 4* below shows the water use as percentage of total water consumed by category for the 2018, 2019 and 2020 meter data.

The City is undergoing rezoning efforts at the time this report was written. WRA was provided with the proposed rezoning plan; all references to zoning or usage categories have been adjusted to reflect the changes in zoning of the 164 parcels indicated in the City of Dover Comprehensive Rezoning Project 2021 DRAFT Map Date 3/8/2021.

Table 4 - Water Consumption by Type

Zone	2018	2019	2020
Manufacturing	25.49%	28.08%	21.95%
Agricultural	0.01%	0.01%	0.02%
Commercial	15.07%	14.06%	11.03%
Institutional	1.61%	1.60%	1.29%
Office	12.08%	11.58%	7.29%
Open Space	0.13%	0.10%	0.03%
Service	0.02%	0.02%	0.02%
Residential	45.09%	44.11%	57.89%
Residential/Com	0.51%	0.46%	0.49%
Total	100.00%	100.00%	100.00%

As shown in *Table 4*, the largest portion of water consumed in the City of Dover is from Residential demands followed by Commercial (including Office Space) and Industrial demands. The remaining demand categories make up less than 3% of total water consumption in the City's service area. For the purpose of simplifying demand projections for this study, water demands will be attributed to residential, commercial, and industrial sources. Residential demand will include water consumption from the residential, residential/commercial, and empty zone categories. Commercial demands will include water consumption attributed to the commercial, institutional, office, open space and service zoning categories while Industrial demands will include consumption by the agricultural and manufacturing zoning categories. Combining categories results in residential, commercial, and industrial water use contributions of approximately 44.9%, 28.3% and 26.8%. *Table 5* below includes the total average day water use as calculated from the metered water consumption files as well as a break down of estimated consumption per use type.

A comparison of the 2020 water use percentages as well as the total average day consumption highlights the changes in water use the City experienced due to the current pandemic. Residential water use contribution increased by approximately 13% while work related contributions (commercial, office, manufacturing, etc.) significantly reduced. In addition, the City saw a 41% reduction in overall average day water consumption.

Table 5 - Metered Water Consumption

Year	Total Average Day Demand (MGD)		Residential Demand (MGD)		Commercial Demand (MGD)		Industrial Demand (MGD)	
2018	~~4.48~~	4.56	~~2.04~~	2.08	~~1.30~~	1.28	~~1.14~~	2.21
2019	~~4.72~~	4.77	~~2.10~~	2.04	~~1.30~~	1.25	~~1.33~~	1.19
2020	~~2.77~~	4.51	~~1.61~~	2.06	~~0.55~~	1.26	~~0.61~~	1.19

1. Data from 2020 is not used in calculating water use percentages as 2020 usage patterns do not match typical or projected patterns.

Metered water consumption in Dover is historically less than water production. This is typical and is usually due to water loss, meter inaccuracy, or unaccounted for flows (fire flows, hydrant flushing, ect.) which are found in any water distribution system. *Table 6* shows the water loss percentages in the City of Dover's system compared to the national average of 16% (EPA 816-F-13-002). Typically, the City's water loss percentage is less than the national average, but data from the year 2020 shows a significant decrease in water use accounted for by water meters.

Table 6 – Yearly Water Loss Percentages

	Year	Yearly Water Consumption (gal)	Yearly Water Production (gal)	Water Loss (%)	
1,665,068,000	2018	~~1,635,780,000~~	1,826,967,000	~~10%~~	8.9%
1,743,929,000	2019	~~1,724,073,000~~	1,882,452,000	~~8%~~	7.4%
1,647,663,000	2020	~~1,012,227,000~~	1,765,218,000	~~43%~~	6.7%

To ensure that hydraulic modeling and recommended future improvements account for the full quantity of water needed, the percentages utilized for *Table 5* were applied to the City's water production numbers to establish a total system water demand (See *Table 7*).

Table 7 - Yearly System Commercial, Residential, and Industrial Water Demand

Year	Total Average Day Production (MGD)	Estimated Residential Demand (MGD)		Estimated Commercial Demand (MGD)		Estimated Industrial Demand (MGD)	
2016	5.23	~~2.35~~	2.38	~~1.48~~	1.46	~~1.40~~	1.38
2017	5.25	~~2.36~~	2.39	~~1.49~~	1.47	~~1.41~~	1.39
2018	5.01	~~2.25~~	2.28	~~1.42~~	1.40	~~1.34~~	1.33
2019	5.16	~~2.32~~	2.35	~~1.46~~	1.45	~~1.38~~	1.37
2020	4.82	~~2.17~~	2.20	~~1.37~~	1.35	~~1.29~~	1.28
Avg.	5.16	~~2.32~~	2.35	~~1.46~~	1.45	~~1.38~~	1.37

1. Data from 2020 is not used in calculating water production averages as 2020 usage patterns do not match typical or projected patterns.

Water Demand Projections

Two methods of projecting water usage were reviewed to estimate the future water demand for the City of Dover: straight-line projection of the historical average day demand and a projection of water demands based on expected population increase and City planning and zoning land annexation estimates. Projections were completed for a 20-year planning period at 5-year increments.

Straight line Projection

Straight-line projections were completed by calculating a linear trendline from the available annual average day production data. Data from 2020 was left out of the calculation as the usage patterns are not typical and inclusion of 2020 data does impact the projection. Straight-Line projection values can be found in *Figure 2* and *Table 8*.

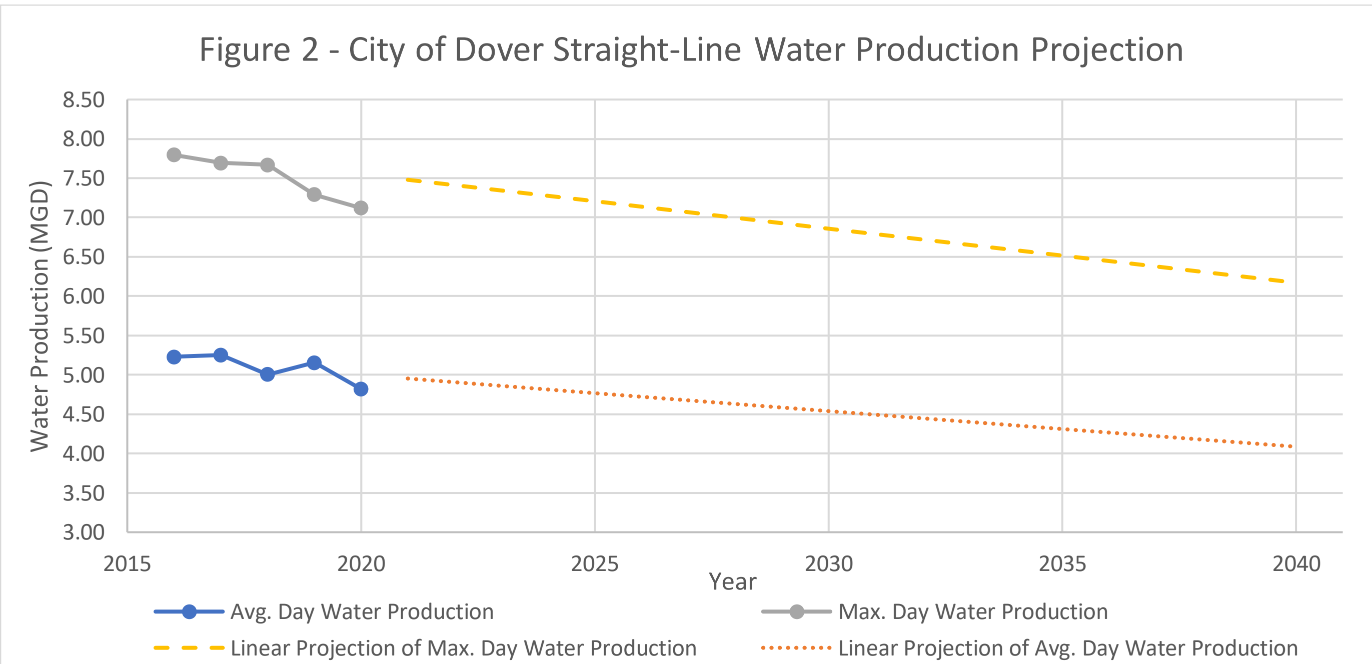


Table 8 – Projected Demands; Straight-Line Projection

Year	Projected Avg. Day Demand (MGD)
2021	4.95
2025	4.77
2030	4.54
2035	4.32
2040	4.09

Based on the linear projection method, projected water demands will decrease to approximately 4.0 MGD by 2040. However, the City anticipates an increase in residential population as well as annexation of lands into the water service area. Therefore, projected demands should reflect the City's growth.

Development, Growth and Land Annexation Projection

Water demand projections were completed by analyzing possible future developments, population growth projections, and the City's planned land annexations.

Unit Demand Calculations

To predict future demands, WRA calculated unit demand numbers for Residential, Commercial, and Industrial users. Residential water demand (as calculated in *Table 7*) was divided by the total population to calculate the water usage per capita (gpdc). Commercial and industrial water production was divided by the total acreage occupied by each respective water use type to calculate the unit water demand per acre.

Current commercial and industrial acreage was calculated utilizing meter designations and GIS parcel information available for the State of Delaware. Parcel areas with assigned commercial or industrial services (as indicated by the metered consumption document) were identified and totaled resulting in a current total commercial and industrial acreage within the City's water service area of 2,628.0 acres (ac) and 623.4 ac, respectively. Commercial and Industrial unit demands were then calculated by dividing the estimated water demand by the respective total area. *Table 9* includes the unit demand calculations for each designated water use.

Table 9 – Commercial, Residential, and Industrial Water Production Unit Demands

Year	Population	Residential Unit Water Production (gpd/capita)		Total Commercial Acreage	Commercial Unit Water Production (gpd/acre)		Total Industrial Acreage	Industrial Unit Water Consumption (gpd/acre)	
2016	37,229	64.02	~~63.11~~	2,628.03	557.42	~~563.96~~	623.35	~~2,247.51~~	2221.70
2017	37,416	63.94	~~63.04~~	2,628.03	559.55	~~566.12~~	623.35	~~2,256.11~~	2230.20
2018	38,008	60.07	~~59.22~~	2,628.03	533.97	~~540.24~~	623.35	~~2,152.97~~	2128.25
2019	38,166	61.61	~~60.74~~	2,628.03	549.96	~~556.41~~	623.35	~~2,217.43~~	2191.97
2020[1]	38,412	57.18	~~56.37~~	2,628.03	513.72	~~519.75~~	623.35	~~2,071.32~~	2047.54
Avg.		62.41	**~~61.53~~**		550.23	**~~556.68~~**		**~~2,218.50~~**	2193.03

1. Data from 2020 is not used in calculating water production averages as 2020 usage patterns do not match typical or projected patterns.

Population Growth and Land Annexation

Future residential demands were estimated using population projections from the City's 2019 Comprehensive Plan and the State of Delaware's 2020 Population Consortium. Future commercial and industrial acreage was estimated from Maps 13-1: Potential Annexation Areas and 13-2: Potential Land Use for Annexation Areas found in the City's 2019 Comprehensive Plan.

The City categorizes the potential annexation areas as Category 1 – High Priority, Category 2 – Priority, Category 3 – Long Term Annexation, and Areas of Concern. After discussions with the City, it was decided that the Category 1 area will be associated with 5 year projections (Year 2025), Category 2 areas will be associated with 10 year projections (Year 2030), and Category 3 areas will be equally split between 15 and 20 year projections (Year 2035 and 2040). The areas of concern will not be considered as part of this study as the likelihood of those areas being annexed is low.

Map 13-2 provided a land use break down of Category 1 and Category 2 annexation lands. WRA calculated areas for each classification and categorized the non-residential uses into commercial and industrial. These quantities were then added to the existing area to project future demands. Land use for Category 3 was not provided. Therefore, WRA assumed the land distribution in Category 3 to be similar to current land distribution; 47% residential use, 43% commercial use, and 10% industrial use. The resulting increase in commercial and industrial areas from the planning and zoning information is summarized in *Table 10*.

Table 10 – Total Projected Population and Commercial and Industrial Land Area

Year	Population	Area of Commercial Land (Acre)	Area of Industrial Land (Acre)
2025	39,606	2,935.28	803.22
2030	40,836	3,030.94	1,146.15
2035	41,887	3,646.53	1,292.16
2040	42,966	4,262.12	1,438.17

Future projections were then calculated by multiplying the unit demands by the estimated population, commercial acreage, and industrial acreage.

Future Development

The City provided WRA with a list of potential future developments. Industrial developments were accompanied by an estimated water demand and the number of potential residential units were provided with Residential developments. For the residential demand calculations, each residential unit was assumed to be occupied by 2.5 people. The residential unit demand calculated in *Table 9* was then applied. A map showing the location of each development, as well as Category 1, 2, and 3 annexation lands can be found in *Figure 3*. Each development, its demand, assigned hydraulic timestep, zoning designation, and a brief description can be found in *Table 11*. Hydraulic timesteps (the year the development is assumed to be constructed and in service) were assigned to each development based on conversations with the City and assumed construction durations.

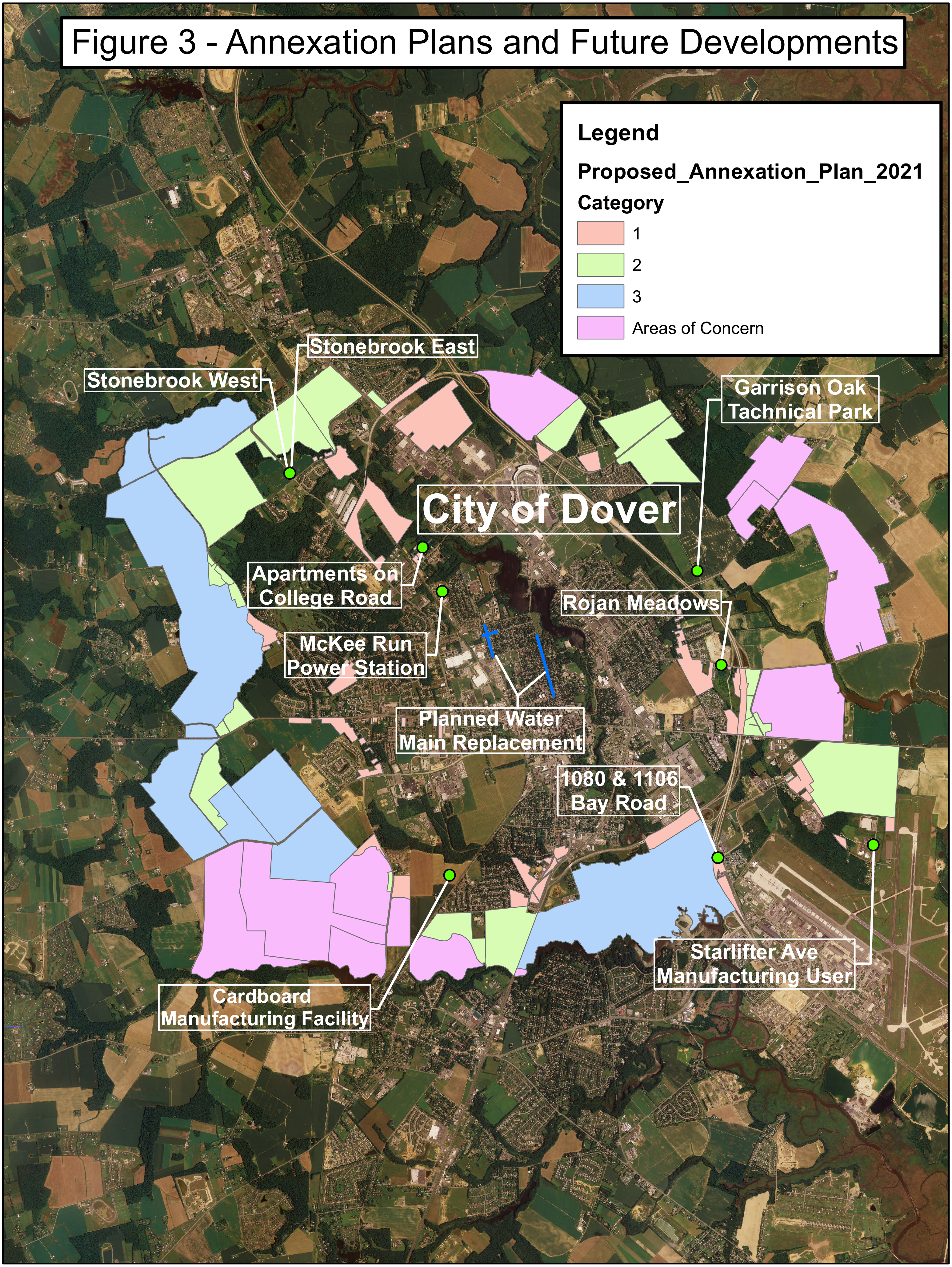


Figure 3 - Annexation Plans and Future Developments
Legend
Proposed_Annexation_Plan_2021
Category
1
2
3
Areas of Concern
Stonebrook East
Stonebrook West
Garrison Oak
Tachnical Park
City of Dover
Apartments on
College Road
Rojan Meadows
McKee Run
Power Station
Planned Water
Main Replacement
1080 & 1106
Bay Road
Starlifter Ave
Manufacturing User
Cardboard
Manufacturing Facility

Table 11 – Future Development Demands and Hydraulic Timestep

Timestep	Development	Average Day Demand Change (gpd)	Zone	Description
2025	McKee Run Power Plant	-64,800	Industrial	Decommissioning of Power Plant
2025	Starlifter Ave. Manufacturing	3,900	Industrial	New Manufacturing User
2025	Cardboard Manufacturing Facility	7,502	Industrial	New Manufacturing User
2025	Garrison Oak Technical Park	45,014	Industrial	New Industrial Development
2025	Stonebrook East	39,111	Residential	255 Unit Apartment Development
2025	Stonebrook West	27,147	Residential	177 Unit Apartment Development
2030	Garrison Oak Technical Park	45,014	Industrial	New Industrial Development
2030	Rojan Meadows	24,387	Residential	159 Unit Apartment Development
2030	1080 & 1106 Bay Road	7,362	Residential	48 Unit Apartment Development
2030	Apartments on College Road	50,307	Residential	328 Unit Apartment Development

Table 12 Assumptions:

1. Residential timesteps were assigned based on projected population growth and estimated time of construction,
2. Industrial timesteps were assigned based on information provided by the City and estimated time of construction.

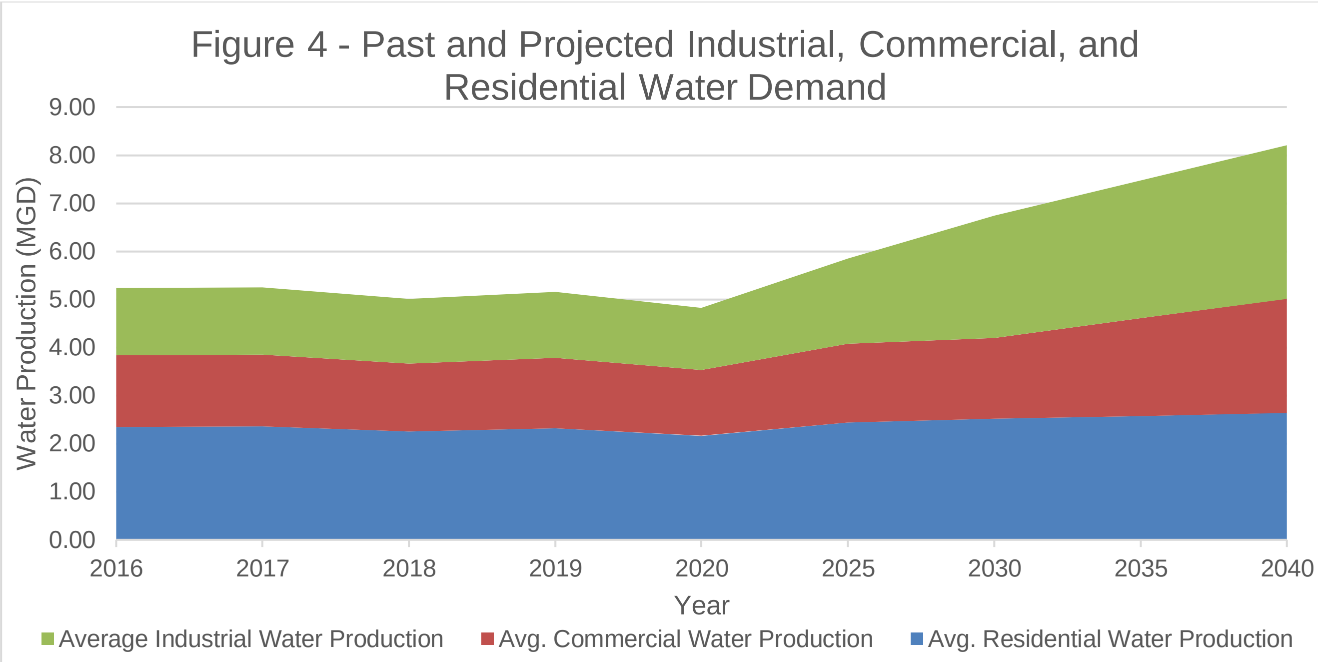
It was observed that none of the upcoming industrial developments are located within the proposed annexed land areas (See *Figure 3*). This indicates that their demands would not be included in those calculated purely on estimated annexed areas. Therefore, WRA added the identified industrial development demand to the industrial water demand calculated through land annexation. Residential demands calculated for each development are assumed to be included in the City's overall projected population increase.

Projected Development, Growth and Land Annexation Demands

Based on calculated unit demands, developments, and proposed residential growth and land area increases, *Table 12* includes the City of Dover's projected water demands at each hydraulic timestep in the planning period and *Figure 4* includes the projected increase.

Table 12 – Projected Water Demands based on Population Growth and Land Annexation

Year	Residential Water Demand (MGD)	Commercial Water Demand (MGD)	Industrial Water Demand (MDG)	Total Average Day Demand (MGD)	Maximum Day Demand (MGD)
2019	2.35 ~~2.32~~	1.45 ~~1.46~~	1.37 ~~1.38~~	5.16	7.79 ~~7.29~~
2025	2.47 ~~2.44~~	1.62 ~~1.63~~	1.75 ~~1.77~~	5.84	8.82 ~~8.83~~
2030	2.55 ~~2.51~~	1.67 ~~1.69~~	2.55 ~~2.58~~	6.77 ~~6.78~~	10.22 ~~10.24~~
2035	2.61 ~~2.58~~	2.01 ~~2.03~~	2.87 ~~2.90~~	7.49 ~~7.51~~	11.31 ~~11.34~~
2040	2.68 ~~2.64~~	2.35 ~~2.37~~	3.19 ~~3.23~~	8.22 ~~8.24~~	12.41 ~~12.45~~



Demand Distribution

Demands associated with specific developments will be added to the hydraulic water model at the locations provided by the City. This allows for any necessary improvements due to the specific developmental increases to be assessed. The demands in *Table 11* do not account for the entirety of projected demand increase at each timestep (*Table 12*). Therefore, the remaining demand increase will be distributed throughout the potential annexed land areas and the existing water model.

Water Storage

The City maintains seven elevated storage tanks with a total storage capacity of 5.25 MG and is planning for the addition of a 1 MG tank on Denneys Rd in 2023. *Table 13* provides a listing of the tanks in the City of Dover System.

Table 13 – Water Tank Storage

Storage Tank	Storage Capacity (MG)
General Foods Tank	0.25
Bayard Ave Tank	0.25
McKee Road Tank	1.0
Dover Park Tank	1.0
Walker Road Tank	1.0
Kent Co. Aeropark Tank	0.25
Garrison Water Tower	1.5
Denneys Road Tank[1]	1.0
Total Current	**5.25**
Total Future	**6.25**

1. Installation planned for 2023

WRA compared the storage capacity with the storage volume required to serve the distribution system. The total system storage required is typically calculated by the following formula which was utilized during the development of the 2006 Master Plan.

STORAGE VOLUME REQUIRED = EQUALIZATION + FIRE FLOW + EMERGENCY

Equalization	=	0.15 x Maximum Daily Demand (MDD)
Fire Flow	=	5,000 gpm for 4 hours (Commercial/multi-family) 1,200,000 gallons
Emergency	=	0.10 x MDD (i.e. Cover raw water main break)

The above storage calculations are summarized below in *Table 14*.

Table 14 – Water Storage Calculations

Scenario	MDD (MGD)	Equalization (MG)	Fire Flow (MG)	Emergency (MG)	Required Storage (MG)	Available Storage (MG)	Difference (MG)
2019	7.29	1.09	1.20	0.73	3.02	5.25	2.23
2025	~~8.83~~ 8.82	~~1.33~~ 8.82	1.20	0.88	~~3.41~~ 3.40	6.25	~~2.84~~ 2.85
2030	~~10.24~~ 10.22	1.53	1.20	1.02	3.75	6.25	~~2.49~~ 2.50
2035	~~11.34~~ 11.31	~~1.69~~ 8.82	1.20	1.13	~~4.02~~ 4.03	6.25	~~2.21~~ 2.22
2040	~~12.45~~ 12.41	1.86	1.20	1.24	4.30	6.25	~~1.94~~ 1.95

1. Calculated storage volume may not all be at a usable hydraulic grade level.

This required volume is based on one method of calculation and does not take into account the amount of "usable" storage volume (volume at a sufficient head to be effective) in the system, or the impact of groundwater wells. The hydraulic model will be used to evaluate the system storage in further detail.

Conclusions

The demand projections will be utilized in the hydraulic water model for analysis of the system and creation of recommended system improvements. This memorandum outlines the build-out flow projections and growth pattern assumptions for the City of Dover water distribution system. The ability of the system to meet the projected demands outlined in the memo will be included as part of the hydraulic analysis and the updated water master plan.

Allyson Merola, P.E.

Appendix B
Field Inspection Reports

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 29, 2021

WELL NO.: 1
LOCATION: Jones Station
DESIGN: 250 gpm @ 280'TDH
PRODUCES, gpm: 155 (per 2017 well report). 144 gpm observed
ELECTRIC: 230v/3PH, 30HP
YEAR DRILLED: 1939
CONSTRUCTION:
CHEMICAL FACILITY: Brick & Block

TYPE: Deep, Confined
AQUIFER: Cheswold
DEPTH, ft.: 228
PUMP FACILITY: Stick Frame w/ vinyl siding (Detachable)

CHEMICAL(S) FED: Sodium Hypochlorite 13%, Hydrofluosilicic Acid 23%

A. ASSESSMENT

1. AREA FENCING: Yes

2. EXTERIOR CONDITION: Good

3. PUMP FACILITY:
   a. Pump Status: Operating
   b. Pump Layout: Submersible pump with blow-off piping, magnetic flow meter, pressure gauge, flow switch, air release valve and check valve.
      (1) Observation: Flow meter reading at 144 gpm. Area of wall need painting.
      (2) Recommendation: Paint wall as needed.
   c. Heating/Ventilation:
      (1) Observation: No-ventilation, Room stay cool with submersible well pump.

4. INSTRUMENTATION/CONTROLS: Siemens magnetic flowmeter and chlorine residual analyzer. The 900MHz serial licensed radio MDS 9710 is obsolete from Manufacturer as of 12/15/12. It is used to communicate facility status include alarms and control. The City is in the process of having it replace with new MDS SD9 radio which are backward compatible with the 9710.

5. CHEMICAL FACILITY:
   a. System Layout: 15-gallon Sodium hypochlorite drums with Pentair transfer pump to fill a day tank and LMI metering feed pump. 15-gallon hydrofluosilicic acid (fluoride) drums fed neat with a LMI metering feed pump. Electronic scale is no longer used. The State no longer require report on chemical usages.

      (1) Observation: Open chemical drums vent vapors/fumes into the room. Corrosion on door. Wall need painting.
      (2) Recommendation:

(a) Use drum-bung fitting to seal day tank opening spaces and run vent to the outside in accordance with RSWW (Recommended Standards for Water Works 2018) Sections 5.1, paragraph 5.1.11.b.
(b) Replace metal door with corrosion resistance fiberglass door and paint walls.

.

b. Heating/Ventilation
   (1) Observation: The chemical room is positively pressurized via supply fan and with two door mounted gravity dampers for exhaust.
   (2) Recommendation: None. The current system is City’s preferred layout.

6. ELECTRICAL:
   a. Observations:
      (1) Lighting is provided by incandescent lamps in Pump Room Area and in the Panel Area. Chemical Room is lighted by surface mounted totally enclosed fluorescent fixture with missing cover.
      (2) Two services provide power at 480V, 3 phase, and 240/120V, single phase.
      Meter # single phase 27082586 Schlumberger
      Meter # three phase 40 171 762 Itron
      (3) No ground fault receptacles are installed. Some receptacle covers are missing
      (4) Conduit in Chemical Room is all PVC.
      (5) Electrical equipment is in good condition.
      (6) Service is 3 phase, 4 wire from Power Co. Aerial pole line runs to pole No. 4-2, then underground to the station and turns up on the outside of building 5 feet above ground where the conduit elbows into building.
      (7) Pump Room -Raceway installed is a mixture of PVC, LFMC and Metallic all in fair condition
   b. Recommendation:
      (1) Provide ground fault receptacles in place of existing receptacles.
      (2) Provide LED A19 socket lamps in place of existing incandescent lamps.
      (3) Replace existing fluorescent fixture with LED equivalent.
      (4) Replace all receptacle covers with in-use type

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WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 29, 2021

WELL NO.: 2
LOCATION: Horsepond
DESIGN: 900 gpm @ 500'TDH
PRODUCES, gpm: 1,127 (per 2011 well report)
ELECTRIC: 480v/3PH, 150HP, Square D VFD
YEAR DRILLED: 1975
CONSTRUCTION:
CHEMICAL FACILITY: Stick Frame w/Vinyl Siding

CHEMICAL(S) FED: Sodium Hypochlorite 13%

TYPE: Deep, Confined
AQUIFER: Piney Point

DEPTH, ft.: 502 ft.

PUMP FACILITY: Stick Frame w/ vinyl siding

A. ASSESSMENT

1. AREA FENCING: Yes

2. EXTERIOR CONDITION: Good

3. PUMP FACILITY:

   a. Pump Status: Operating
   b. Pump Layout: Vertical turbine, by-pass piping, magnetic flow meter, pressure gauge, flow switch, air release valve and check valve.
      (1) Observation: Portable standby generator and transfer switch. Corrosion on door. Piping need repainting.
      (2) Recommendation: none
   c. Heating/Ventilation:
      (1) Observation: Two wall mounted air conditioning unit with roof mounted exhaust.
      (2) Recommendation: none.

4. INSTRUMENTATION/CONTROLS: Siemens magnetic flowmeter and chlorine residual analyzer. The 900MHz serial licensed radio MDS 9710 is obsolete from Manufacturer as of 12/15/12. It is used to communicate facility status include alarms and control. The City is in the process of having it replace with new MDS SD9 radio which are backward compatible with the 9710.

5. CHEMICAL FACILITY:
   a. System Layout: 15-gallon Sodium hypochlorite drums with Pentair transfer pump to fill a day tank and LMI metering feed pump. Electronic scale is no longer used. The State no longer require report on chemical usages.
      (1) Observation: Open chemical drum vent vapors/fumes inside the room. Corrosion on lower door.
      (2) Recommendation:

(a) Use drum-bung fitting to seal day tank opening spaces and run vent to the outside in accordance with RSWW (Recommended Standards for Water Works 2018) Sections 5.1, paragraph 5.1.11.b.
(b) Replace metal door with corrosion resistance fiberglass door.

b. Heating/Ventilation
   (1) Observation: The chemical room is positively pressurized via supply fan and with one door mounted gravity damper for exhaust.
   (2) Recommendation: None. The current system is City's preferred layout.

6. ELECTRICAL:
   a. Observations:
      (1) Utility Meter #46 494 256 ITRON
      (2) Service 480v 3 phase
      (3) Exterior CT cabinet, Meter, and utility main disconnect switch mounted to Unistrut support system NEMA 3R.
      (4) Well pump is 150 Hp, 460V, 3 phase, VFD Controlled. The VFD model 58M currently installed is out of production and is at or approaching end of life in addition supplemental cooling has been provided but we cannot verify if it would be sufficient to keep the space withing the necessary ambient conditions for proper VFD operations.
      (5) Chemical Room - All PVC conduit, no GFI receptacles, lighting fixtures are fluorescent type surface mounted totally enclosed.
      (6) Pump Room - Raceway installed is a mixture of PVC, LFMC and Metallic all in fair condition, no GFI receptacles, lighting fixtures are fluorescent type surface mounted totally enclosed. Power panel and transformer provides 120/240 volt power, with a 100 amp main breaker and 20 Spaces, Transformer is single phase 15 kVA.
      (7) Electrical equipment is in good condition.

   b. Recommendation:
      (1) Replace existing receptacles with GFI type and provide in-use covers.
      (2) Replace existing fluorescent fixtures with LED equivalent.
      (3) Replace existing VFD with a newer model drive.

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 29, 2021

WELL NO.: 3
LOCATION: Dover East
DESIGN: Unknown
PRODUCES, gpm: 299 (per 2019 well report). 255 gpm @ 56.5 hz observed
ELECTRIC: 230v/3PH, 30HP, VFD
YEAR DRILLED: 1948
CONSTRUCTION:
CHEMICAL FACILITY: Brick & Block
CHEMICAL(S) FED: Sodium Hypochlorite 13%, Hydrofluosilicic Acid 23%

TYPE: Deep, Confined
AQUIFER: Cheswold
DEPTH, ft.: 222 ft.
PUMP FACILITY: Stick Frame w/ vinyl siding (Detachable)

A. ASSESSMENT

1. AREA FENCING: Yes

2. EXTERIOR CONDITION: Good

3. PUMP FACILITY:

   a. Pump Status: operating
   b. Pump Layout: Submersible, blow-off piping, pressure gauge, check valve, flow switch and magnetic flow meter inside a vault.
      (1) Observation: pump operating at 255 gpm @ 56.5 Hz. Discharge pressure is at 57 psi. All pipe, valves and fittings are in good condition.
      (2) Recommendation: None.
   c. Heating/Ventilation:
      (1) Observation: Adequate ventilation and heating.
      (2) Recommendation: None.

4. INSTRUMENTATION/CONTROLS: Siemens magnetic flowmeter and chlorine residual analyzer. The 900MHz serial licensed radio MDS 9710 is obsolete from Manufacturer as of 12/15/12. It is used to communicate facility status include alarms and control. The City is in the process of having it replace with new MDS SD9 radio which are backward compatible with the 9710.

5. CHEMICAL FACILITY:
   a. System Layout: 15-gallon Sodium hypochlorite drums with Pentair transfer pump to fill a day tank and LMI metering feed pump. 15-gallon hydrofluosilicic acid (fluoride) drums fed neat with a LMI metering feed pump. Electronic scale is no longer used. The State no longer require report on chemical usages.

(1) Observation: Open chemical drums vent vapors/fumes into the room.
(2) Recommendation:
(a) Use drum-bung fitting to seal day tank opening spaces and run vent to the outside in accordance with RSWW (Recommended Standards for Water Works 2018) Sections 5.1, paragraph 5.1.11.b.
(b) Replace metal door with corrosion resistance fiberglass door.

b. Heating/Ventilation
(1) Observation: The chemical room is positively pressurized via supply fan and with wall mounted gravity damper for exhaust.
(2) Recommendation: None. The current system is City's preferred layout.

6. ELECTRICAL:
a. Observations:
(1) Chemical Room
All PVC conduit, no ground fault receptacles.
Conduit for light and light switch box are metal with EMT conduit. Lighting fixtures are glass globes with incandescent lamps.
Fan on light switch with contactor and no timer.
(2) Electric Room
Raceway installed is a mixture of PVC or Metallic all in fair condition, no ground fault receptacles
Meter # single phase 46 493 748 Itron
Meter # 40 171 763, three phase. Itron
Disconnect, VFD and power panel all found in good condition
(3) Service is from 3 pole mounted transformers, 3- 25kVA on the corner outside property at Dover and South New Street from Pole #58. Aerial line runs to pole #59 and underground into a wireway inside the building.
b. Recommendation:
(1) Replace existing receptacles with GFI type and provide in-use covers
(2) Provide equivalent LED A19 socket lamps in place of existing incandescent lamps.
(3) Evaluate ambient conditions in the space for proper VFD operations

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 29, 2021

WELL NO.: 4
LOCATION: West Water Street
DESIGN: Unknown
PRODUCES, gpm: 240 (per 2011 well report)
ELECTRIC: 230v/3PH, 30HP, NEMA3 Starter (Square D)
YEAR DRILLED: 1952
CONSTRUCTION:
CHEMICAL FACILITY: Stick Frame with Vinyl Siding
CHEMICAL(S) FED: Sodium Hypochlorite 13%, Hydrofluosilicic Acid 23%

TYPE: Deep, Confined
AQUIFER: Cheswold
DEPTH, ft.: 221
PUMP FACILITY: Brick & Block

A. ASSESSMENT

1. AREA FENCING: None

2. EXTERIOR CONDITION: Good

3. PUMP FACILITY:

   a. Pump Status: Operating
   b. Pump Layout: Submersible, blow-off piping, check valve, pressure gauge, flow switch, sodium hypochlorite & fluoride injection points and an outside magnetic flow meter vault include a small dedicated water meter.
      (1) Observation: Piping surface rust.
      (2) Recommendation: Remove piping surface rust and repaint as needed. Replace metal door with corrosion resistance fiberglass door.
   c. Heating/Ventilation:
      Observation: No-ventilation. Room stay cool with submersible well pump.

4. INSTRUMENTATION/CONTROLS: Siemens magnetic flowmeter and chlorine residual analyzer. The 900MHz serial licensed radio MDS 9710 is obsolete from Manufacturer as of 12/15/12. It is used to communicate facility status include alarms and control. The City is in the process of having it replace with new MDS SD9 radio which are backward compatible with the 9710.

5. CHEMICAL FACILITY:
   a. System Layout: 15-gallon Sodium hypochlorite drums with Pentair transfer pump to fill a day tank and LMI metering feed pump. 15-gallon hydrofluosilicic acid (fluoride) drums fed neat with a LMI metering feed pump. Electronic scale is no longer used. The State no longer require report on chemical usages.

      (1) Observation: Open chemical drums vent vapors/fumes into the room.
      (2) Recommendation:

(a) Use drum-bung fitting to seal day tank opening spaces and run vent to the outside in accordance with RSWW (Recommended Standards for Water Works 2018) Sections 5.1, paragraph 5.1.11.b.
(b) Replace metal door with corrosion resistance fiberglass door.

b. Heating/Ventilation
(1) Observation: The chemical room is positively pressurized via supply fan and with two wall mounted louvers with gravity dampers for exhaust.
(2) Recommendation: None. The current system is City’s preferred layout.

6. ELECTRICAL:
a. Observations:
(1) Utility Meter #40 171 764
(2) Service 240v 3 phase
(3) Exterior Meter and interior utility main disconnect switch
(4) Well pump is 30 Hp, 240V, 3 phase, with size 3 FVNR starter.
(5) Chemical Room - All PVC conduit, no GFI receptacles, lighting fixtures are fluorescent type surface mounted totally enclosed with missing lens
(6) Pump Room - Raceway installed is a mixture of PVC, LFMC and Metallic all in fair condition, no GFI receptacles, lighting fixtures are socket type. Power panel provides 120/240-volt power, with a 100 amp main breaker and 20 Spaces. Existing Pump Starter is showing signs of corrosion.
(7) Electrical equipment is in good condition.

b. Recommendation:
(1) Replace existing receptacles with GFI type and provide in-use covers.
(2) Replace existing fluorescent fixtures with LED equivalent.
(3) Provide equivalent LED A19 socket lamps for all socket fixtures
(4) Plan to replace existing motor starter within 5 years.

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION**:** March 29, 2021

WELL NO.: 6
LOCATION: Rodney Village
DESIGN: 700 gpm @ 380'TDH
PRODUCES, gpm: 777 (per 2017 well report). 708 gpm observed
ELECTRIC: 480v/3PH, 100HP, Square D VFD w/by-pass starter
YEAR DRILLED: 1970
CONSTRUCTION:
CHEMICAL FACILITY: Stand-alone stick frame with vinyl siding

CHEMICAL(S) FED: Sodium Hypochlorite 13%

TYPE: Deep, Confined
AQUIFER: Piney Point
DEPTH, ft.: 456
PUMP FACILITY: Detached- stick frame with vinyl siding

A. ASSESSMENT

1. AREA FENCING: Yes

2. EXTERIOR CONDITION: Good but some areas have mildew.

3. PUMP FACILITY:

   a. Pump Status: Operating
   b. Pump Layout: Vertical turbine, blow-off piping, magnetic flow meter (exterior), pressure gauge, flow switch, air release valve and check valve.

      (1) Observation: pump running at 708 gpm @ full speed on the VFD. Gauge pressure reading is at 66 psi. Exterior mildew on siding. Interior walls need painting.

      (2) Recommendation: Clean and paint inside walls. Power wash exterior siding. Replace metal door with corrosion resistant fiberglass door.

   c. Heating/Ventilation:
      (1) Observation: Roof mounted. exhaust fans with window mounted air conditioner.

      (2) Recommendation: none.

4. INSTRUMENTATION/CONTROLS: Siemens magnetic flowmeter and chlorine residual analyzer. The 900MHz serial licensed radio MDS 9710 is obsolete from Manufacturer as of 12/15/12. It is used to communicate facility status include alarms and control. The City is in the process of having it replace with new MDS SD9 radio which are backward compatible with the 9710.

5. CHEMICAL FACILITY:

a. System Layout: System Layout: 15-gallon Sodium hypochlorite drums with Pentair transfer pump to fill a day tank (55-gal. drum) and a LMI metering feed pump.
   (1) Observation: Open chemical drums vent vapors/fumes into the room. Interior wall need painting. Corrosion on bottom of exterior door.

   (2) Recommendation:
      (a) Use drum-bung fitting to seal day tank opening spaces and run vent to the outside in accordance with RSWW (Recommended Standards for Water Works 2018) Sections 5.1, paragraph 5.1.11.b.
      (b) Clean and paint inside walls. Replace metal door with corrosion resistant fiberglass door.

b. Heating/Ventilation
   (1) Observation: Corrosion on fan box.

   (2) Recommendation: Replace fan with new fan that has corrosion resistant coating.

6. ELECTRICAL:

a. Observations:

   (1) Chemical Building - no GFI receptacles, all PVC conduit and fluorescent surface mounted fixtures. Some metal conduit supports were installed and are corroded the non-metallic supports installed are in good.

   (2) Pump House 125Hp pump motor 460v, 3 phase, VDF controlled The VFD model 58M currently installed is out of production and is at or approaching end of life in addition supplemental cooling has been provided but we cannot verify where it would be sufficient to keep the space withing the necessary ambient conditions for proper VFD operations. Raceway installed is a mixture of PVC, LFMC and Metallic all in fair condition

   (3) Lighting fixtures were porcelain outlet with 60W bulb. provides lighting, transformer 25kVA single phase 480//120/240V, service 480V, 3 phase, 4 wire, all PVC conduit, RTU in a Steel Box. The VFD, panelboards, and transformer are all in fair condition.

   (4) Vent system - separate from lighting switch add thermostat and recycle timer.

   (5) Service is from 3 pole mounted transformers outside fence area.

   (6) Meter #46 494 030 ITRON Pole #2

b. Recommendations

   (1) Replace existing receptacles with GFI type and provide in-use covers.
   (2) Replace existing fluorescent fixtures with LED equivalent.
   (3) Replace existing VFD with a newer model drive.
   (4) Provide LED A19 socket lamps in place of existing incandescent lamps.
   (5) Replace all corroded metallic conduit supports in the Chem Feed room with non-metallic type

WELL FACILITIES INSPECTION

PROJECT: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 29, 2021

WELL NO.: 7
LOCATION: McKee
DESIGN: 200 gpm @ 430'TDH 2017 new pump
PRODUCES, gpm: 225 (per 2019 well report). 250 observed
ELECTRIC: 480v/3PH, 30HP. NEMA 3 Starter (Square D)
YEAR DRILLED: 1961
CONSTRUCTION:
CHEMICAL/PUMP FACILITY: Stick frame with vinyl siding (Rebuilt in 2020)
CHEMICAL(S) FED: Sodium Hypochlorite 13%

TYPE: Deep, Confined
AQUIFER: Piney Point

DEPTH, ft.: 382

A. ASSESSMENT

1. AREA FENCING: Yes, it is located inside a fenced City complex.

2. EXTERIOR CONDITION: Very good, newly renovated.

3. PUMP FACILITY:

   a. Pump Status: Operating
   b. Pump Layout: Submersible, blow-off piping, check valve, magnetic flow meter, pressure gauge, flow switch and sodium hypochlorite injection point.

      (1) Observation: Piping surface rust, bent pressure gauge needle, corrosion at door bottom.

      (2) Recommendation: Remove piping surface rust and repaint as needed. Replace pressure gauge and replace metal door with corrosion resistant fiberglass door.

   c. Heating/Ventilation:
      (1) Observation: No-ventilation. Room stay cool with submersible well pump.

4. INSTRUMENTATION/CONTROLS: Siemens magnetic flowmeter and chlorine residual analyzer. The 900MHz serial licensed radio MDS 9710 is obsolete from Manufacturer as of 12/15/12. It is used to communicate facility status include alarms and control. The City is in the process of having it replace with new MDS SD9 radio which are backward compatible with the 9710.

5. CHEMICAL FACILITY:
   a. System Layout: 15-gallon chemical drums with Pentair transfer pump to fill a day tank and LMI metering feed pump. Electronic scale is no longer used. The State no longer require report on chemical usages.

(1) Observation: Opening on day tank releases vapors/fumes into the room. Corrosion in bottom of door.

(2) Recommendation:
  (a) Use drum-bung fitting to seal day tank opening spaces and run vent to the outside in accordance with RSWW (Recommended Standards for Water Works 2018) Sections 5.1, paragraph 5.1.11.b.
  (b) Replace metal door with corrosion resistance fiberglass door.

b. Heating/Ventilation
  (1) Observation: The chemical room has a light switch-controlled supply fan with gravity damper/louver for positive pressure ventilation.
  (2) Recommendation: None. The current system is City's preferred layout.

6. ELECTRICAL:

a. Observation:
  (1) Meter #51 955 245 ITRON
  150kVA pad mounted transformer provides service at 277/480V, three phase.
  (2) A step-down dry type transformer inside building provides single phase power, 15kVA 120/240V.

  (3) 30 HP pump, Square D starter, NEMA Size 3. Fair condition.

  (4) All electrical panels disconnect and wireway are in fair to good condition.

  (5) A Cutler-Hammer 30A disconnect switch and transformer is installed on wall but not connected.

  (6) No ground fault receptacle.

  (7) Light fixtures are enclosed surface fluorescent. With fixture in chemical Room missing lense

  (8) Raceway installed is a mixture of PVC, and LFMC all in good to fair condition.

b. Recommendation

  (1) Provide GFI receptacles with in-use covers
  (2) Replace existing fluorescent fixtures with LED equivalent.

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 29, 2021

WELL NO.: 8R
LOCATION: Blue Hen Mall Access road
DESIGN: 400 gpm @ 250'TDH
PRODUCES, gpm: 402 (per 2019 well report)
ELECTRIC: 480V/3PH, 40HP, Cutler-Hammer VFD
YEAR DRILLED: 2008
CONSTRUCTION:
CHEMICAL FACILITY: Brick & Block

TYPE: Deep, Confined
AQUIFER: Cheswold
DEPTH, ft.: 225
PUMP FACILITY: Exterior pump head, Stick Frame w/ vinyl siding (Detachable)

CHEMICAL(S) FED: Sodium Hypochlorite 13%, Hydrofluosilicic Acid 23%

A. ASSESSMENT

1. AREA FENCING: Yes

2. EXTERIOR CONDITION: good.

3. PUMP FACILITY:

   a. Pump Status: Operating
   b. Pump Layout: Submersible turbine pump with exterior pump head and pitless adaptor. Blow-off piping, magnetic flow meter, pressure gauge, flow switch, air release valve and check valve.
      (1) Observation: pump was operating at 308 gpm @ 60 Hz, 50 psi.
      (2) Recommendation: none
   c. Heating/Ventilation:
      (1) Observation: No-ventilation
      (2) Recommendation: none. Room stay cool with the submersible well pump outside.

4. INSTRUMENTATION/CONTROLS: Siemens magnetic flowmeter and chlorine residual analyzer. The 900MHz serial licensed radio MDS 9710 is obsolete from Manufacturer as of 12/15/12. It is used to communicate facility status include alarms and control. The City is in the process of having it replace with new MDS SD9 radio which are backward compatible with the 9710.

5. CHEMICAL FACILITY:
   a. System Layout: 15-gallon Sodium hypochlorite drums with Pentair transfer pump to fill a day tank and LMI metering feed pump. 15-gallon hydrofluosilicic acid (fluoride) drums fed neat with a LMI metering feed pump. Electronic scale is no longer used. The State no longer require report on chemical usages.

(1) Observation: Open chemical drums vent vapors/fumes into the room. Wall need painting.
(2) Recommendation:
(a). Use drum-bung fitting to seal day tank opening spaces and run vent to the outside in accordance with RSWW (Recommended Standards for Water Works 2018) Sections 5.1, paragraph 5.1.11.b.
(b). Paint wall.

b. Heating/Ventilation
(1) Observation: The chemical room is positively pressurized via supply fan with door mounted gravity dampers for exhaust.
(2) Recommendation: None. The current system is City's preferred layout.

6. ELECTRICAL:
a. Observations:
(1) Two services provide power at 480V, 3 phase, and 240/120V, single phase.
Meter # single phase 46 179 553 Itron
Meter # three phase 51 955 265 Itron
(2) Well pump is 40 Hp, 480V, 3 phase, VFD Controlled.
(3) Chemical Room - All PVC conduit, no GFI receptacles, lighting fixture is fluorescent type surface mounted totally enclosed with missing lens
(4) Pump Room and Panel Area - Raceway installed is a mixture of PVC, LFMC and Metallic all in fair condition, no GFI receptacles, lighting fixtures are socket type. Power panel provides 120/240-volt power, with a 100-amp main breaker and 20 Spaces. Existing Pump VFD is Eaton and is in good condition.
(5) Electrical equipment is in good condition.
(6) Panel Area where VFD is located is not conditioned.
b. Recommendation:
(1) Provide ground fault receptacles in place of existing receptacles.
(2) Provide LED A19 socket lamps in place of existing incandescent lamps.
(3) Replace existing fluorescent fixture with LED equivalent.
(4) Provide and or replace all receptacle covers with in-use type
(5) Evaluate environmental conditions in the space for Proper VFD operations

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 29, 2021

WELL NO.: 9
LOCATION: Kerbin Street
DESIGN: 500 gpm @ 308'TDH
PRODUCES, gpm: 570 (per 2019 well report). 536 gpm @ 58 Hz observed
ELECTRIC: 240v/3PH, 50HP. Cutler Hammer VFD
YEAR DRILLED: 1977
CONSTRUCTION:
CHEMICAL FACILITY: Stick frame with vinyl siding

CHEMICAL(S) FED: Sodium Hypochlorite 13%, Hydrofluosilicic Acid 23%

TYPE: Deep, Confined
AQUIFER: Cheswold
DEPTH, ft.: 220
PUMP FACILITY: Stick frame with vinyl siding (Detachable)

A. ASSESSMENT

1. AREA FENCING: Yes

2. EXTERIOR CONDITION: Weed whacker damage to the lower portion of siding all around. Backside of building need power wash. Station located in flood plain.

3. PUMP FACILITY:

   a. Pump Status: Operating
   b. Pump Layout: Vertical turbine, Air/vacuum valve, pressure gauge, check valve, flow switch and an outside magnetic flow meter vault.
      (1) Observation: Saturated gravel floor. Station is located within flood plain.
      (2) Recommendation: Station need to be raised up above the flood plain. The design is in progress per City. Replace weed whacker damaged lower siding.
   c. Heating/Ventilation:
      (1) Observation: Roof mounted fan with two (2) wall air conditioners.
      (2) Recommendation: None.

4. INSTRUMENTATION/CONTROLS: Siemens magnetic flowmeter and chlorine residual analyzer. The 900MHz serial licensed radio MDS 9710 is obsolete from Manufacturer as of 12/15/12. It is used to communicate facility status include alarms and control. The City is in the process of having it replace with new MDS SD9 radio which are backward compatible with the 9710.

5. CHEMICAL FACILITY:
   a. System Layout: 15-gallon Sodium hypochlorite drums with Pentair transfer pump to fill a day tank and LMI metering feed pump. 15-gallon hydrofluosilicic acid (fluoride) drums fed neat with a LMI metering feed pump. Electronic scale is no longer used. The State no longer require report on chemical usages.

(1) Observation: Open chemical drums vent vapors/fumes into the room. Corroded metal door.
(2) Recommendation:
   (a) Use drum-bung fitting to seal day tank opening spaces and run vent to the outside in accordance with RSWW (Recommended Standards for Water Works 2018) Sections 5.1, paragraph 5.1.11.b.
   (b) Replace metal door with corrosion resistance fiberglass door.

b. Heating/Ventilation
   (1) Observation: The chemical room is positively pressurized via supply fan and with two door mounted gravity dampers/louvers for exhaust.
   (2) Recommendation: None. The current system is City's preferred layout.

6. ELECTRICAL:
   a. Observations:
      (1) Service provide power at 240/120v, 3 phase, 4w.
      Meter # three phase 51 955 278 Itron
      (2) Well pump is 50 Hp, 240V, 3 phase, VFD Controlled.
      (3) Chemical Room - All PVC conduit, no GFI receptacles, lighting fixture is fluorescent type surface mounted totally enclosed.
      (4) Pump Room and Panel Area - Raceway installed is a mixture of PVC, LFMC and Metallic all in fair to good condition, no GFI receptacles, lighting fixtures are socket type. Power panel provides 120/240-volt power, with a 100-amp main breaker and 20 Spaces but is extensively corroded. Existing Pump VFD is an Eaton SVX 9000 type in a NEMA type 1 Enclosure and is in Fair condition.
      (5) Electrical equipment is in good condition.
      (6) Panel Area where VFD is located is not a clean space.

   b. Recommendation:
      (1) Provide ground fault receptacles in place of existing receptacles.
      (2) Provide LED A19 socket lamps in place of existing incandescent lamps.
      (3) Replace existing fluorescent fixture with LED equivalent.
      (4) Provide and or replace all receptacle covers with in-use type
      (5) Evaluate environmental conditions in the space for Proper VFD operations. Existing Enclosure is NEMA type 1 with no filters. The space conditions with stone floor at a minimum should be in a NEMA type 12 enclosure with filters to prevent dust and debris from entering the enclosure.
      (6) Replace 120/240v panelboard

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 29, 2021

WELL NO.: 10
LOCATION: Danner Farm
DESIGN: 1000 gpm @ 420'TDH, new pump 2009
PRODUCES, gpm: 1,000 (per 2019 well report)
ELECTRIC: 480V/3PH, 150HP. Square D VFD w/ bypass starter
YEAR DRILLED: 1965
CONSTRUCTION:
CHEMICAL FACILITY: Stick frame with vinyl siding

CHEMICAL(S) FED: Sodium Hypochlorite 13%

TYPE: Deep, Confined
AQUIFER: Piney Point

DEPTH, ft.: 480

PUMP FACILITY: Stick Frame w/ vinyl siding (Detachable)

A. ASSESSMENT

1. AREA FENCING: Yes

2. EXTERIOR CONDITION: Good, recently renovated.

3. PUMP FACILITY:

   a. Pump Status: Operating
   b. Pump Layout: Vertical turbine, blow-off piping, pressure gauge, flow switch, air release valve and check valve.
      (1) Observation: Electrical and control is located inside the adjacent Well No.14.
      (2) Recommendation: none
   c. Heating/Ventilation:
      (1) Observation: Roof mounted exhaust fan with air conditioner to dissipate the heat generation from the turbine motor.
      (2) Recommendation: none.

4. INSTRUMENTATION/CONTROLS: Siemens magnetic flowmeter and chlorine residual analyzer. The 900MHz serial licensed radio MDS 9710 is obsolete from Manufacturer as of 12/15/12. It is used to communicate facility status include alarms and control. The City is in the process of having it replace with new MDS SD9 radio which are backward compatible with the 9710.

5. CHEMICAL FACILITY:
   a. System Layout: 15-gallon Sodium hypochlorite drums with Pentair transfer pump to fill a day tank and a LMI metering feed pump.

      (1) Observation: Open chemical drums vent vapors/fumes into the room. Interior wall need painting. Corrosion on bottom of exterior door.

(2) Recommendation:
   (a) Use drum-bung fitting to seal day tank opening spaces and run vent to the outside in accordance with RSWW (Recommended Standards for Water Works 2018) Sections 5.1, paragraph 5.1.11.b.
   (b) Clean and paint inside walls. Replace metal door with corrosion resistance fiberglass door.

b. Heating/Ventilation
   (1) Observation: The chemical room is positively pressurized via large sidewall mounted roof type supply fan and louver on the door.
   (2) Recommendation: none.

6. ELECTRICAL:

a. Observation:

   (1) Building only contains the Well Pump and Chemical equipment, no electrical service or equipment is in the building, power feeds from Well House #14.

   (2) Well Pump is 150 HP, 460V, 3 phase, VFD controlled located in well house #14

   (3) Chemical Room - All PVC conduit, no GFI receptacles, lighting fixture is fluorescent type surface mounted totally enclosed.

   (4) Pump Room - Raceway installed is a mixture of PVC, LFMC and Metallic all in fair to good condition, no GFI receptacles, lighting fixtures are socket type. Metallic boxes are corroded

b. Recommendation:
   (1) Provide GFI receptacles with in-use covers
   (2) Provide LED A19 socket lamps in place of existing incandescent lamps.
   (3) Replace existing fluorescent fixture with LED equivalent.
   (4) Replace all corroded metallic boxes.

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 29, 2021

WELL NO.: 11
LOCATION: Crossgates
DESIGN: 475 gpm @ 425'TDH new pump 2004
PRODUCES, gpm: 458 (per 2019 well report). 408 gpm @ 54 Hz observed
ELECTRIC: 480v/3PH, 75HP. Cutler Hammer VFD
YEAR DRILLED: 1965
CONSTRUCTION:
CHEMICAL ROOM: Brick & Block
CHEMICAL(S) FED: Sodium Hypochlorite 13%

TYPE: Deep, Confined
AQUIFER: Piney Point
DEPTH, ft.: 443
PUMP ROOM: Stick Frame w/ vinyl siding (Detachable)

A. ASSESSMENT

1. AREA FENCING: Yes

2. EXTERIOR CONDITION: good.

3. PUMP FACILITY:

   a. Pump Status: Operating
   b. Pump Layout: Submersible turbine pump with a tilting disc check valve, blow-off piping, air release valve with remote magnetic flow meter. All electrical and control panels are located in an adjacent room.

      (1) Observation: The original vertical turbine pump has been replaced with a submersible turbine pump in 2019. Exterior door and trim need painting.

      (2) Recommendation: Clean and paint door trim and replace metal door with corrosion resistant fiberglass door.

   c. Heating/Ventilation:
      (1) Observation: Existing roof mounted exhaust fan in the pump side of the building. An exterior wall mounted dome exhaust fan and air conditioner in the electrical and control side of the building.

      (2) Recommendation: None.

4. INSTRUMENTATION/CONTROLS: Siemens magnetic flowmeter and chlorine residual analyzer. The 900MHz serial licensed radio MDS 9710 is obsolete from Manufacturer as of 12/15/12. It is used to communicate facility

status include alarms and control. The City is in the process of having it replace with new MDS SD9 radio which are backward compatible with the 9710.

5. CHEMICAL FACILITY:
   a. System Layout: System Layout: 15-gallon Sodium hypochlorite drums with Pentair transfer pump to fill a day tank (55-gal. drum) and a LMI metering feed pump.

      (1) Observation: Open chemical drums vent vapors/fumes into the room. Interior wall need painting. Corrosion on bottom of exterior door.

      (2) Recommendation:
         (a) Use drum-bung fitting to seal day tank opening spaces and run vent to the outside in accordance with RSWW (Recommended Standards for Water Works 2018) Sections 5.1, paragraph 5.1.11.b.
         (b) Clean and paint inside walls. Replace metal door with corrosion resistant fiberglass door.

   b. Heating/Ventilation
      (1) Observation: The chemical room has a light switch-controlled exhaust fan with supply louver for negative pressure ventilation. Corrosion on fan box.
      (2) Recommendation: Replace fan with new fan that have corrosion resistance coating.

6. ELECTRICAL:
   a. Observations:
      (1) Two services provide power at 480V, 3 phase, and 240/120V, single phase.
          Meter # single phase 59 296 526 Itron
          Meter # three phase 40 171 802 Itron
      (2) Well pump is 75 Hp, 480V, 3 phase, VFD Controlled.
      (3) Chemical Room - All PVC conduit, no GFI receptacles, lighting fixture is fluorescent type surface mounted totally enclosed. Some metallic cover plates and screws installed are showing signs of corrosion
      (4) Pump Room and Panel Area - Raceway installed is a mixture of PVC, LFMC and Metallic all in fair condition, no GFI receptacles, lighting fixtures are socket type. Power panel provides 120/240-volt power, with a 100-amp main breaker and 20 Spaces. Existing Pump VFD is an Eaton SVX 9000 and is in good condition. LFMC connection from wire box to pump is broken at pump connector.
      (5) Electrical equipment is in good condition.

   b. Recommendation:
      (1) Provide ground fault receptacles in place of existing receptacles.
      (2) Provide LED A19 socket lamps in place of existing incandescent lamps.
      (3) Replace existing fluorescent fixture with LED equivalent.
      (4) Provide and or replace all receptacle covers with in-use type
      (5) Replace LFMC at pump connector box

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 29, 2021

WELL NO.: 12R
LOCATION: Schutte Park
DESIGN: 600 gpm @ 417'TDH new pump house 2013
PRODUCES, gpm: 600 (per 2013 well report). 490 gpm @ 55 Hz observed
ELECTRIC: 480v/3PH, 100HP. VFD Schneider Altivar 61
YEAR DRILLED: 2013
CONSTRUCTION:
CHEMICAL FACILITY: Brick and Block

TYPE: Deep, Confined
AQUIFER: Piney Point
DEPTH, ft.: 410
PUMP FACILITY: Brick and Block with exterior well head

CHEMICAL(S) FED: Sodium Hypochlorite 13%

A. ASSESSMENT

1. AREA FENCING: Yes

2. EXTERIOR CONDITION: Good, new building.

3. PUMP FACILITY:
   a. Pump Status: operating
   b. Pump Layout: Submersible pump with check valve, magnetic flow meter, blow-off piping, surge relief valve, pressure gauge, flow switch, air/vacuum valve, and check valve.
      (1) Observation: Facility newly constructed in 2013 at this new location replaced the old well No.12. This facility included a standby Kohler generator with belly fuel tank.
      (2) Recommendation: none
   c. Heating/Ventilation:
      (1) Observation: exterior wall mounted dome fan and a wall mounted air conditioner.
      (2) Recommendation: none.

4. INSTRUMENTATION/CONTROLS: New Siemen SCADA system with Intra-Link 013000 communication.

5. CHEMICAL FACILITY:
   a. System Layout: 15-gallon Sodium hypochlorite drums with Pentair transfer pump to fill a day tank and a LMI metering feed pump.

(1) Observation: Open chemical drums vent vapors/fumes into the room.
(2) Recommendation:
Use drum-bung fitting to seal day tank opening spaces and run vent to the outside in accordance with RSWW (Recommended Standards for Water Works 2018) Sections 5.1, paragraph 5.1.11.b.

b. Heating/Ventilation
(1) Observation: Wall mounted fan and a wall mounted air conditioner.
(2) Recommendation: none

6. ELECTRICAL:
a. Observations:
(1) Service power at 480/277V, 3 phase, 4 wire
Meter # three phase 40 495 623 Itron
(2) Well house provided with 150KW diesel backup power generator with Transfer switch
(2) Well pump is 100 Hp, 480V, 3 phase, VFD Controlled.
(3) Chemical Room - All PVC conduit, GFI receptacles, NON-GFCI receptacles, lighting fixture is fluorescent type surface mounted totally enclosed.
(4) Pump Room and Panel Area - Raceway installed is a mixture of PVC, FMC, LFMC and Metallic all in Excellent condition, some Non GFI receptacles, lighting fixtures are fluorescent type surface mounted totally enclosed. Power panels provides 480/277v and 208/120v power Via a 30 Kva transformer, with a 100-amp main breaker and 30 Spaces. Pump VFD is a Square-D type Altivar 61 and is in excellent condition.
(5) Electrical equipment is in excellent condition.
(6) LFMC installed through a metal vent
(7) Exterior fixture wall Pack HPS

b. Recommendation:
(1) Provide ground fault receptacles in place of existing non-GFCI receptacles.
(2) Replace existing fluorescent fixture with LED equivalent.
(3) Provide and or replace all receptacle covers with in-use type
(4) Provide conduit sleeve to protect LFMC installed thru metal vent
(5) Replace exterior wall pack with LED equivalent

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 29, 2021

WELL NO.: 13R
LOCATION: Bayard Ave
DESIGN: 350 gpm @ 270'TDH new pump 2009
PRODUCES, gpm: 331 (per 2014 well report)
ELECTRIC: 480v/3PH, 30HP. Cutler Hammer VFD
YEAR DRILLED: 2000
CONSTRUCTION:
CHEMICAL FACILITY: Split-face block

TYPE: Deep, Confined
AQUIFER: Cheswold

DEPTH, ft.: 238

PUMP FACILITY: None, exposed outside wellhead

CHEMICAL(S) FED: Sodium Hypochlorite 13%, Hydrofluosilicic Acid 23%

A. ASSESSMENT

1. AREA FENCING: Yes

2. EXTERIOR CONDITION: Very good.

3. PUMP FACILITY:

   a. Pump Status: Off
   b. Pump Layout: Submersible sump with pitless adapter, blow-off, pressure gauge, flow switch, air release valve, check valve and magnetic flow meter.
      (1) Observation: Corrosion on both doors.
      (2) Recommendation: Replace metal door with corrosion resistance fiberglass doors.

   c. Heating/Ventilation:
      (1) Observation: Exterior wall mounted dome supply fan with wall mounted gravity damper/louver for exhaust.
      (2) Recommendation: None.

4. INSTRUMENTATION/CONTROLS: Siemens magnetic flowmeter and chlorine residual analyzer. The control and communication system is located inside the abandoned Well House No. 5. The 900MHz serial licensed radio MDS 9710 is obsolete from Manufacturer as of 12/15/12. It is used to communicate facility status include alarms and control. The City is in the process of having it replace with new MDS SD9 radio which are backward compatible with the 9710.

5. CHEMICAL FACILITY:
   a. System Layout: 15-gallon Sodium hypochlorite drums with Pentair transfer pump to fill a day tank and LMI metering feed pump. 15-gallon hydrofluosilicic acid (fluoride) drums fed neat with a LMI metering feed pump. Electronic scale is no longer used. The State no longer require report on chemical usages.

(1) Observation: Open chemical drums vent vapors/fumes into the room. Walls need painting. Corrosion on bottom of door.
(2) Recommendation:
    (a) Use drum-bung fitting to seal day tank opening spaces and run vent to the outside in accordance with RSWW (Recommended Standards for Water Works 2018) Sections 5.1, paragraph 5.1.11.b.
    (b) Replace metal door with corrosion resistance fiberglass door.
    (c) Paint interior wall.

b. Heating/Ventilation
(1) Observation: The chemical room is positively pressurized via supply fan and with a wall mounted gravity damper/louver for exhaust.
(2) Recommendation: None. The current system is City's preferred layout.

6. ELECTRICAL:
a. Observations:
(1) Service at 480V, 3 phase.
Meter # three phase 51 955 277 Itron
(2) Well pump is 30 Hp, 480V, 3 phase, VFD Controlled with remote Non Metallic Nema 4X disconnect switch at pump head.
(3) Chemical Room - All PVC conduit, no GFI receptacles, lighting fixture is fluorescent type surface mounted totally enclosed missing cover.
(4) Pump Room and Panel Area - Raceway installed is a mixture of PVC, LFMC and Metallic all in good condition, no GFI receptacles, lighting fixture is fluorescent type surface mounted totally enclosed. 208/120-volt power provided by a Square D mini zone panel, Catalog #MPZ15T2F with a 40AMB on the 480V side and a 3 pole 60A secondary main breaker, 6- 1 pole, 20 A, 2- 2 pole 20A, and 2- 1 pole spaces. Existing Pump VFD is an Eaton SVX 9000 and is in good condition
(5) Electrical equipment is in good condition.
(6) Panel Area where VFD is located is not conditioned.

b. Recommendation:
(1) Provide ground fault receptacles in place of existing receptacles.
(2) Replace existing fluorescent fixture with LED equivalent.
(4) Provide and or replace all receptacle covers with in-use type
(5) Evaluate environmental conditions in the space for Proper VFD operations. Existing Enclosure is NEMA type 1 with no filters. Due to the space conditions consider adding filters to the intakes to prevent dust and debris from entering the enclosure.

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 29, 2021

WELL NO.: 14
LOCATION: Danner Farm
DESIGN: 265 gpm new pump 1999
PRODUCES, gpm: 79.5 (per 2011 well report). 118 gpm observed.
ELECTRIC: 230v/3PH, 15HP. NEMA 2 Starter
YEAR DRILLED: 1964
CONSTRUCTION:
CHEMICAL FACILITY: Brick & Block
CHEMICAL(S) FED: Sodium Hypochlorite 13%, Hydrofluosilicic Acid 23%

TYPE: Deep, Confined
AQUIFER: Cheswold
DEPTH, ft.: 218
PUMP FACILITY: Stick Frame w/ wood siding (Detachable)

A. ASSESSMENT

1. AREA FENCING: Yes

2. EXTERIOR CONDITION: Building exterior trims need painting.

3. PUMP FACILITY:
   a. Pump Status: Operating
   b. Pump Layout: Submersible pump with blow-off piping, pressure gauge, flow switch, air release valve, check valve & magnetic flow meter.
      (1) Observation: Pressure gauge reading @ 50psi. Wall need painting.
      (2) Recommendation: Paint walls.
   c. Heating/Ventilation:
      (1) Observation: Air conditioner
      (2) Recommendation: none.

4. INSTRUMENTATION/CONTROLS: Siemens magnetic flowmeter and chlorine residual analyzer. The 900MHz serial licensed radio MDS 9710 is obsolete from Manufacturer as of 12/15/12. It is used to communicate facility status include alarms and control. The City is in the process of having it replace with new MDS SD9 radio which are backward compatible with the 9710.

5. CHEMICAL FACILITY:
   a. System Layout: 15-gallon Sodium hypochlorite drums with Pentair transfer pump to fill a day tank and LMI metering feed pump. 15-gallon hydrofluosilicic acid (fluoride) drums fed neat with a LMI metering feed pump. Electronic scale is no longer used. The State no longer require report on chemical usages.

      (1) Observation: Open chemical drums vent vapors/fumes into the room.

(2) Recommendation:
   (a) Use drum-bung fitting to seal day tank opening spaces and run vent to the outside in accordance with RSWW (Recommended Standards for Water Works 2018) Sections 5.1, paragraph 5.1.11.b.

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b. Heating/Ventilation
   (1) Observation: The chemical room is positively pressurized via a side wall mounted roof type supply fan.
   (2) Recommendation: None. The current system is City's preferred layout.

6. ELECTRICAL:
a. Observation:
   (1) Three services feed the Well House
      a. (1) 480v 3 phase feeding 150HP pump in well House #10 pump room
         i. Meter # 40 171 932 Itron
      b. (2) 240v 3 phase service feeding 15 HP pump in pump rm
         i. Meter # 40 168 354
      c. (3) 240/120v single phase service feeding 100 amp load center
         i. Meter # 57 907 097
   (2) Well pump is 15 HP, 240v 3 phase, with FVNR size 2 starter
   (3) The VDF installed for the 150 HP pump in well house #10 is a Square-D model 58M which is out of production and is at or approaching end of life.
   (4) Chemical Room - All PVC conduit, no GFI receptacles, lighting fixture is fluorescent type surface mounted totally enclosed.
   (5) Pump/equipment Rooms - Raceway installed is a mixture of PVC, LFMC or Metallic all in fair to good condition, no GFI receptacles, lighting fixtures are socket type.
   (6) All equipment was found to be in fair to good condition

b. Recommendation:
   (1) Provide GFI receptacles with in-use covers
   (2) Provide LED A19 socket lamps in place of existing incandescent lamps.
   (3) Replace existing fluorescent fixture with LED equivalent.
   (4) Replace existing VFD with newer model.

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 29, 2021

WELL NO.: 15
LOCATION: Dover Street Park
DESIGN: 500 gpm @ 300'TDH new pump 2009
PRODUCES, gpm: 280 (per 2019 well report). 141 observed @ 50 hz
ELECTRIC: 480v/3PH, 50HP. Cutler Hammer VFD
YEAR DRILLED: N/A
CONSTRUCTION:
CHEMICAL FACILITY: Split-face block

TYPE: Deep, Confined
AQUIFER: Cheswold
DEPTH, ft.: 255
PUMP FACILITY: FRP box enclose the exterior wellhead

CHEMICAL(S) FED: Sodium Hypochlorite 13%, Hydrofluosilicic Acid 23%

A. ASSESSMENT

1. AREA FENCING: None

2. EXTERIOR CONDITION: Good

3. PUMP FACILITY:

   a. Pump Status: Operating
   b. Pump Layout: Submersible pump with pitless adapter, air/vacuum valve, blow-off piping, pressure gauge, flow switch, air release valve, check valve and magnetic flow meter.
      (1) Observation: Chemical room wall need painting.
      (2) Recommendation: Paint chemical room walls as needed. Replace replace metal door with corrosion resistance fiberglass door.
   c. Heating/Ventilation:
      (1) Observation: Wall mounted dome exhaust fan.
      (2) Recommendation: None.

4. INSTRUMENTATION/CONTROLS: Siemens magnetic flowmeter and chlorine residual analyzer. The 900MHz serial licensed radio MDS 9710 is obsolete from Manufacturer as of 12/15/12. It is used to communicate facility status include alarms and control. The City is in the process of having it replace with new MDS SD9 radio which are backward compatible with the 9710.

5. CHEMICAL FACILITY:
   a. System Layout: 15-gallon Sodium hypochlorite drums with Pentair transfer pump to fill a day tank and LMI metering feed pump. 15-gallon hydrofluosilicic acid (fluoride) drums fed neat with a LMI metering feed pump. Electronic scale is no longer used. The State no longer require report on chemical usages.

      (1) Observation: Open chemical drums vent vapors/fumes into the room.

(2) Recommendation:
  (a) Use drum-bung fitting to seal day tank opening spaces and run vent to the outside in accordance with RSWW (Recommended Standards for Water Works 2018) Sections 5.1, paragraph 5.1.11.b.
  (b) Replace metal door with corrosion resistance fiberglass door.

b. Heating/Ventilation
  (1) Observation: Observation: The chemical room is positively pressurized via supply fan and a gravity damper for exhaust.
  (2) Recommendation: None. The current system is City's preferred layout.

6. ELECTRICAL:
  a. Observations:
    (1) Service at 480V, 3 phase.
    Meter # three phase 51 955 277 Itron
    (2) Well pump is 30 Hp, 480V, 3 phase, VFD Controlled with remote Non Metallic Nema 4X disconnect switch at pump head.
    (3) Chemical Room - All PVC conduit, no GFI receptacles, lighting fixture is fluorescent type surface mounted totally enclosed missing cover.
    (4) Pump Room and Panel Area - Raceway installed is a mixture of PVC, LFMC and Metallic all in good condition, no GFI receptacles, lighting fixture is fluorescent type surface mounted totally enclosed. 208/120-volt power provided by a Square D mini zone panel, Catalog #MPZ15T2F with a 40AMB on the 480V side and a 3 pole 60A secondary main breaker, 6- 1 pole, 20 A, 2- 2 pole 20A, and 2- 1 pole spaces. Existing Pump VFD is an Eaton SVX 9000 and is in good condition
    (5) Electrical equipment is in good condition.
    (6) Panel Area where VFD is located is not conditioned.

  b. Recommendation:
    (1) Provide ground fault receptacles in place of existing receptacles.
    (2) Replace existing fluorescent fixture with LED equivalent.
    (4) Provide and or replace all receptacle covers with in-use type
    (4) Evaluate environmental conditions in the space for Proper VFD operations. Existing Enclosure is NEMA type 1 with no filters. Due to the space conditions consider adding filters to the intakes to prevent dust and debris from entering the enclosure.

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 30, 2021

WELL NO.: PW1A
LOCATION: Chandelle
PRODUCES, gpm: 500
ELECTRIC: 480v/3PH, 15HP
YEAR DRILLED: 1991
CONSTRUCTION:

TYPE: Shallow, Unconfined
AQUIFER: Columbia
DEPTH, ft.: 70

PUMP FACILITY: Below grade Precast Valve Vault

CHEMICAL(S) FED: None locally, all treatment is at the Water Treatment Plant

A. ASSESSMENT

1. AREA FENCING: None

2. EXTERIOR CONDITION: Remote

3. PUMP FACILITY:

a. Pump Status: Off
b. Pump Layout: Submersible pump located within the precast vault with access hatches, automatic throttling/ pump check service valve controlled via maintaining the aquifer level, magnetic flow meter, pressure gauge, and air/vacuum valve. All electrical panels are located inside the vault. The control panels are located at grade.

(1) Observation: Inside valve vault was very muddy, problem with occasional flooding. The vault utilizes two small sump pumps to keep dry and a high-level float for alarm. Some area of piping need painting. No ladder safety grab-bar for easier/safer access.

(2) Recommendation: To keep the vault drier to avoid potential electrocution, suggest replacing the polypropylene float type sump pump level control with a more sensitive level switch to start/stop the sump pump at a lower sump water level and possibly replace the small sump pumps with large capacity pumps. Paint piping. and install a ladder safety grab-bar.

c. Heating/Ventilation:
(1) Observation: new unit heater
(2) Recommendation: None.

4. INSTRUMENTATION/CONTROLS: The City have a program under way to replace the throttling/ pump check service valve with regular swing check valve and use VFD to remotely control the pumping capacity. The current control and radio communication are Control Systems Interalink 01300 with MDS Transnet 900.

5. SAFETY:

In general, the precast valve vault would be categorized as a confined space, therefore; all entries into the vault should be in accordance with the City of Dover's confined space entry program. Also, wet floor should be avoided for potential electrocution.

6. ELECTRICAL:
   a. Observations:
      (1) Service at 480V, 3 phase, 200 amp
          Meter # three phase 46 494 363 Itron
      (2) Well pump is 15 Hp, 480V, 3 phase, Pump Control panel with size 2 FVNR starter. Well pump controller was deenergized at the time of the inspection
      (3) Well Pit - Raceway installed is a mixture of PVC, LFMC and Metallic mostly in good condition except all Metallic conduits, supports and fittings are showing corrosion, some receptacles installed are not GFCI, lighting fixture is fluorescent type surface mounted totally enclosed. Power panel 480V- 225 amp MLO- 3 pH, 5 KVA 480//240/120v enclosed Transformer, 240/120v, 12 space single phase load center 125A MLO
      (4) Electrical equipment is in fair to poor condition.

   b. Recommendation:
      (1) Provide ground fault receptacles in place of existing receptacles.
      (2) Replace existing fluorescent fixture with LED equivalent.
      (3) Provide and or replace all receptacle covers with in-use type
      (4) Replace all electrical equipment and relocate to above ground in NEMA 3R Enclosure(s).
      (5) Replace all metallic raceway, supports, fittings and boxes with PVC in well pit.

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 30, 2021

WELL NO.: PW2A
LOCATION: Long Point
PRODUCES, gpm: 500. 443 gpm @ 31 psi observed
ELECTRIC: 480v/3PH, 15HP
YEAR DRILLED: 1985
CONSTRUCTION:

TYPE: Shallow, Unconfined
AQUIFER: Columbia
DEPTH, ft.: 70

PUMP FACILITY: Below grade Precast Valve Vault

CHEMICAL(S) FED: None locally, all treatment is at the Water Treatment Plant

A. ASSESSMENT

1. AREA FENCING: None

2. EXTERIOR CONDITION: Good

3. PUMP FACILITY:

a. Pump Status: on
b. Pump Layout: Submersible pump located within the precast vault with access hatches, automatic throttling/ pump check service valve controlled via maintaining the aquifer level, magnetic flow meter, pressure gauge, and air/vacuum valve. Free standing electrical and control panels at grade due to flood plain location.

(1) Observation: Inside valve vault was very muddy, problem with occasional flooding. The vault utilizes two small sump pumps to keep dry and a high-level float for alarm. Some area of piping need painting. No ladder safety grab-bar for easier/safer access.

(2) Recommendation: To keep the vault drier to avoid potential electrocution, suggest replacing the polypropylene float type sump pump level control with a more sensitive level switch to start/stop the sump pump at a lower sump water level and possibly replace the small sump pumps with large capacity pumps. Paint piping. and install a ladder safety grab-bar.

c. Heating/Ventilation:
(1) Observation: unit heater
(2) Recommendation: None.

4. INSTRUMENTATION/CONTROLS: The City have a program under way to replace the throttling/ pump check service valve with regular swing check valve and use VFD to remotely control the pumping capacity. The current control and radio communication are Control Systems Interalink 01300 with MDS Transnet 900.

5. SAFETY:
   In general, the precast valve vault would be categorized as a confined space, therefore; all entries into the vault should be in accordance with the City of Dover's confined space entry program. Also, wet floor should be avoided for potential electrocution.

6. ELECTRICAL:
   a. Observations:
      (1) Service at 480V, 3 phase, 200 amp
          Meter # three phase 46 494 373 Itron
      (2) Well pump is 15 Hp, 480V, 3 phase, Pump Control panel with size 2 FVNR starter in NEMA 4x Non Metallic enclosure.
      (3) Surface NEMA 3R Cabinet - Raceway installed is a mixture of PVC, LFMC and Metallic mostly in good condition except all Metallic conduits, supports and fittings are showing corrosion. Metallic wireway has open knockouts on the top and some signs of corrosion. Power panel 480V- 225 amp MLO- 3 pH, 5 KVA 480//240/120v enclosed Transformer, 240/120v, 12 space single phase load center 125A MLO all showing signs of mild corrosion. lighting fixture is fluorescent type surface mounted with exposed lamps
      (4) Well Pit - Raceway installed is a mixture of PVC, LFMC and Metallic mostly in good condition except all Metallic conduits, supports and fittings are showing corrosion, Receptacles installed are GFCI, lighting fixture is fluorescent type surface mounted totally enclosed.
      (4) Electrical equipment is in fair to good condition.

   b. Recommendation:

      (1) Replace existing fluorescent fixtures with enclosed LED equivalent.
      (2) Replace fixture in surface cabinet for safety issue if lamps are struck, they may shatter causing injury. At a minimum provide protective sleeve for each exposed fluorescent lamps
      (3) Provide and or replace all receptacle covers with in-use type
      (4) Replace all metallic raceway, supports, fittings and boxes with PVC in well pit.
      (5) Provide hole plugs for all unused knockouts in wireway

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 30, 2021

WELL NO.: PW4B
LOCATION: Slaughter
PRODUCES, gpm: 400
ELECTRIC: 240/120v, Single Phase, 15 HP
YEAR DRILLED: 1991
CONSTRUCTION:

TYPE: Shallow, Unconfined
AQUIFER: Columbia
DEPTH, ft.: 70

PUMP FACILITY: Brick & Block Well House with Roof Hatch

CHEMICAL(S) FED: None locally, all treatment is at the Water Treatment Plant

A. ASSESSMENT

1. AREA FENCING: Yes

2. EXTERIOR CONDITION: good

3. PUMP FACILITY:

   a. Pump Status: Off
   b. Pump Layout: Submersible pump located inside the well house with roof hatch, automatic throttling/ pump check service valve controlled via maintaining the aquifer level, magnetic flow meter, pressure gauge, and air/vacuum valve. All electrical panels are also located inside the well house.

      (1) Observation: The well house is well maintained, and all of the equipment is in good working condition. Interior walls and piping need painting.

      (2) Recommendation: Paint interior walls and piping.

   c. Heating/Ventilation:
      (1) Observation: Roof mounted exhaust fan with wall mounted supply louver, and thermostat control. There is also a unit heater for freeze protection. The supply louver needs bird screen to keep out birds and small mammals.
      (2) Recommendation: Install corrosion resistance bird screen to the louver to keep out birds and small mammals.

4. INSTRUMENTATION/CONTROLS: The City have a program under way to replace the throttling/ pump check service valve with regular swing check valve and use VFD to remotely control the pumping capacity. The current control and radio communication are Control Systems Interalink 01300 with MDS Transnet 900.

5. SAFETY:
   No safety issues.

6. ELECTRICAL:
   a. Observations:
      (1) Utility Meter #Unknown
      (2) Service 240/120v 3 phase, 3 wire
      (3) Well pump is 15 Hp, 240V, single phase, 72 FLA with size 3 FVNR starter.
      (4) Well House - Raceway installed is a mixture of PVC or Metallic all in good condition, not all receptacles are GFCI, lighting fixture surface mounted enclosed fluorescent. Power panel provides 120/240-volt power, with a 225-amp main breaker and 200 amp sub feed breaker to pump controller and 30 Spaces.
      (5) Electrical equipment is in good condition.

   b. Recommendation:
      (1) Replace existing non GFCI receptacles with GFCI type and provide in-use covers on all devices
      (2) Replace existing fluorescent fixtures with LED equivalent.

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 30, 2021

WELL NO.: PW5A
LOCATION: Tarburton
PRODUCES, gpm: 365 gpm @ 3 psi observed.
ELECTRIC: 240/120v, Single Phase, 15 HP
YEAR DRILLED: 1991
CONSTRUCTION:

TYPE: Shallow, Unconfined
AQUIFER: Columbia
DEPTH, ft.: 70

PUMP FACILITY: Below grade Precast Valve Vault

CHEMICAL(S) FED: None locally, all treatment is at the Water Treatment Plant

A. ASSESSMENT

1. AREA FENCING: None

2. EXTERIOR CONDITION: good

3. PUMP FACILITY:

   a. Pump Status: On
   b. Pump Layout: Submersible pump located within the precast vault with access hatches, automatic throttling/ pump check service valve controlled via maintaining the aquifer level, magnetic flow meter, pressure gauge, and air/vacuum valve. All electrical panels are also located inside the vault. The control panels are located at grade.

      (1) Observation: The vault utilizes a small sump pump to keep dry and a high-level float for alarm. Some area of the floor is wet. All control panels have been recently moved out of the vault. Some area of piping need painting. Perimeter French drain system recently installed to improve the area drainage.

      (2) Recommendation: To keep the vault drier to avoid potential electrocution, suggest replacing the polypropylene float type sump pump level control with a more sensitive level switch to start/stop the sump pump at a lower sump water level. Paint piping.

   c. Heating/Ventilation:
      (1) Observation: Unit heater
      (2) Recommendation: None.

4. INSTRUMENTATION/CONTROLS: The City have a program under way to replace the throttling/ pump check service valve with regular swing check valve and use VFD to remotely control the pumping capacity. The current control and radio communication are Control Systems Interalink 01300 with MDS Transnet 900.

5. SAFETY:
   In general, the precast valve vault would be categorized as a confined space, therefore; all entries into the vault should be in accordance with the City of Dover's confined space entry program. Also, wet floor should be avoided for potential electrocution.

6. ELECTRICAL:
   a. Observations:
      (1) Utility Meter #40 168 638
      (2) Service 240/120v 3 phase, 3 wire
      (3) Well pump is 15 Hp, 240V, single phase, 72 FLA with size 3 FVNR starter. Showing signs of corrosion
      (4) Well Vault - Raceway installed is a mixture of PVC or Metallic all in Fair condition, all receptacles are not GFCI, lighting fixture surface mounted enclosed fluorescent. Power panel provides 120/240-volt power, with a 225-amp main breaker and 200-amp sub feed breaker to pump controller and 30 Spaces.
      (5) Electrical equipment is in fair to poor condition.

   b. Recommendation:
      (1) Replace existing receptacles with GFCI type and provide in-use covers on all devices
      (2) Replace existing fluorescent fixtures with LED equivalent.
      (3) Suggest relocating the electrical equipment to above grade NEMA 3R Cabinet

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 30, 2021

WELL NO.: PW6A
LOCATION: Tilcon
PRODUCES: 368 gpm @ 5 psi observed
ELECTRIC: 240/120v, Single Phase, 15 HP
YEAR DRILLED: 1991
CONSTRUCTION:

TYPE: Shallow, Unconfined
AQUIFER: Columbia
DEPTH, ft.: 70'

PUMP FACILITY: Below grade Precast Valve Vault

CHEMICAL(S) FED: None locally, all treatment is at the Water Treatment Plant

A. ASSESSMENT

1. AREA FENCING: None

2. EXTERIOR CONDITION: Good

3. PUMP FACILITY:

a. Pump Status: On
b. Pump Layout: Submersible pump located within the precast vault with access hatches, automatic throttling/ pump check service valve controlled via maintaining the aquifer level, magnetic flow meter, pressure gauge, and air/vacuum valve. All electrical and control panels are at grade.

(1) Observation: The vault utilizes a small and a large capacity sump pumps to keep dry and a high-level float for alarm. Some area of the floor is wet. All electrical and control panels have been recently moved out of the vault. Some area of piping need painting.

(2) Recommendation: To keep the vault drier to avoid potential electrocution, suggest replacing the polypropylene float type sump pump level control with a more sensitive level switch to start/stop the sump pump at a lower sump water level. Paint piping.

c. Heating/Ventilation:
(1) Observation: New unit heater
(2) Recommendation: None.

4. INSTRUMENTATION/CONTROLS: The City have a program under way to replace the throttling/ pump check service valve with regular swing check valve and use VFD to remotely control the pumping capacity. The current control and radio communication are Control Systems Interalink 01300 with MDS Transnet 900.

5. SAFETY:
   In general, the precast valve vault would be categorized as a confined space, therefore; all entries into the vault should be in accordance with the City of Dover's confined space entry program. Also, wet floor should be avoided for potential electrocution.

6. ELECTRICAL:
   a. Observations:
      (1) Utility Meter #52 184 442
      (2) Service 240/120v 3 phase, 3 wire
      (3) Well pump is 15 Hp, 240V, single phase, 72 FLA with size 3 FVNR starter. In surfaceNema 3R enclosure
      (4) Surface NEMA 3R power panel provides 120/240-volt power, with a 225-amp main breaker and 200-amp sub feed breaker to pump controller and 30 Spaces.
      (4) Well Vault - Raceway installed is a mixture of PVC or Metallic all in Fair condition, all receptacles are not GFCI, lighting fixture surface mounted enclosed fluorescent.
      (5) Electrical equipment is in good condition.

   b. Recommendation:
      (1) Replace existing receptacles with GFCI type and provide in-use covers on all devices
      (2) Replace existing fluorescent fixtures with LED equivalent.
      (3) Replace all corroded boxes and conduit remaining in the well vault.

WELL FACILITIES INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 30, 2021

WELL NO.: PW8A
LOCATION: White Oak
PRODUCES, gpm: 300
ELECTRIC: 480v, 3PH, 10 HP
YEAR DRILLED: 1991
CONSTRUCTION:

TYPE: Shallow, Unconfined
AQUIFER: Columbia
DEPTH, ft.: 59

PUMP FACILITY: Brick & Block Well House with Roof Hatch

CHEMICAL(S) FED: None locally, all treatment is at the Water Treatment Plant

A. ASSESSMENT

1. AREA FENCING: None

2. EXTERIOR CONDITION: Good

3. PUMP FACILITY:

a. Pump Status: Off
b. Pump Layout: Submersible pump located inside the well house with roof hatch, automatic throttling/ pump check service valve controlled via maintaining the aquifer level, magnetic flow meter, pressure gauge, and air/vacuum valve. All electrical panels are also located inside the well house.

(1) Observation: The well house is well maintained, and all of the equipment is in good working condition. Door need painting.

(2) Recommendation: Paint door.

c. Heating/Ventilation:
(1) Observation: Ceiling mounted exhaust fan with wall mounted supply louver/damper, and thermostat control. There is also a unit heater for freeze protection
(2) Recommendation: None.

4. INSTRUMENTATION/CONTROLS: The City have a program under way to replace the throttling/ pump check service valve with regular swing check valve and use VFD to remotely control the pumping capacity. The current control and radio communication are Control Systems Interalink 01300 with MDS Transnet 900.

5. SAFETY:
   none.

6. ELECTRICAL:
   a. Observations:
      (1) Utility Meter #46 494 245
      (2) Service 480v 3 phase, 3 wire
      (3) Well pump is 10 Hp, 460v, 3 phase, with size 2 FVNR starter.
      (4) Well House - Raceway installed is a mixture of PVC, LFMC and Metallic all in good condition, not all receptacles are GFCI, lighting fixture surface mounted enclosed fluorescent.. Power panel 480V- 225 amp MLO- 3 pH, 5 KVA 480//240/120v enclosed Transformer, 240/120v, 12 space single phase load center 125A MLO
      (5) Electrical equipment is in good condition.

   b. Recommendation:
      (1) Replace existing non GFCI receptacles with GFCI type and provide in-use covers on all devices
      (2) Replace existing fluorescent fixtures with LED equivalent.

WATER TREATMENT PLANT INSPECTION

Project: Update to the City of Dover Water Master Plan RFP 21-0013WW

DATE OF INSPECTION: March 30, 2021

A walk-through inspection of the water treatment plant was made on this date. The purpose of the inspection was to identify the areas of the treatment plant that need improvements based on the established industrial standards and sound engineering practices. The following attendees were present at the inspection:

Kate Mills	City of Dover
John Sisson	City of Dover
Dave Chung	Whitman, Requardt and Associates
Scott Miles	Whitman, Requardt and Associates

A. OBSERVATIONS AND RECOMMENDATIONS

1. Treatment Process:

a. The original treatment plant design capacity was for 5 MGD. Currently the newly installed pressure filters are designed for 3 MGD total and the current permitted Columbia Aquifer Wells have a safe capacity yield of 3.1 MGD.

b. The original Ozone system has been completely removed and replaced with the new pressure filtration system to treat the iron and manganese in the water.

c. In order to optimize the performance of the new pressure filters, a new mixing tank has been added to the process to raise the raw water pH with lime prior to the existing intermediate pumps wet well. in addition, a new pre-chlorine feed has also been added to the intermediate pumps discharge prior to the pressure filters.

d. Downstream of the new pressure filters, the original five-60,000 gal. (100,000 lbs. total) carbon absorbers remain in service for taste and odor control.

e. A new 95,000 gallons Backwash tank with a 16,000 gallons residuals tank and a three bay Sand Drying Beds have been incorporated to handle the pressure filters backwash waste stream. The backwash supernatant is recycled back ahead of the pressure filters.

f. The original lime feed system has been modified to include a new pneumatic transfer system to feed additional lime to the new mix tank in order to raise the well water pH prior to the pressure filters.

g. The original FRP bulk sodium hypochlorite outside storage tank area has been enclosed and converted into a new sodium hypochlorite room to house and feed from 55-gallon drums.

h. The original abandoned stainless-steel bulk Aqua Ammonia outside storage tank area has also been converted into an outside storage room. The original system was never put in use, primary due to the use of Chloramines treatment for system residual was not recognized by the State at the time.

i. There are three-finished water pumps designed for two pumps to handle max plant capacity with third installed as a spare.

j. The abandoned polyphosphate feed/storage room has been modified into a fluoride feed and storage room. Hydrofluosilicic Acid is currently used for fluoride feed and is consists of two-metering pumps with one as a standby unit, feeding from the 150-gal. drums.

k. The onsite standby generator provides enough standby services for the laboratory and the office with the understanding during a power failure, if the wells do not have power, there would be no water to treat.

l. Only the laboratory and the office space are air conditioned.

2. RECOMMENDATIONS: The following list of recommendations are based on our observations:

a. The existing Ozone generator room is very hot with lack of sufficient ventilation to remove the heat generated by the electrical gear. It is recommended to convert/replace the existing supply fan SF-2 to an exhaust fan (keeping the ductwork in-place) and also to convert/replace exhaust fan EF-4&5 to supply fans. This will bring fresh air in down below and exhaust the hot air in the upper space out. It is also recommended to install window shades or window films to the huge glass wall to minimize the direct heat from the sun.

b. Install a tepid water emergency shower and eye wash station inside the sodium hypochlorite room for personnel safety.

c. The floor of the new backwash tank is flat, and the iron solids settle very quick. It is recommended to slope the tank bottom toward the residual pump suction to improve solids pick-up and to minimize pigeon-hole effects at the pump suction.

d. Currently, the labels on the plant influent (well water) analyzers (Fluoride, Chlorine, Turbidity, and pH) prior to the new mixing tank are labeled “Treated”. We believed this should read “Raw Water” instead. Whereas, the pH analyzer downstream of the mix tank should read “Treated” instead of “Raw Water” since lime has been added. Also, the analyzers (Turbidity, Chlorine and pH) ahead of the pressure filters should read “Treated” instead of “Raw Water”.

e. Add barbed wire to the existing fence for security. The existing double gate does not appear to have sufficient size to be functional. It is recommended to install an automatic key-card control sliding gate to control access. It is also recommended to install closed circuit video cameras located at the gate and at all doors exiting the building. Additional lighting may be needed at the main gate for nighttime surveillance.

3. ELECTRICAL RECOMMENDATIONS:

a. In general, it appears the majority of the electrical distribution equipment has been replaced recently and is in excellent condition. However, some equipment, devices, and fixtures remain that have now been in service for about 25 years and wear and tear has taken its toll.

b. Older exit signs and emergency lights with integral batteries need servicing or replacement to make them meet the NFPA codes to provide 90 minutes of power.

c. Recessed fluorescent fixtures in the Lobby, Office, Laboratory, Lunchroom Areas need to be replaced with LED equivalent fixtures. In addition, we recommend upgrading the lighting controls to meet current ASHRE 90.1 standards.

d. Replace any remaining incandescent A19 socket lamps with LED equivalent.

e. The duplex receptacles on the reagent shelf in the Laboratory within 6 ft of a sink are not of the ground fault interrupter type (GFI) they should be replaced with GFCI type to meet code requirements.

f. Flood lights at the front of the building and all exterior wall packs are HID and should be replaced with LED equivalent.

g. The pole mounted parking lot lighting fixture was on during day light hours. Replace failed local Photocell

h. The SO cords to instruments on the (5) GAC tanks needs to be replaced. Insulation is cracked and pulled loose at fittings and should be replaced with LFMC raceways. Other equipment, boxes and raceways are corroded and should be replace as needed.

i. All existing HID high and low bay lighting fixtures should be replaced with LED equivalent fixtures. The high bay lighting fixtures in the new electrical room should be provided with a lowering device to permit plant personnel to replace lamps or LED drives when needed.

j. A security fence with barb wire to control access should be provided along with closed circuit television cameras located at the gate and at all doors exiting the building. Additional lighting may be needed at the main gate for nighttime surveillance. A motorized gate with card access and a two-way Ai-phone video system with gate control should be provided to allow visitor access.

k. The Exterior Generator has had a shelter/shed built around it after installation. A generator with a standard weather tight enclosure is not designed with the intent to be put indoors. We would recommend a study be performed to insure that the combustion and ventilation air requirements are being met to avoid generator damage and possible future generator failures.

Appendix C
Tower Inspection Review

Review and Comments on Tank Inspection Reports for The City of Dover, Delaware

Performed by Corrosion Control Corp. (CCC) March, 2020

DOVER PARK

1,000,000 gal. Fluted Column Elevated (aka. "Hydropillar")

Year built: 1987

Year last painted: 2016 by CCC
Inside "wet"; Inside" dry"; outside

Inspection Report Recommendations:

- Repair: Cleaning and Painting
  - Inside – None
  - Outside - None
- Repair: Structural (metal) – None

Review Comments

1. Tank was repainted by CCC but details of specification for type of cleaning and specified coating systems were not provided. No information that a one year warranty inspection was performed.

2. Tank was not drained, only portions of inside roof was visible. Report states that all interior "wet" area is in good condition.

3. Report states there were small areas of grout breaking loose. It is not stated but I therefore assume it is the support grout underneath the column base plate. No photo provided. No repair is recommended at this time.

Review Recommendation

1. Photo of grout condition would have helped; any failure should be documented to show the extent. Minor repairs may halt further degradation.

2. No mention of conditions of vent, overflow, ladders, safety climb, security.

WALKER ROAD

1,000,000 gal. Fluted Column Elevated (aka. "Hydropillar")

Year built: 1987

Year last painted: 2014 by CCC
Inside "wet"; Inside" dry"; outside

Inspection Report Recommendations:

- Repair: Cleaning and Painting
  - Inside – None
  - Outside – Overcoat in 2 to 3 years
- Repair: Structural (metal) - None

Review Comments

1. Tank was repainted by CCC but details of specification for type of cleaning and specified coating systems were not provided. No information that a one year warranty inspection was performed.

2. Tank was not drained, only portions of inside roof was visible. Report states that all interior "wet" area is in sound condition except for minor rusting on edges of roof framing.

3. Report states there were small areas of grout breaking loose. It is not stated but I therefore assume it is the support grout underneath the column base plate. No photo provided. No repair is recommended at this time.

4. Report states that 55(sic) 55% ? of outside top coat is peeling from undercoat.

5. Report notes antennas mounted on roof and roof edge.

Review Recommendation

1. Photo on grout condition would have helped; any failure should be documented to show the extent. Minor repairs may halt further degradation.

2. The failure of the top coat estimated to be on 55% of the entire exterior seems like a lot to be let go for 2 to 3 years. If this is true I would think the City would not want this unsightly condition with the possibility of paint chips floating in the air. Could this be a typo error, the 5 and the % are on same key.

3. No mention of conditions of vent, overflow, ladders, safety climb, security.

4. No detailed information provided on the antennas of how they might affect the painting.

GARRISON OAK

1,500,000 gal Composite Elevated

Year built: 2016

Year last painted: 2016 new construction

Inspection Report Recommendations:

- Repair: Cleaning and Painting
  - Inside – None
  - Outside - None
- Repair: Structural (metal) - None

Review Comments

1. Report states there were small areas of grout breaking loose.

2. Tank was not drained, only portions of inside roof was visible. Report states that all interior “wet” area is in good condition except for minor rusting on edges of roof framing.

3. Report notes antennas mounted on roof and roof edge.

Review Recommendation

1. Photo of grout location and condition would have helped. Composite tanks do not have base plates and therefore are not grouted.

2. No mention of conditions of vent, overflow, ladders, safety climb, security.

3. No detailed information provided on the antennas and cables and how they might affect future painting.

McKEE ROAD

1,000,000 gal. Column Elevated

Year built: 1974

Year last painted: 2012 by CCC
Inside "wet"; Inside" dry"; outside

Inspection Report Recommendations:

- Repair: Cleaning and Painting
  - Inside – None
  - Outside – None
- Repair: Structural (metal) - None

Review Comments

1. Tank was repainted by CCC but details of specification for type of cleaning and specified coating systems were not provided. No information that a one year warranty inspection was performed.
2. Report states there is minor surface cracking of grout under column base plates
3. There is also minor surface cracking on column concrete piers
4. Valve pit has 1 to 2 inches of water on floor
5. Tank was not drained, only portions of inside roof was visible. Report states that all interior "wet" area is in sound condition except for minor rusting on edges of roof framing and lap seams.
6. Top portion of ladder was visible and showed spot rusting of rungs.
7. Outside coating exhibits chalking but judged to be in good condition.
8. Report notes there are three cell carriers on the tank; will create difficult repainting situation.

Review Recommendation

1. No photos to show concrete and grout cracking condition. No mention if hollow sounding test performed to indicate deterioration.
2. Valve pit was noted to have 1 to 2 inches of standing water on floor. Report states that no pipes/valves are leaking. No other possible source of leaking investigated.
3. Photos show bolted covers over roof antenna cables. No mention of the condition of roof coating under the covers. No suggestions offered on means to proceed with future painting.
4. No mention of conditions of vent, overflow, safety climb, security.

AEROPARK

250,000 gal. Column Elevated

Year built: Re-erected on site 1993

Year last painted: 2014 by CCC
Inside; Outside

Inspection Report Recommendations:

- Repair: Cleaning and Painting
  - Inside – None
  - Outside – None
- Repair: Structural (metal) - None

Review Comments

1. Tank was repainted by CCC but details of specification for type of cleaning and specified coating systems were not provided. No information that a one year warranty inspection was performed.
2. Report states inside coating is in sound condition with minor rusting on roof framing. Outside coating is judged to be still protecting the steel but do not recommend overcoating existing system in the future.
3. Tank does not have inside ladder.
4. Tank has cellular antennas on roof.

Review Recommendation

1. No recommendation given when tank should be scheduled for refurbishing and suggested coatings.
2. No recommendation for installing interior shell ladder for use in servicing tank.
3. No mention of conditions of vent, overflow, ladders, safety climb, security.
4. Tank was re-erected on current site in 1993. Is there information when tank was originally built?
5. No confirmation is noted that tank ladders, manholes and roof openings meet current OSHA standards.

BAYARD AVE.

250,000 gal. Column Elevated

Year built: 1955

Year last painted: 2011 by CCC
Inside "wet"; Inside" dry"; outside

Inspection Report Recommendations:

- Repair: Cleaning and Painting
  - Inside – None
  - Outside – None
- Repair: Structural (metal) - None

Review Comments

1. Tank was repainted by CCC but details of specification for type of cleaning and specified coating systems were not provided. No information that a one year warranty inspection was performed.
2. Prior repairs to the column concrete piers are failing.
3. Photo shows tank to have interior center overflow pipe without any top support rods to shell.
4. It is noted that the tank has an inside ladder but photo shows Tank has no interior ladder.
5. Tank was not drained, only portions of inside roof was visible. Report states that all interior "wet" area is in sound condition except for minor rusting on edges of roof framing.
6. Tank has significant number of cell carriers

Review Recommendations

1. Tank was repainted by CCC but details of specification for type of cleaning and specified coating systems were not provided. No information that a one year warranty inspection was performed.
2. No confirmation is noted that tank ladders, manholes and roof openings meet current OSHA standards.
3. No mention of conditions of vent, overflow, ladders, safety climb, security.
4. Report says that no structural repairs or painting are recommended at this time. It appears though that the condition of the piers should be reevaluated. Also, I have concerns about the integrity of the free standing overflow pipe inside the bowl.
5. The condition of the antenna and cable supports and the portion of roof plate were not fully described.

GENERAL FOODS

250,000 gal. Column Elevated

Year built: 1955

Year last painted: 2009 inside by CCC (overcoat)
2009 outside by CCC (overcoat)

Inspection Report Recommendations:

- Repair: Cleaning and Painting
  - Inside – 2 to 3 years
  - Outside – 2 to 3 years
- Repair: Structural (metal) - None

Review Comments

1. Tank was repainted by CCC but details of specification for type of cleaning and specified coating systems were not provided
2. Recommendation is to fully remove inside and outside coating systems.
3. Noted minor surface cracking on concrete column piers.
4. Significant number of cell phone carriers on the tank
5. Tank interior was not drained
6. The condition of the outside paint is judged to be poor on areas with scattered degree of spot rusting showing light to medium rusting to extreme metal loss on anchor bolts.
7. Inside paint was merely overcoated at last painting and is recommended for full removal and new system, description not noted in the report.

Review Recommendation

1. With the recommendation for refurbishing this tank, no analytical laboratory test report for lead and chromates from paint chips was performed and submitted with the inspection report.
2. In order to properly paint and repair this tank all cellular cables and equipment have to be removed by the cellular companies. Also, equipment shelters under or adjacent to the tank have to be protected from any possible damage during the surface preparation and painting phases. All cables and antennas must be moved to a temporary pole for the duration of all work. The City must inform the carriers well in advance.
3. No detailed description is supplied of the current conditions of vent, overflow, ladders, safety climb, and tank security.
4. Tank was built in 1955. No information supplied that during past refurbishing work that certain appurtenances i.e. tank ladders, manholes, roof openings platforms and handrails were brought up to current OSHA Standards.

Appendix D
Model Calibration

CITY OF DOVER, DE

UNIDIRECTIONAL FLOW TESTING PLAN

APRIL 2021

Equipment:

- Pitot Gauge / Flow Diffuser (1)
- 2.5” Hydrant Cap with Pressure Gauge (2)

UDF Procedure:

1. Notify customers of Fire Flow/Hydrant flushing
2. Start with Test #1. Close valve(s) indicated on map.
3. Install hydrant caps and pressure gauges on Residual Hydrant #1 and #2.
4. Open hydrants and bleed air from column.
5. Flush Flow Hydrant to remove sediment. Install pitot gauge / diffuser, and open hydrant fully.
6. Record flow at Flow hydrant, and pressures at Residual Hydrants once pressure and flow is stable.
7. Close all hydrants, remove equipment, open valve(s) closed in Step #2.
8. Proceed to next test.

CITY OF DOVER, DE
WATER SYSTEM MASTER PLAN

HYDRAULIC EVALUATION

Field Hydrant Testing

Test #: ______________________________ Personnel: ________________________________

Location: ____________________________ ________________________________

Date: ________________________________ ________________________________

Time: ________________________________ Hydrant Outlet Flowed: 2½" 4" (circle)

Main Size: __________________________ (in) Gauge ID:________________________________

Pre-Test Pressure: ________________ (psi)

Residual Pressure: ________________ (psi)

Hydrant Flow: ____________________ (gpm)

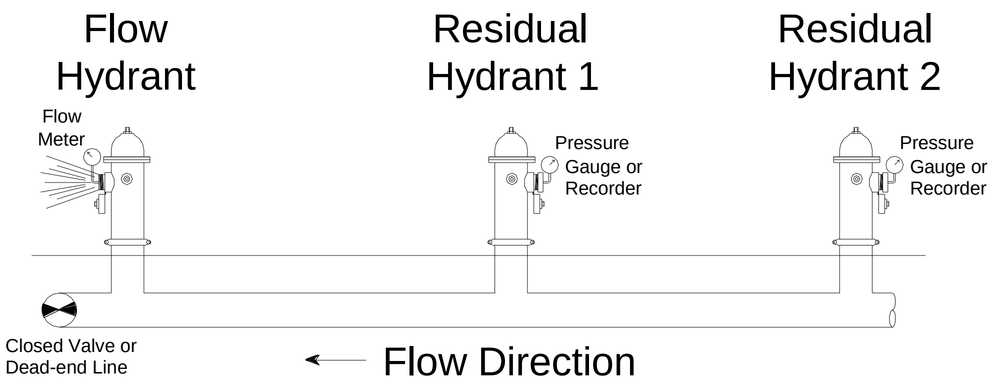
Duration of Flow: ________________ (min)

Comments:

____

____

____



Procedure:
1. Measure Pressure at flow hydrant prior to test.
2. Open hydrant, Notify other personnel.
3. Read flow meter when a steady flow rate is reached.

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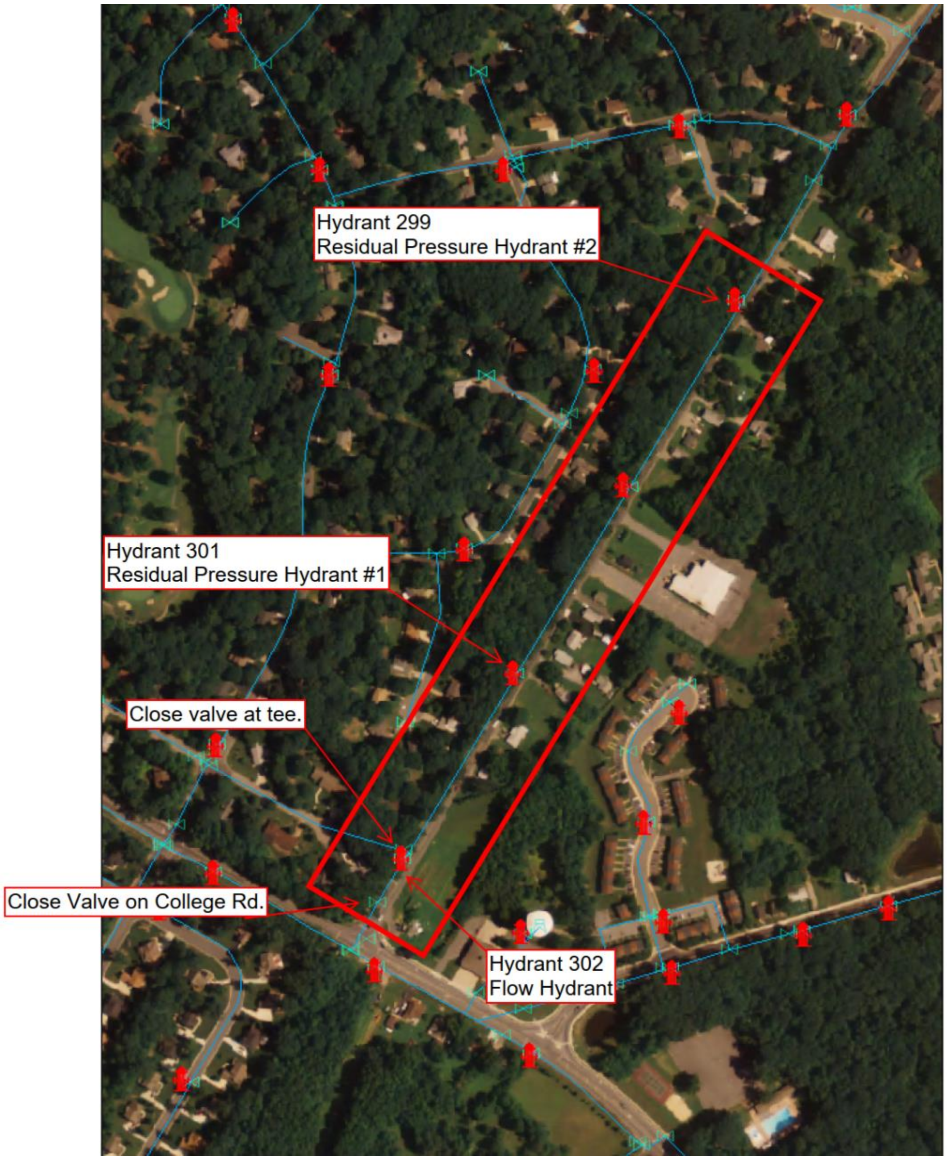
Test #: 1

Location: College Rd between Kenton Rd and Oakmont Dr

Main Size: 12-inch

Material/Age: Cast Iron / 1969

PROCEDURE MAP



Fire Hydrant Table		
Fire Hydrant Number	Fire Hydrant Location	Test Use
302	College Rd, noted above	Flow hydrant
301	College Rd, noted above	Residual 1
299	College Rd, noted above	Residual 2

Valves to be closed: Valves to be closed as noted above.

CITY OF DOVER, DE
WATER SYSTEM MASTER PLAN

HYDRAULIC EVALUATION

Field Hydrant Testing

Test #: 1

Location: 299

Date: 8 April 30 2

Time: 11:00

Main Size: 12 (in)

Personnel: City of Dover

Hydrant Outlet Flowed: 2½" 4" (circle)

Gauge ID:

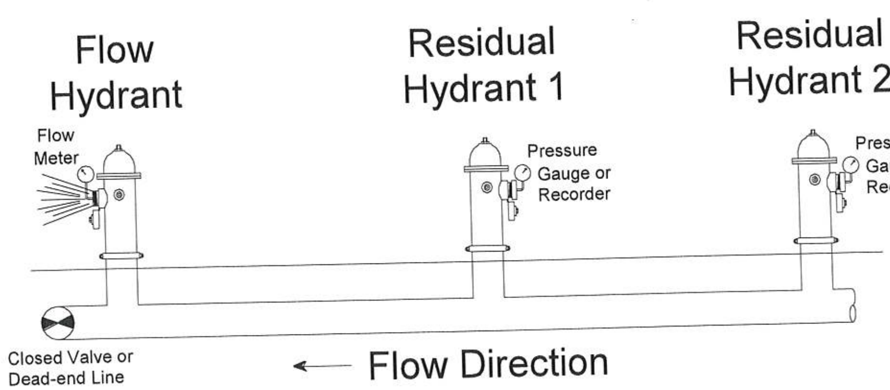
Pre-Test Pressure: 45 (psi)

Residual Pressure: 41 (psi)

Hydrant Flow: – (gpm)

Duration of Flow: – (min)

Comments: Residual Hyd 2



Procedure:
1. Measure Pressure at flow hydrant prior to test.
2. Open hydrant, Notify other personnel.
3. Read flow meter when a steady flow rate is reached.

WRA

N:\14466-000\Corresp\Memos\Unidirectional Flow\Flow Test Form.docx

CITY OF DOVER, DE
WATER SYSTEM MASTER PLAN

HYDRAULIC EVALUATION

Field Hydrant Testing

Test #: 1
Location: 301
Date: April 30 2021
Time: 11:05 am
Main Size: 12 (in)

Personnel: City of Dover

Hydrant Outlet Flowed: 2½" 4" (circle)
Gauge ID:

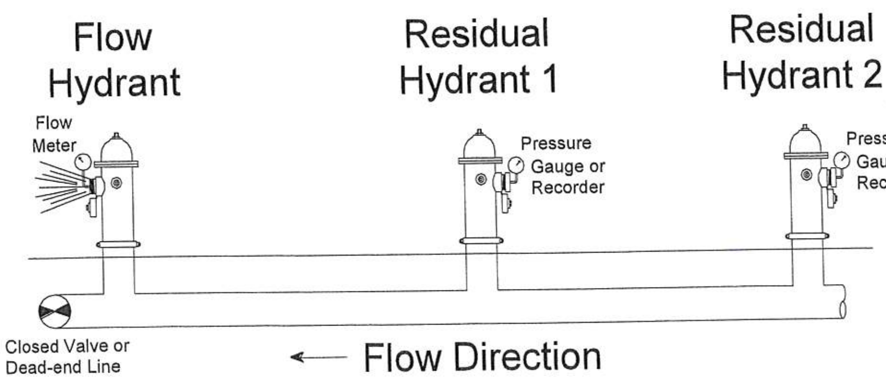
Pre-Test Pressure: 41 (psi)

Residual Pressure: 40 (psi)

Hydrant Flow: – (gpm)

Duration of Flow: – (min)

Comments: Residual Hyd 1



Procedure:

1. Measure Pressure at flow hydrant prior to test.
2. Open hydrant, Notify other personnel.
3. Read flow meter when a steady flow rate is reached.

N:\14466-000\Corresp\Memos\Unidirectional Flow\Flow Test Form.docx

CITY OF DOVER, DE
WATER SYSTEM MASTER PLAN

HYDRAULIC EVALUATION

Field Hydrant Testing

Test #: 1
Location: 302
Date: April 30 2021
Time: 1100
Main Size: 12 (in)

Personnel: City of dover

Hydrant Outlet Flowed: 2½" 4" (circle)
Gauge ID:

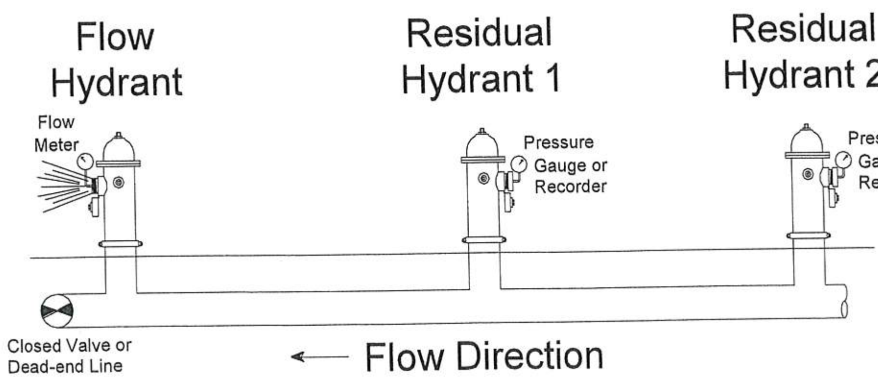
Pre-Test Pressure: 42 (psi)

Residual Pressure: 30 (psi) R

Hydrant Flow: ______ (gpm)

Duration of Flow: 5 (min)

Comments:
Flow Hyd



Procedure:
1. Measure Pressure at flow hydrant prior to test.
2. Open hydrant, Notify other personnel.
3. Read flow meter when a steady flow rate is reached.

WRA

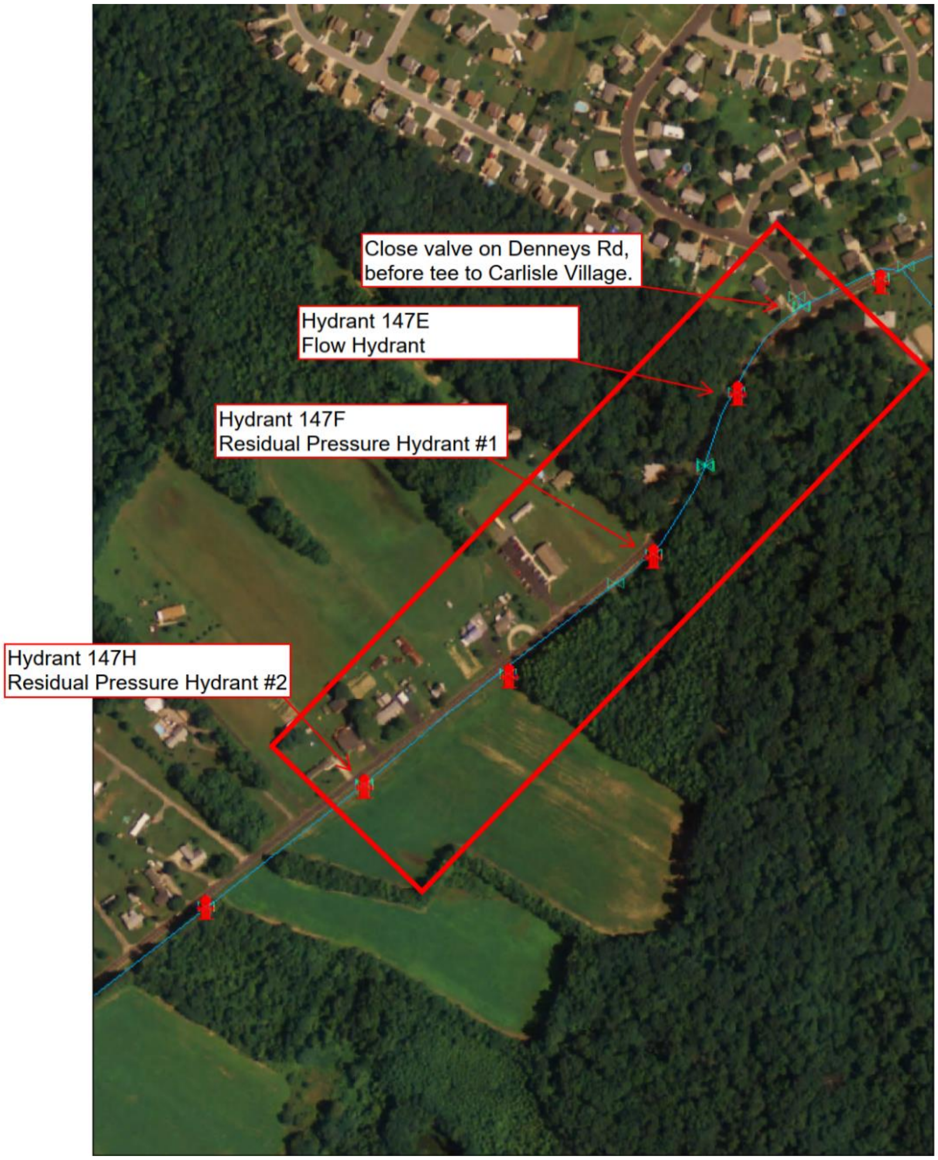
Test #: 2

Location: Denneys Rd between Carlisle Dr and Kenton Rd

Main Size: 12-inch

Material/Age: Ductile Iron / 1997

PROCEDURE MAP



Fire Hydrant Table		
Fire Hydrant Number	Fire Hydrant Location	Test Use
147E	Denneys Rd, noted above	Flow hydrant
147F	Denneys Rd, noted above	Residual 1
147H	Denneys Rd, noted above	Residual 2

Valves to be closed: Valves to be closed as noted above.

Test #: 3

Location: Stoney Rd between Forrest Ave and Tallowick Ln
Main Size: 8-inch
Material/Age: Ductile Iron / 1984

PROCEDURE MAP

Fire Hydrant Table		
Fire Hydrant Number	Fire Hydrant Location	Test Use
381	Stoney Rd, noted above	Flow hydrant
382	Stoney Rd, noted above	Residual 1
384	Stoney Rd, noted above	Residual 2

Valves to be closed: Valves to be closed as noted above.

CITY OF DOVER, DE
WATER SYSTEM MASTER PLAN

HYDRAULIC EVALUATION

Field Hydrant Testing

Test #: 3
Location: Residual HyD1 382
Date: April 28 2021
Time: 1045
Main Size: 8 (in)

Personnel: City of Dover

Hydrant Outlet Flowed: 2½" 4" (circle)
Gauge ID: ____

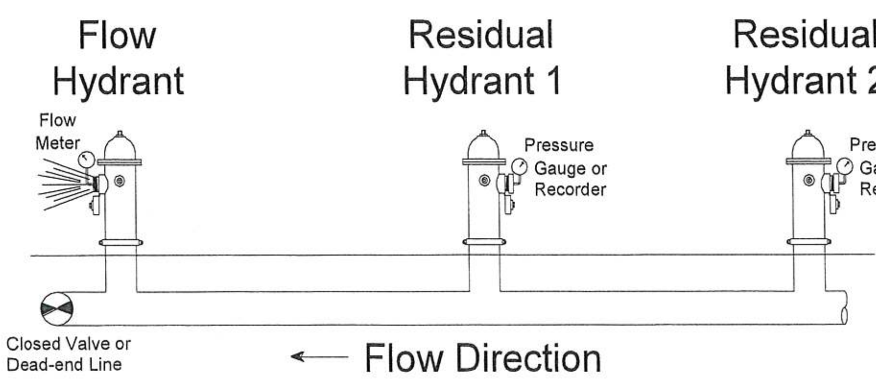
Pre-Test Pressure: 45 (psi)

Residual Pressure: 42 (psi)

Hydrant Flow: – (gpm)

Duration of Flow: – (min)

Comments:
HyD 382



Procedure:
1. Measure Pressure at flow hydrant prior to test.
2. Open hydrant, Notify other personnel.
3. Read flow meter when a steady flow rate is reached.

WRA

CITY OF DOVER, DE
WATER SYSTEM MASTER PLAN

HYDRAULIC EVALUATION

Field Hydrant Testing

Test #: 3

Location: Flow HyD

Date: 4/28/21

Time: 1045

Main Size: 8 (in)

Personnel: City of Dover

Hydrant Outlet Flowed: 2½" 4" (circle)

Gauge ID: ______

Pre-Test Pressure: 45 (psi)

R

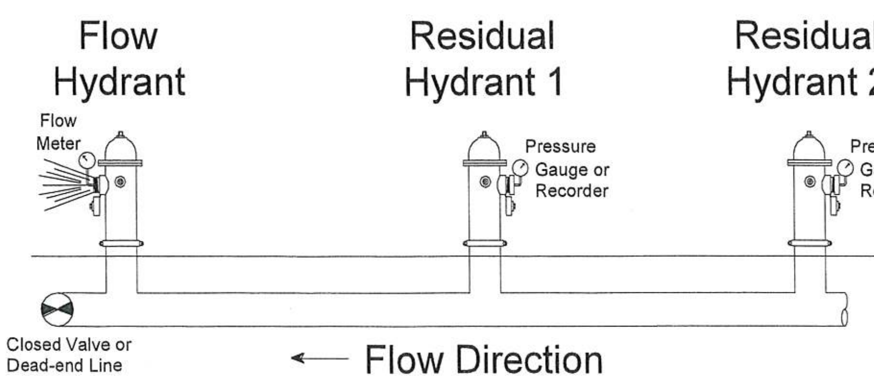
Residual Pressure: 30 (psi)

Hydrant Flow: ______ (gpm)

Duration of Flow: 4. (min)

Comments:

Flow HyD



Procedure:
1. Measure Pressure at flow hydrant prior to test.
2. Open hydrant, Notify other personnel.
3. Read flow meter when a steady flow rate is reached.

WRA

CITY OF DOVER, DE
WATER SYSTEM MASTER PLAN

HYDRAULIC EVALUATION

Field Hydrant Testing

Test #: ~~3~~ 3 Personnel: City of DOVER
Location: Residua #2
Date: 4/28/
Time: 1045
Main Size: 8 (in)

Hydrant Outlet Flowed: 2½" 4" (circle)
Gauge ID: ______

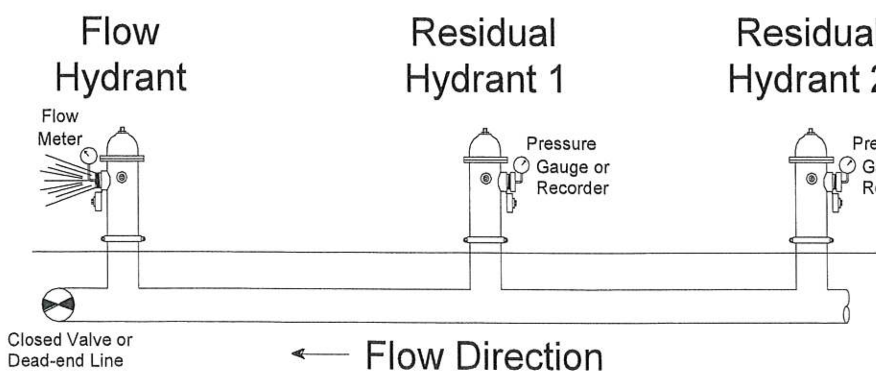
Pre-Test Pressure: 47 (psi)

Residual Pressure: 45 (psi)

Hydrant Flow: — (gpm)

Duration of Flow: — (min)

Comments:
HYD 384



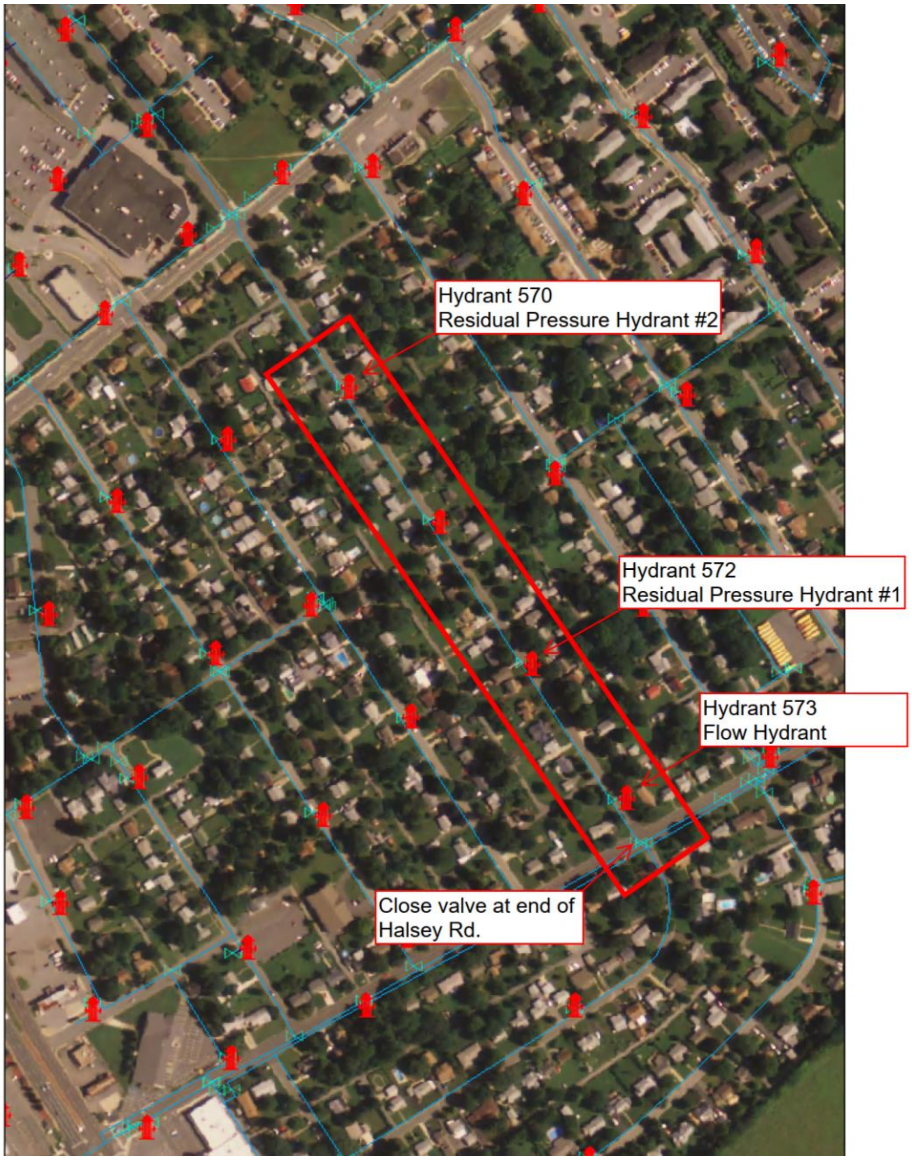
Procedure:
1. Measure Pressure at flow hydrant prior to test.
2. Open hydrant, Notify other personnel.
3. Read flow meter when a steady flow rate is reached.

WRA

Test #: 4

Location: North Halsey Rd between Division and White Oak Rd
Main Size: 6-inch
Material/Age: Cast Iron / 1963

PROCEDURE MAP



Fire Hydrant Table		
Fire Hydrant Number	Fire Hydrant Location	Test Use
573	North Halsey Rd, noted above	Flow hydrant
572	North Halsey Rd, noted above	Residual 1
570	North Halsey Rd, noted above	Residual 2

Valves to be closed: Valves to be closed as noted above.

CITY OF DOVER, DE
WATER SYSTEM MASTER PLAN

HYDRAULIC EVALUATION

Field Hydrant Testing

Test #: 4

Location: N. Halsey RD

Date: 4/22/21

Time: 1:55 pm

Main Size: 6" (in)

Personnel: City of Dover

Hydrant Outlet Flowed: 2½" 4" (circle)

Gauge ID:

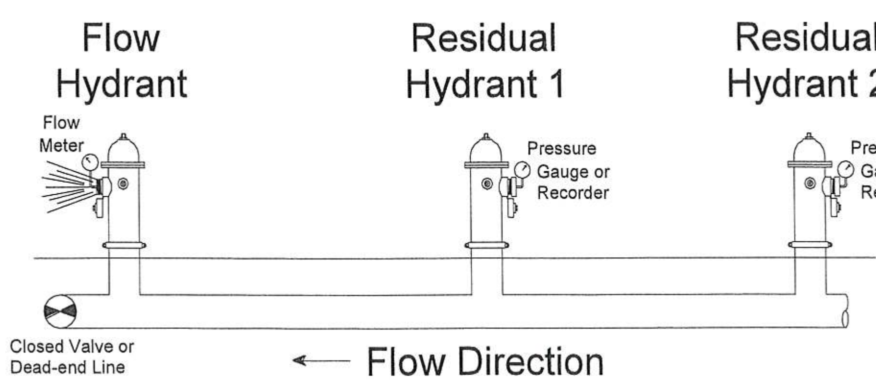
Pre-Test Pressure: 48 (psi)

Residual Pressure: 43 (psi)

Hydrant Flow: 0 (gpm)

Duration of Flow: 5 (min)

Comments: Residual Hyd # 1 572



Procedure:

1. Measure Pressure at flow hydrant prior to test.
2. Open hydrant, Notify other personnel.
3. Read flow meter when a steady flow rate is reached.

WRA

CITY OF DOVER, DE
WATER SYSTEM MASTER PLAN

HYDRAULIC EVALUATION

Field Hydrant Testing

Test #: 4
Location: N. Halsey RD
Date: 4/22/21
Time: 155 pm
Main Size: 6" (in)

Personnel: City of Dover

Hydrant Outlet Flowed: 2½" 4" (circle)
Gauge ID:

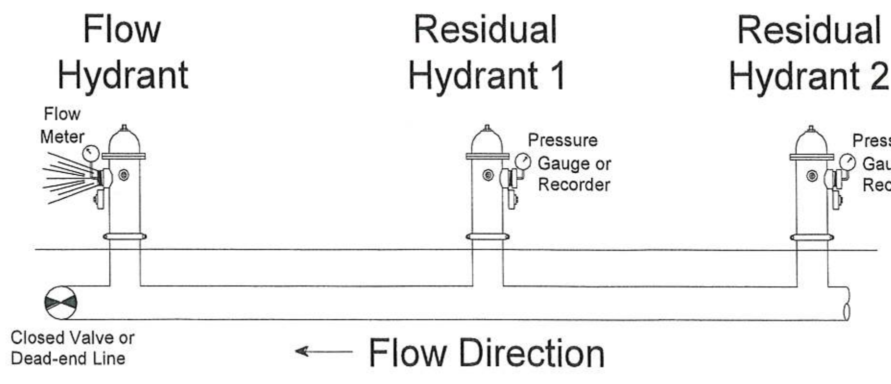
Pre-Test Pressure: 50 (psi)

Residual Pressure: 49 (psi)

Hydrant Flow: 0 (gpm)

Duration of Flow: 5 (min)

Comments: Residual Hyd # 2 570



Procedure:
1. Measure Pressure at flow hydrant prior to test.
2. Open hydrant, Notify other personnel.
3. Read flow meter when a steady flow rate is reached.

CITY OF DOVER, DE
WATER SYSTEM MASTER PLAN

HYDRAULIC EVALUATION

Field Hydrant Testing

Test #: 4
Location: N. Halsey RD
Date: 4/22/21
Time: 155 PM
Main Size: 6" (in)

Personnel: City of Dover

Hydrant Outlet Flowed: 2½" 4" (circle)
Gauge ID:

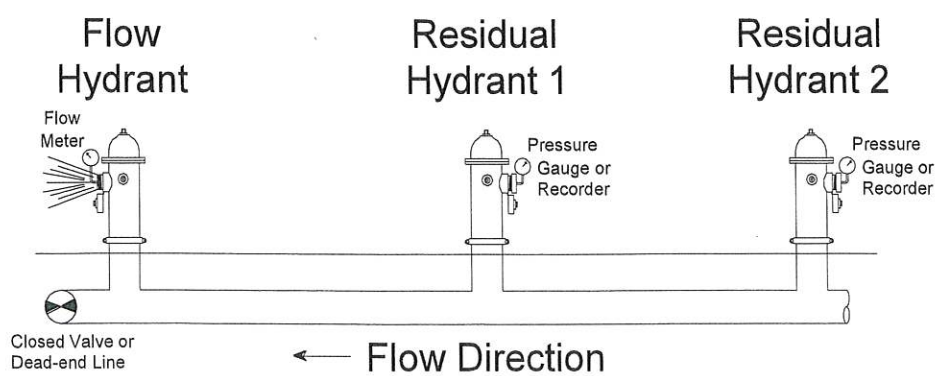
Pre-Test Pressure: – 50 (psi)

Residual Pressure: - 30 (psi) (30)

Hydrant Flow: ____ (gpm)

Duration of Flow: 4 (min)

Comments:
Flow Hydrant 573



Procedure:
1. Measure Pressure at flow hydrant prior to test.
2. Open hydrant, Notify other personnel.
3. Read flow meter when a steady flow rate is reached.

WRA

Test #: 5

Location: Kesselring Ave between Alder Rd and Fiddlers Green
Main Size: 8-inch
Material/Age: Cast Iron / 1963

PROCEDURE MAP

Fire Hydrant Table		
Fire Hydrant Number	Fire Hydrant Location	Test Use
1150	Kesselring Ave, noted above	Flow hydrant
1151	Kesselring Ave, noted above	Residual 1
1152	Kesselring Ave, noted above	Residual 2

Valves to be closed: Valves to be closed as noted above.

CITY OF DOVER, DE
WATER SYSTEM MASTER PLAN

HYDRAULIC EVALUATION

Field Hydrant Testing

Test #: 5

Location: Kesselring AVE

Date: 4/27/21

Time: 2 30 pm

Main Size: 8 (in)

Personnel: City of Dove

Hydrant Outlet Flowed: 2½" 4" (circle)

Gauge ID: ________

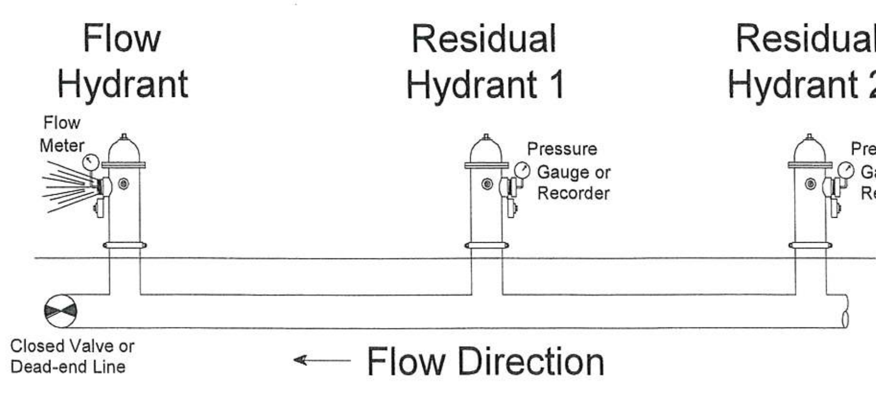
Pre-Test Pressure: 52 (psi)

Residual Pressure: 46 (psi)

Hydrant Flow: 0 (gpm)

Duration of Flow: — (min)

Comments: 1152 Residual 2



Procedure:

1. Measure Pressure at flow hydrant prior to test.
2. Open hydrant, Notify other personnel.
3. Read flow meter when a steady flow rate is reached.

WRA

CITY OF DOVER, DE
WATER SYSTEM MASTER PLAN

HYDRAULIC EVALUATION

Field Hydrant Testing

Test #: 5
Location: Kesselring AVE
Date: 4/22/21
Time: 2 30
Main Size: 8 (in)

Personnel: City of Dover

Hydrant Outlet Flowed: 2½" 4" (circle)
Gauge ID:

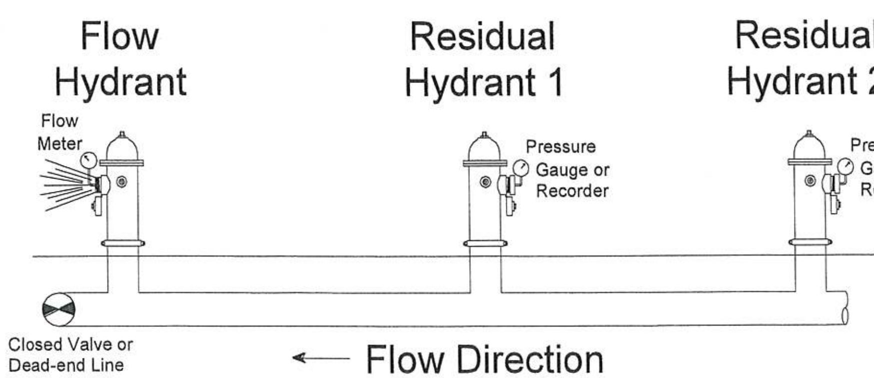
Pre-Test Pressure: 50 (psi)

Residual Pressure: 46 (psi)

Hydrant Flow: 0 (gpm)

Duration of Flow: – (min)

Comments: 1151 Residual Hy 1



Procedure:
1. Measure Pressure at flow hydrant prior to test.
2. Open hydrant, Notify other personnel.
3. Read flow meter when a steady flow rate is reached.

CITY OF DOVER, DE
WATER SYSTEM MASTER PLAN

HYDRAULIC EVALUATION

Field Hydrant Testing

Test #: 5
Location: Kesselring
Date: 4/22/21
Time: 2:30
Main Size: 8 (in)

Personnel: City of DOVER

Hydrant Outlet Flowed: 2½" 4" (circle)
Gauge ID: ______

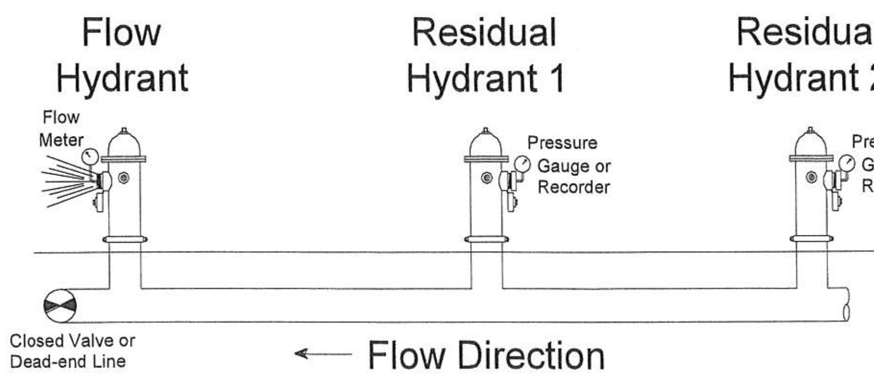
Pre-Test Pressure: 55 (psi)

Residual Pressure: 25 (psi) R

Hydrant Flow: ______ (gpm)

Duration of Flow: 4 (min)

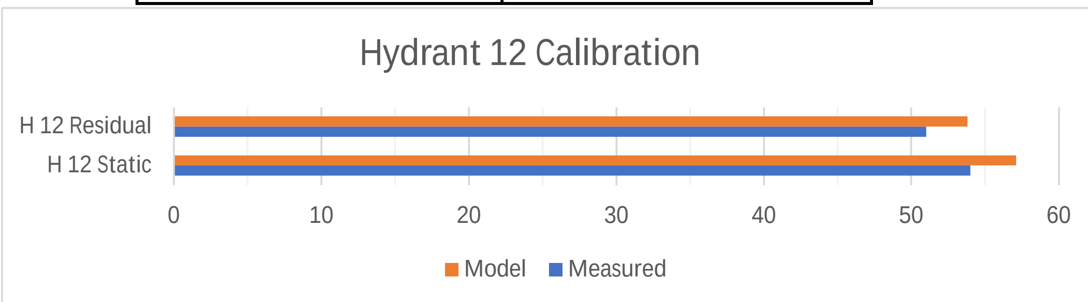
Comments:
1150 Flow Hyd



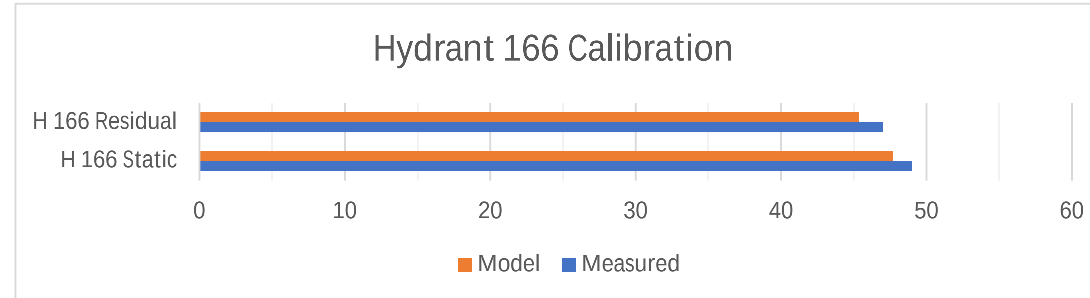
Procedure:
1. Measure Pressure at flow hydrant prior to test.
2. Open hydrant, Notify other personnel.
3. Read flow meter when a steady flow rate is reached.

WRA

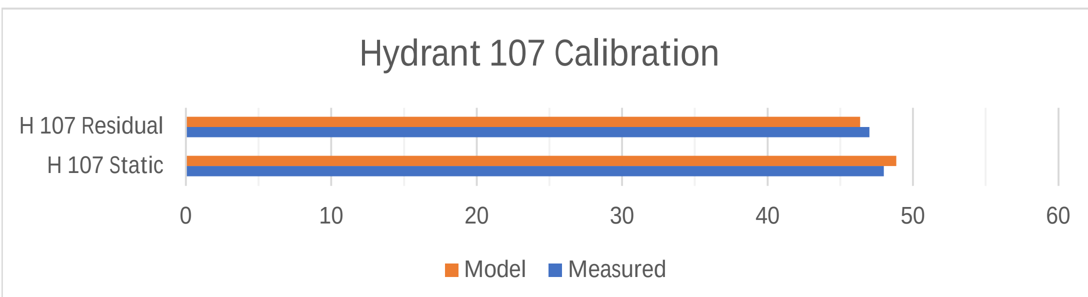
Hydrant: 12	Static	Residual
Field Measurement	54	51
Model Measurement	57.08	53.8
Date: Fall 2019	Time:	11:40 AM



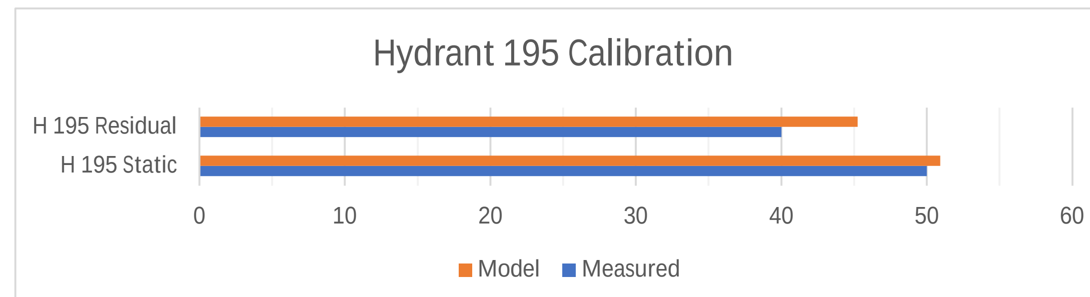
Hydrant: 166	Static	Residual
Field Measurement	49	47
Model Measurement	47.75	45.36
Date: Summer 2018	Time:	1:55 PM



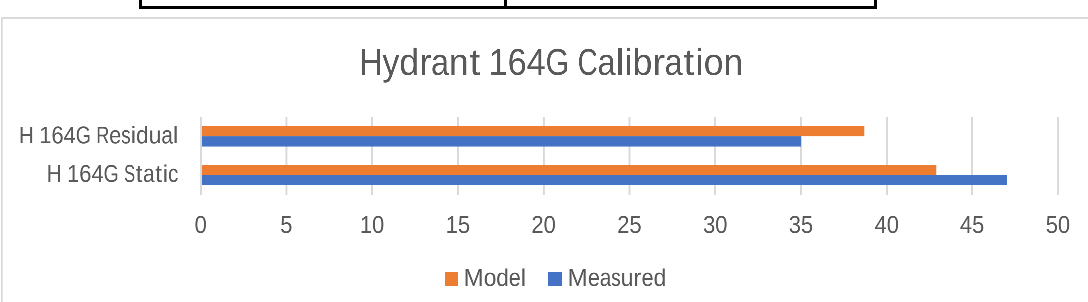
Hydrant: 107	Static	Residual
Field Measurement	48	47
Model Measurement	48.85	46.37
Date: Spring 2018	Time:	10:38 AM



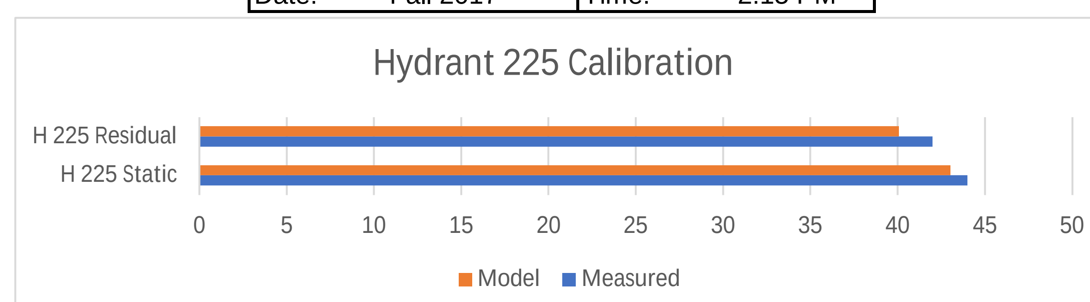
Hydrant: 195	Static	Residual
Field Measurement	50	40
Model Measurement	50.93	45.25
Date: Fall 2017	Time:	1:38 PM



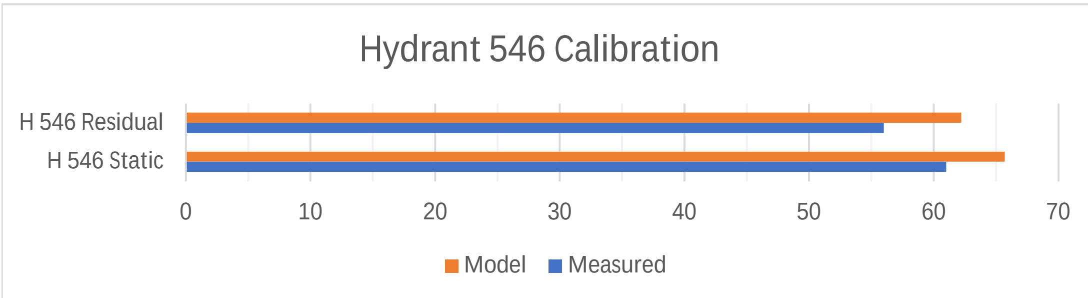
Hydrant: 164G	Static	Residual
Field Measurement	47	35
Model Measurement	42.92	38.7
Date: Summer 2018	Time:	7:55 AM



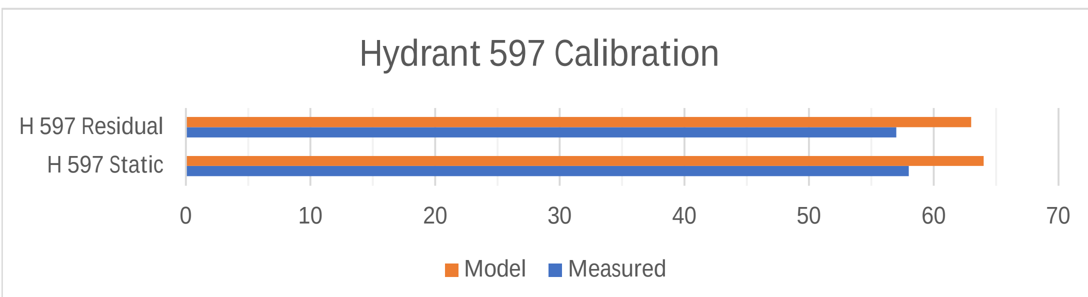
Hydrant: 225	Static	Residual
Field Measurement	44	42
Model Measurement	43.03	40.08
Date: Fall 2017	Time:	2:15 PM



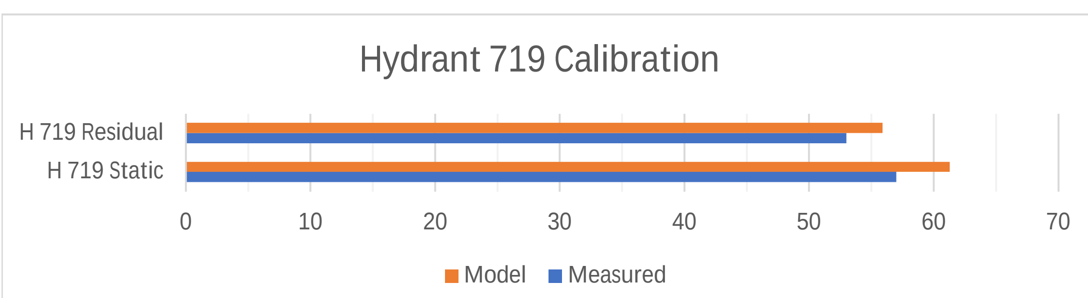
Hydrant: 546	Static	Residual
Field Measurement	61	56
Model Measurement	65.69	62.21
Date: Spring 2019	Time:	1:30 PM



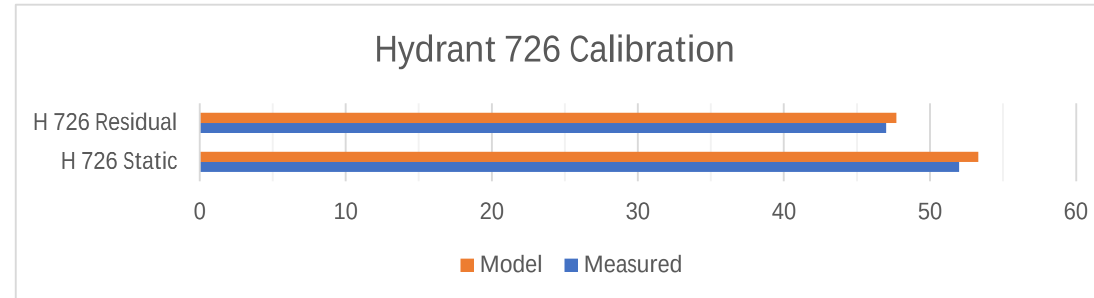
Hydrant: 597	Static	Residual
Field Measurement	58	57
Model Measurement	64.07	63
Date: Fall 2019	Time:	12:40 PM



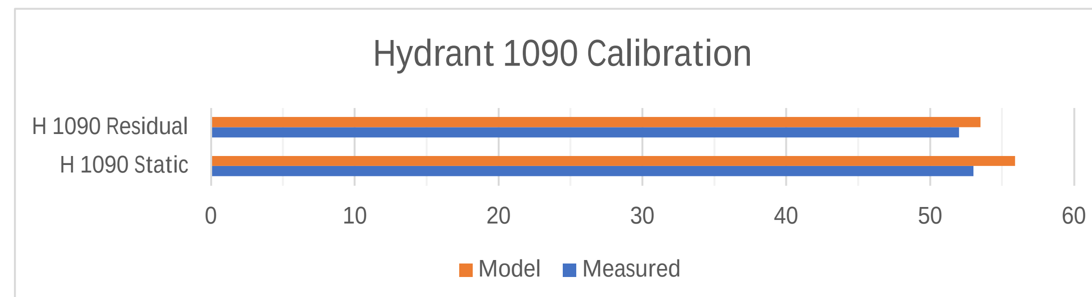
Hydrant: 719	Static	Residual
Field Measurement	57	53
Model Measurement	61.28	55.96
Date: Spring 2019	Time:	1:45 PM



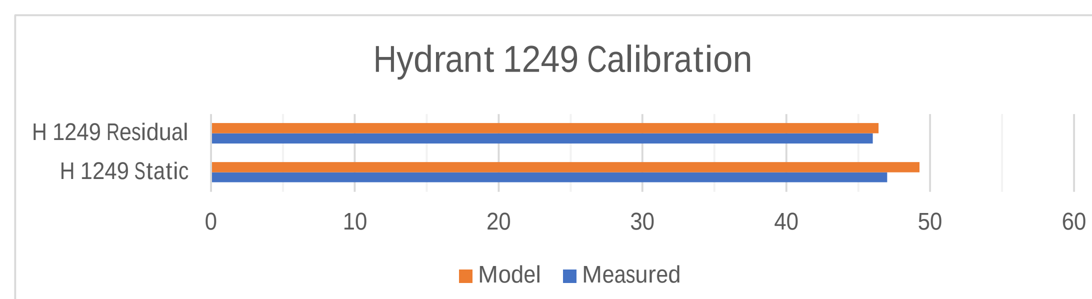
Hydrant: 726	Static	Residual
Field Measurement	52	47
Model Measurement	53.29	47.71
Date: Fall 2018	Time:	1:40 PM



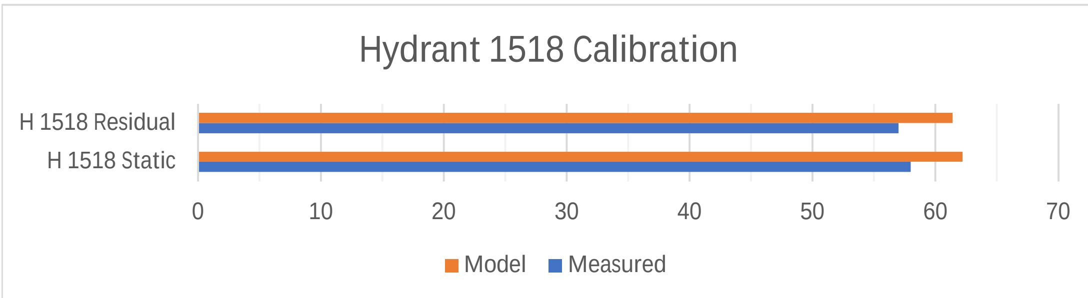
Hydrant: 1090	Static	Residual
Field Measurement	53	52
Model Measurement	55.9	53.54
Date: Fall 2019	Time:	11:00 AM



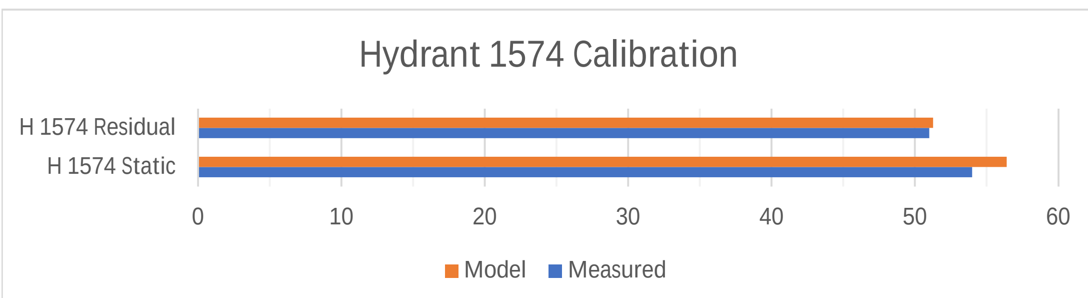
Hydrant: 1249	Static	Residual
Field Measurement	47	46
Model Measurement	49.26	46.41
Date: Spring 2018	Time:	11:35 AM



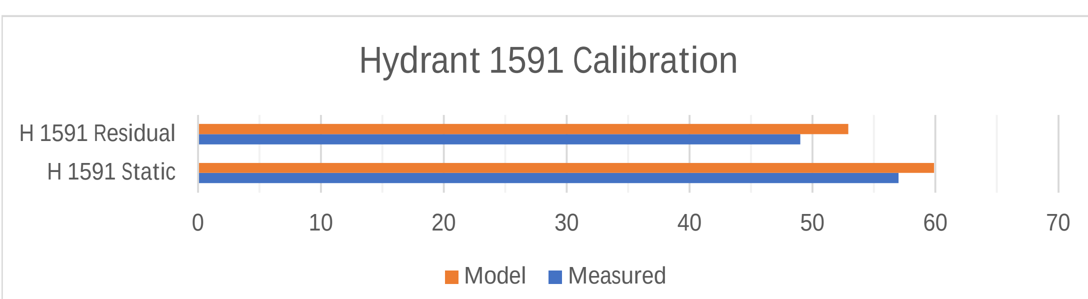
Hydrant: 1518	Static	Residual
Field Measurement	58	57
Model Measurement	62.19	61.43
Date: Fall 2018	Time:	1:07 PM



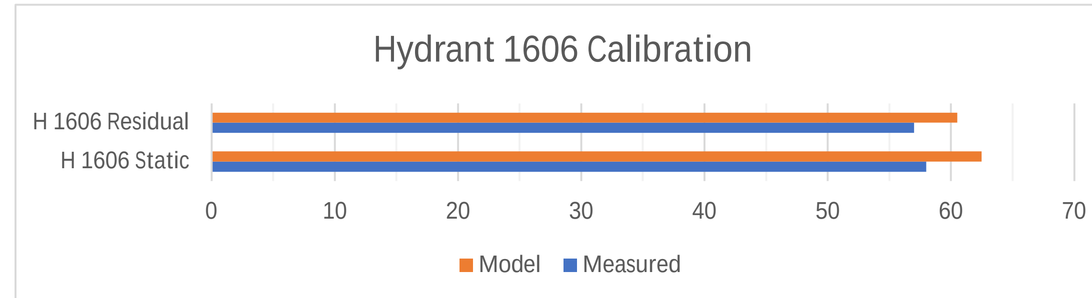
Hydrant: 1574	Static	Residual
Field Measurement	54	51
Model Measurement	56.41	51.26
Date: Smr 2018	Time:	7:35 AM



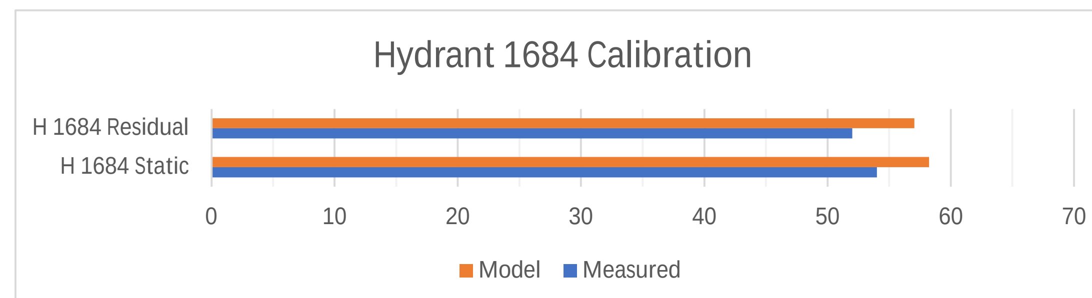
Hydrant: 1591	Static	Residual
Field Measurement	57	49
Model Measurement	59.96	52.91
Date: Spring 2019	Time:	2:07 PM



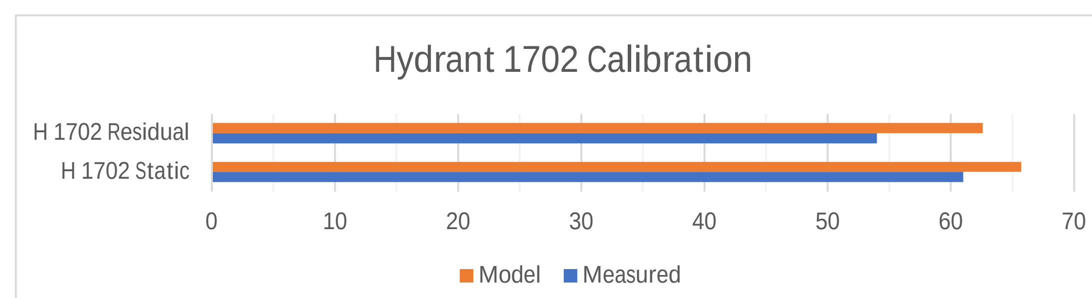
Hydrant: 1606	Static	Residual
Field Measurement	58	57
Model Measurement	62.49	60.52
Date: Fall 2019	Time:	1:25 PM



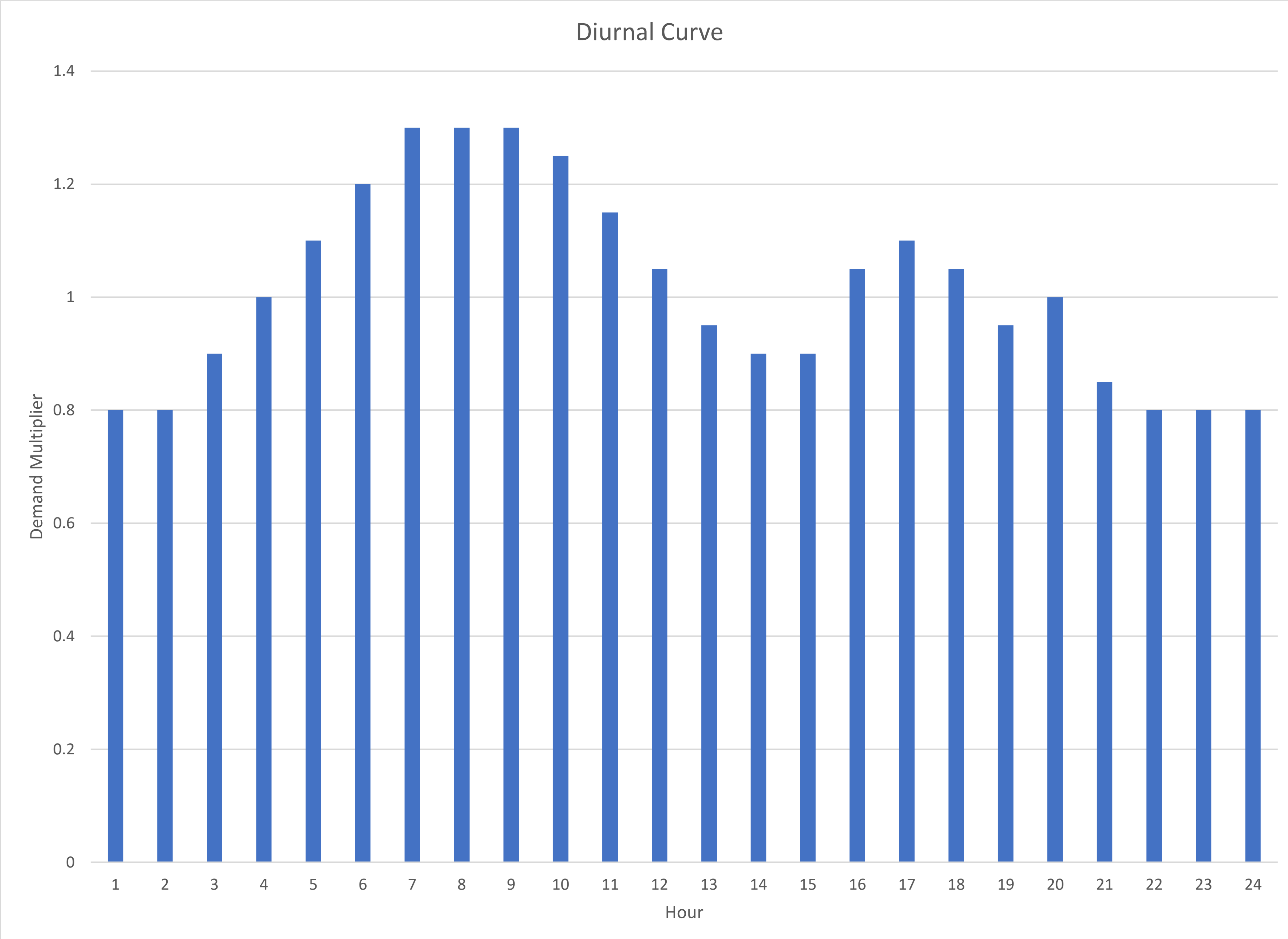
Hydrant: 1684	Static	Residual
Field Measurement	54	52
Model Measurement	58.23	57.04
Date: Fall 1018	Time:	1:20 PM



Hydrant: 1702	Static	Residual
Field Measurement	61	54
Model Measurement	65.77	62.6
Date: Fall 2019	Time:	1:10 PM



Appendix E
Model Operational Data


Diurnal Curve
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Demand Multiplier
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour

Pump Rule Control

GeneralFoods		NORMAL			ENABLED		Date:	01/12/16	
Start	Stop	Step	Sun	Mon	Tue	Wed	Thu	Fri	Sat
24.00	26.00	1	10	7	10	7	10	7	10
23.80	25.80	2	2	10	2	10	2	10	2
23.60	25.60	3	6	2	6	2	6	2	6
23.40	25.40	4	15	4	4	6	4	4	15
23.20	25.20	5	4	6	9	3	9	6	4
23.00	25.00	6	13R	11	11	4	11	11	13R
22.80	24.80	7	3	15	15	9	15	15	3
22.60	24.60	8	9	13R	13R	11	13R	13R	9
22.40	24.40	9	11	3	3	15	3	3	11
22.20	24.20	10		9		13R		9	
22.00	24.00	11	~	48 Hz					
21.80	23.80	12	~	51 Hz					
21.60	23.60	13	~	54 Hz					
21.40	23.40	14	~	57 Hz					
21.20	23.20	15	~	60 Hz					

WalkerRd		NORMAL			ENABLED		Date:	01/12/16	
Start	Stop	Step	Sun	Mon	Tue	Wed	Thu	Fri	Sat
33.80	35.80	1	10	7	10	7	10	7	10
33.60	35.60	2	2	10	2	10	2	10	2
33.40	35.40	3	6	2	6	2	6	2	6
33.20	35.20	4	15	4	4	6	4	4	15
33.00	35.00	5	4	6	9	3	9	6	4
32.80	34.80	6	13R	11	11	4	11	11	13R
32.60	34.60	7	3	15	15	9	15	15	3
32.40	34.40	8	9	13R	13R	11	13R	13R	9
32.20	34.20	9	11	3	3	15	3	3	11
32.00	34.00	10		9		13R		9	
31.80	33.80	11	~	48 Hz					
31.60	33.60	12	~	51 Hz					
31.40	33.40	13	~	54 Hz					
31.20	33.20	14	~	57 Hz					
31.00	33.00	15	~	60 Hz					

McKee		NORMAL			ENABLED		Date:	01/12/16	
Start	Stop	Step	Sun	Mon	Tue	Wed	Thu	Fri	Sat
36.60	38.60	1	10	7	10	7	10	7	10
36.40	38.40	2	2	10	2	10	2	10	2
36.20	38.20	3	6	2	6	2	6	2	6
36.00	38.00	4	15	4	4	6	4	4	15
35.80	37.80	5	4	6	9	3	9	6	4
35.60	37.60	6	13R	11	11	4	11	11	13R
35.40	37.40	7	3	15	15	9	15	15	3
35.20	37.20	8	9	13R	13R	11	13R	13R	9
35.00	37.00	9	11	3	3	15	3	3	11
34.80	36.80	10		9		13R		9	
34.60	36.60	11	~	48 Hz					
34.40	36.40	12	~	51 Hz					
34.20	36.20	13	~	54 Hz					
34.00	36.00	14	~	57 Hz					
33.80	35.80	15	~	60 Hz					

Wells Normally in HAND									
Start	Stop	Step	Sun	Mon	Tue	Wed	Thu	Fri	Sat
ON			1	1	1	1	1	1	1
	OFF		5	5	5	5	5	5	5
ON			8R	8R	8R	8R	8R	8R	8R
ON			12R	12R	12R	12R	12R	12R	12R
ON			14	14	14	14	14	14	14
	BLUE:	Controlled by VFD, starts @ 45 Hz (min flow),							
		speed increases w/ Steps 11-15.							
	RED:	No VFD, starts & runs at 100% at Step indicated.							
	GREEN:	VFD controlled manually at present (study).							
	BLACK:	Out of Service							

WATER QUALITY IMPROVEMENT PROJECTS	#	FY 2022	%	#	FY 2023	%	#	FY 2024	%	#	FY 2025	%	#	FY 2026	%
State Street (Division - Pennsylvania)	1	965,300		1	520,500										
GROWTH [capacity upsize 8"]		153,483	15.9%		82,760	15.9%									
NON-GROWTH [base 4"]		811,817	84.1%		437,741	84.1%									
Survey for Future Projects				2	75,000										
GROWTH [capacity upsize 8"]					3,750	5.0%									
NON-GROWTH [base 4"]					71,250	95.0%									
West Street East Alley (William Street to Walker Road)							2	410,000							
GROWTH [capacity upsize 8"]								16,810	4.1%						
NON-GROWTH [base 4"]								393,190	95.9%						
Fairview Ave East Alley (William Street to Walker Road)							1	420,000							
GROWTH [capacity upsize 8"]								18,480	4.4%						
NON-GROWTH [base 4"]								401,520	95.6%						
Fairview Ave West Alley (William Street to Walker Road)							1	420,000							
GROWTH [capacity upsize 8"]								18,480	4.4%						
NON-GROWTH [base 4"/6"]								401,520	95.6%						
N. Bradford Street (Walker to Ross)							1	140,000							
GROWTH [capacity upsize 8"]								9,100	6.5%						
NON-GROWTH [base 4"]								130,900	93.5%						
Queen Street (William St. to Loockerman)										1	632,400				
GROWTH [capacity upsize 8"]											27,826	4.4%			
NON-GROWTH [base 4"]											604,574	95.6%			
New Street (William St. to Loockerman)										1	632,400				
GROWTH [capacity upsize 8"]											27,826	4.4%			
NON-GROWTH [base 4""]											604,574	95.6%			
Bradford Street (Division to Loockerman)													1	278,000	
GROWTH [capacity upsize 8"]														72,558	26.1%
NON-GROWTH [base 4"/6"]														205,442	73.9%
Kings Highway (Division to Loockerman)													1	238,000	
GROWTH [capacity upsize 8"]														20,706	8.7%
NON-GROWTH [base 4"]														217,294	91.3%
Reed Street (West Street to State Street)													1	284,000	
GROWTH [capacity upsize 8"]														24,140	8.5%
NON-GROWTH [base 4"]														259,860	91.5%
Queen Street (North Street to Water Street)													1	150,000	
GROWTH [capacity upsize 8"]														9,000	6.0%
NON-GROWTH [base 4""]														141,000	94.0%
Bank Lane (West Street to The Green)													1	300,000	
GROWTH [capacity upsize 8"]														33,900	11.3%
NON-GROWTH [base 4"/6"]														266,100	88.7%

Appendix F
Hydraulic Modeling Results

Legend

Junction

Min. Pressure (PSI)

- less than 20.00
- 20.00 ~ 35.00
- 35.00 ~ 40.00
- 40.00 ~ 50.00
- 50.00 ~ 70.00

Pipe

Max. Velocity (ft/s)

- less than 1.00
- 1.00 ~ 2.00
- 2.00 ~ 3.00
- 3.00 ~ 4.00
- 4.00 ~ 5.00

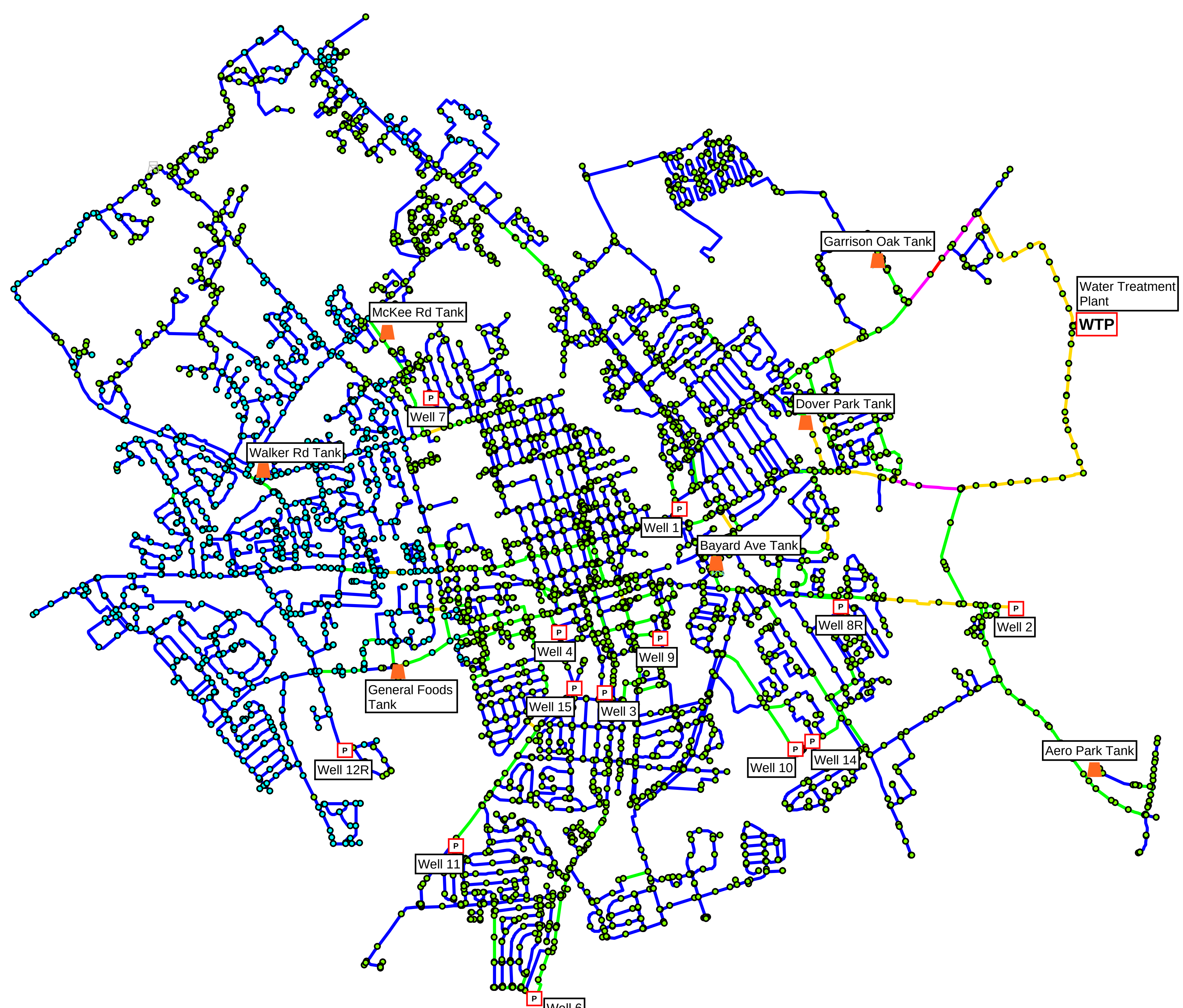
Tank

Pump and Well House

P

Water Treatment Plant

WTP



Whitman, Requardt & Associates, LLP 1915 100 YEARS 2015

0 0.25 0.5 1 1.5 2 Miles

N W E S

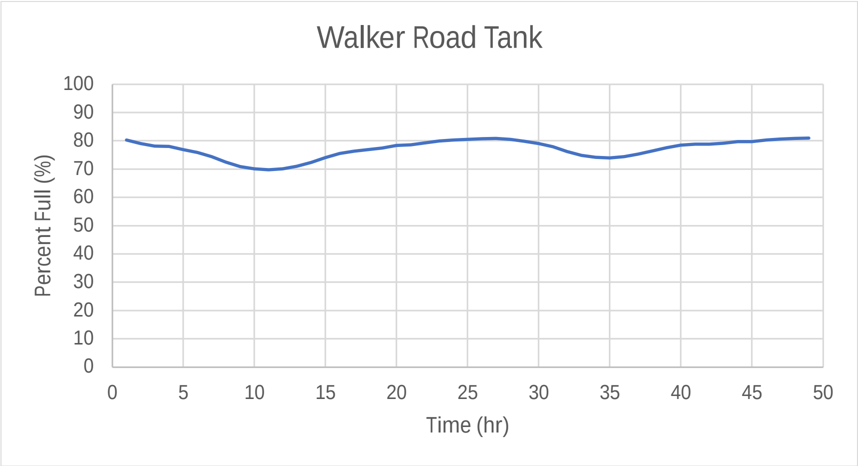
City of Dover, Delaware
Water System Master Plan

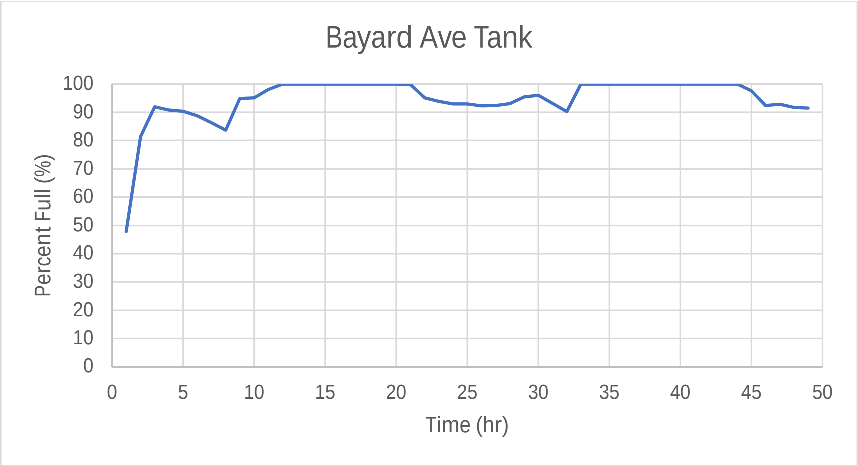
Appendix F.1
2019 System Minimum Pressure and Maximum Water Velocity

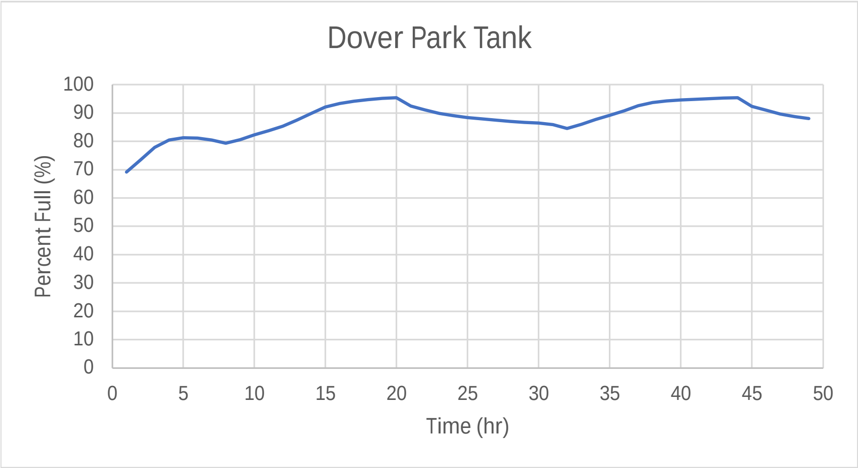
2019 MDD TANK LEVELS

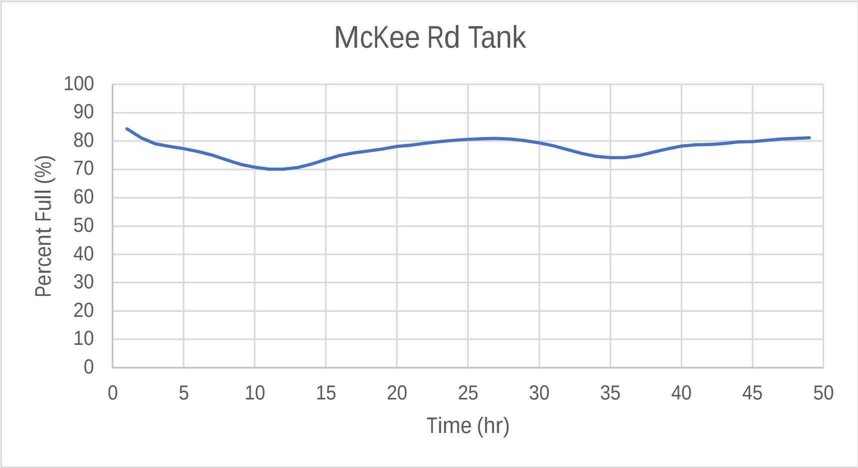
City of Dover, DE
Water Master Plan Draft

Appendix F
June 2021





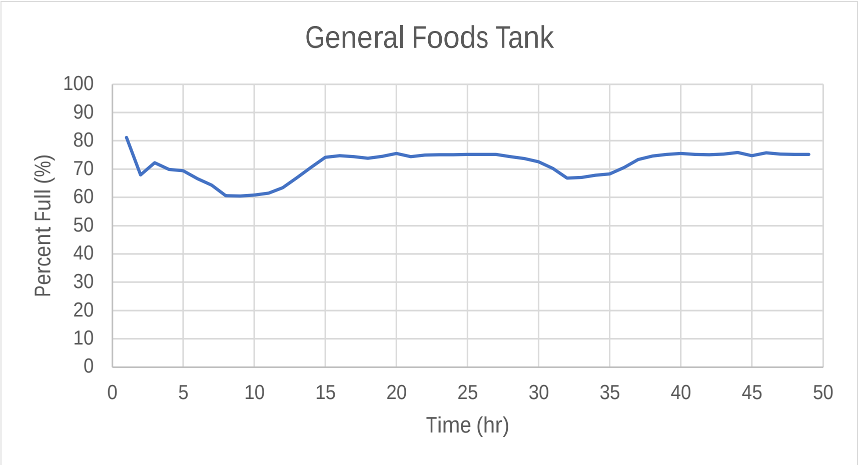


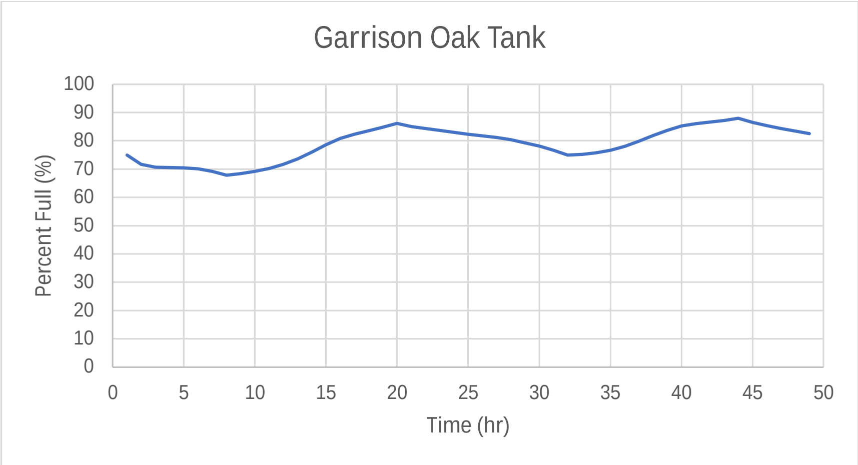


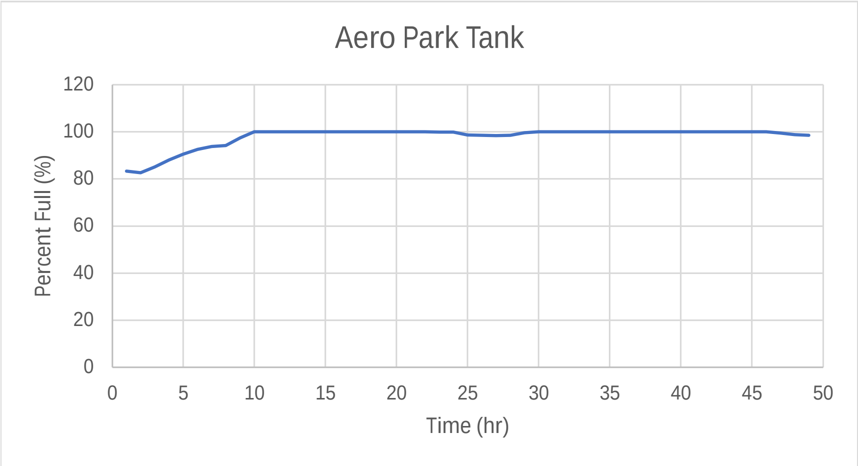
2019 MDD TANK LEVELS

City of Dover, DE
Water Master Plan Draft

Appendix F
June 2021







Legend

Junction

Hydrant Flow Available (gpm)

- less than 1,900.00
- 1,900.00 ~ 2,000.00
- 2,000.00 ~ 10,000.00

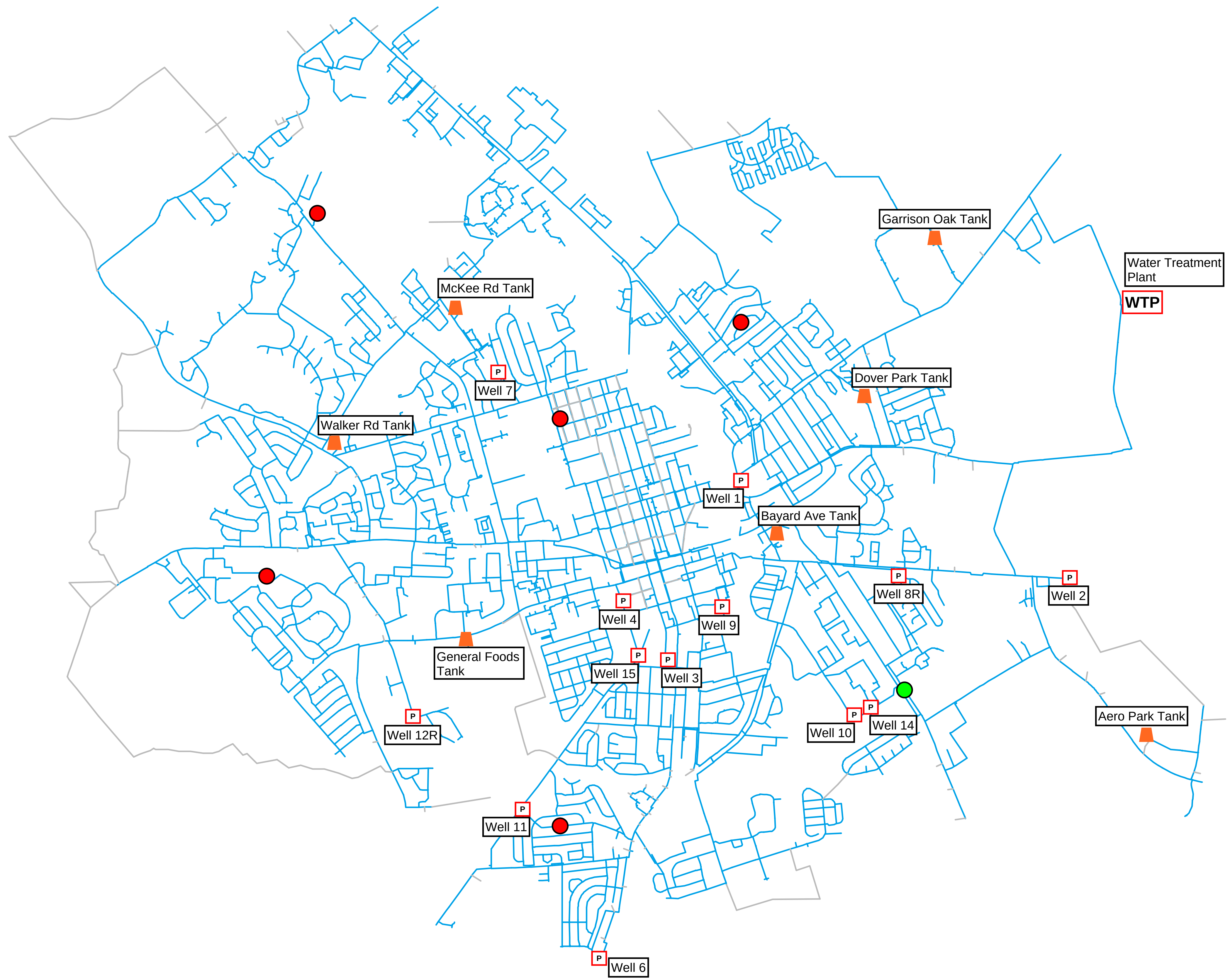
Tank

Pump and Well House

P

Water Treatment Plant

WTP



Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

0 0.25 0.5 1 1.5 2 Miles

City of Dover, Delaware
Water System Master Plan

Appendix F.2
2019 Max. Day
Steady State Fire Flow (6 ft/s)

ID	Static Demand (gpm)	Static Pressure (psi)	Static Head (ft)	Fire-Flow Demand (gpm)	Residual Pressure (psi)	Hydrant Available Flow (gpm)	Hydrant Pressure at Available Flow (psi)	Critical Pipe ID at Available Flow	Critical Pipe Velocity at Available Flow (ft/s)
J12706	0.00	51.51	148.89	2,000.00	44.36	3,711.36	31.54	P1049	6.01
J13954	1.77	53.53	143.53	2,000.00	-37.14	1,007.27	27.67	4404	6
J18624	0.00	46.53	142.39	2,000.00	36.92	1,461.23	40.87	P5085	6.04
J19914	0.00	41.11	142.87	2,000.00	24.11	1,745.73	27.78	P6435	6
J24268	0.55	48.06	143.91	2,000.00	-6.59	682.31	40.26	P8017	6.01
J6626	3.29	51.93	147.84	2,000.00	18.92	1,820.85	24.18	3431	6

ID	Static Demand (gpm)	Static Pressure (psi)	Static Head (ft)	Fire-Flow Demand (gpm)	Residual Pressure (psi)	Hydrant Available Flow (gpm)	Hydrant Pressure at Available Flow (psi)	Critical Pipe ID at Available Flow	Critical Pipe Velocity at Available Flow (ft/s)
J12706	0	51.51	148.89	2,000.00	44.36	2,474.24	41.4	P1049	4.02
J13954	1.77	53.53	143.53	2,000.00	-37.14	671.51	41.07	4404	4
J18624	0	46.53	142.39	2,000.00	36.92	960.88	43.66	P5085	4
J19914	0	41.11	142.87	2,000.00	24.11	1,163.82	34.63	P6435	4
J24268	0.55	48.06	143.91	2,000.00	-6.59	454.88	44.22	P8017	4.01
J6626	3.29	51.93	147.84	2,000.00	18.92	1,213.90	38.39	3431	4.01

Legend

Junction

Min. Pressure (PSI)

- less than 20.00
- 20.00 ~ 30.00
- 30.00 ~ 40.00
- 40.00 ~ 50.00
- 50.00 ~ 80.00

Pipe

Max. Velocity (ft/s)

- less than 1.00
- 1.00 ~ 2.00
- 2.00 ~ 3.00
- 3.00 ~ 4.00
- 4.00 ~ 30.00

Tank

Pump and Well House

P

Water Treatment Plant

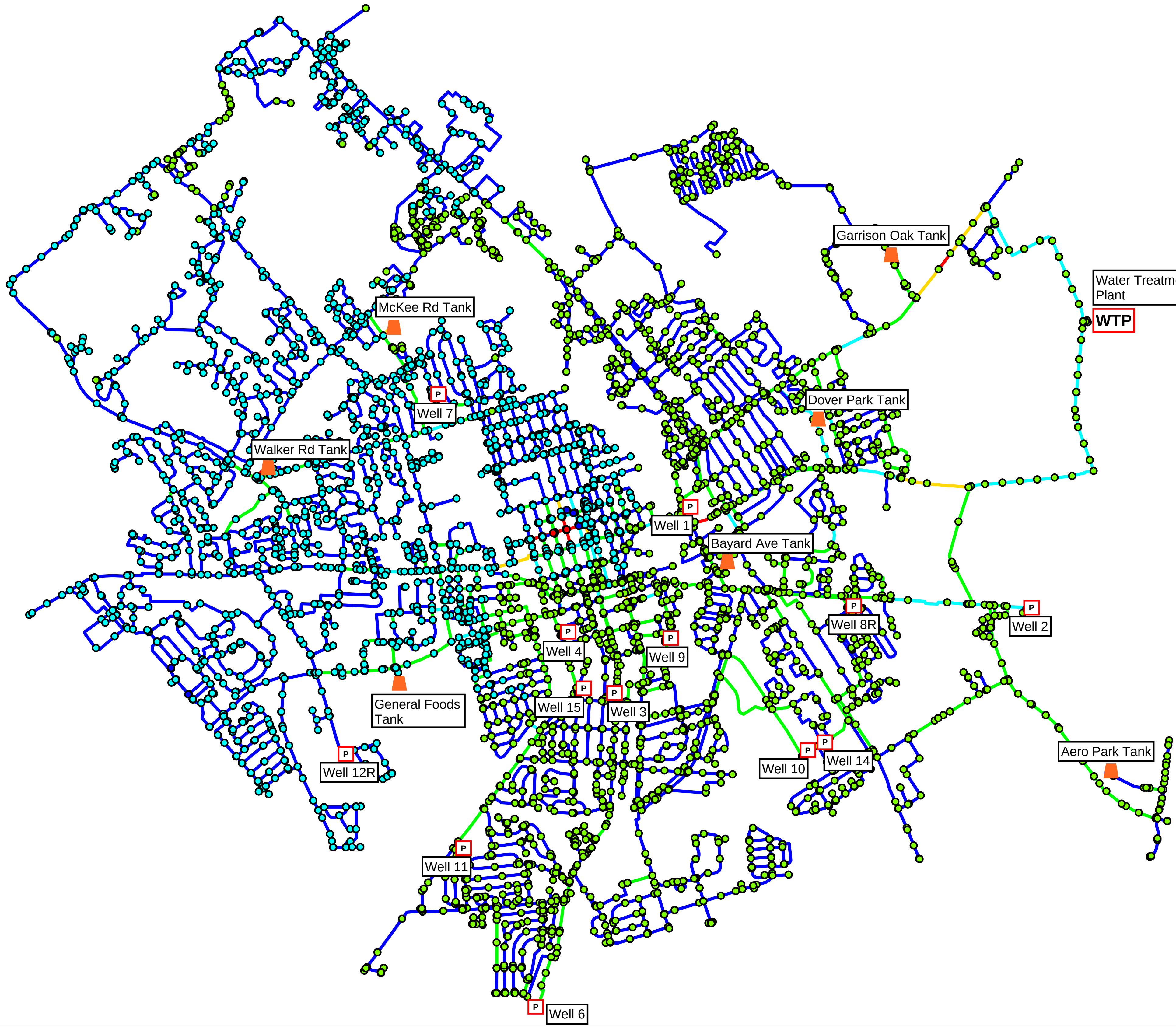
WTP

0 0.25 0.5 1 1.5 2 Miles

Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

City of Dover, Delaware
Water System Master Plan

Appendix F.3
2019 J15534 Fire Flow
Minimum Pressure and
Maximum Water Velocity



Legend

Junction

Min. Pressure (PSI)

- less than 20.00
- 20.00 ~ 30.00
- 30.00 ~ 40.00
- 40.00 ~ 50.00
- 50.00 ~ 80.00

Pipe

Max. Velocity (ft/s)

- less than 1.00
- 1.00 ~ 2.00
- 2.00 ~ 3.00
- 3.00 ~ 4.00
- 4.00 ~ 30.00

Tank

Pump and Well House

P

Water Treatment Plant

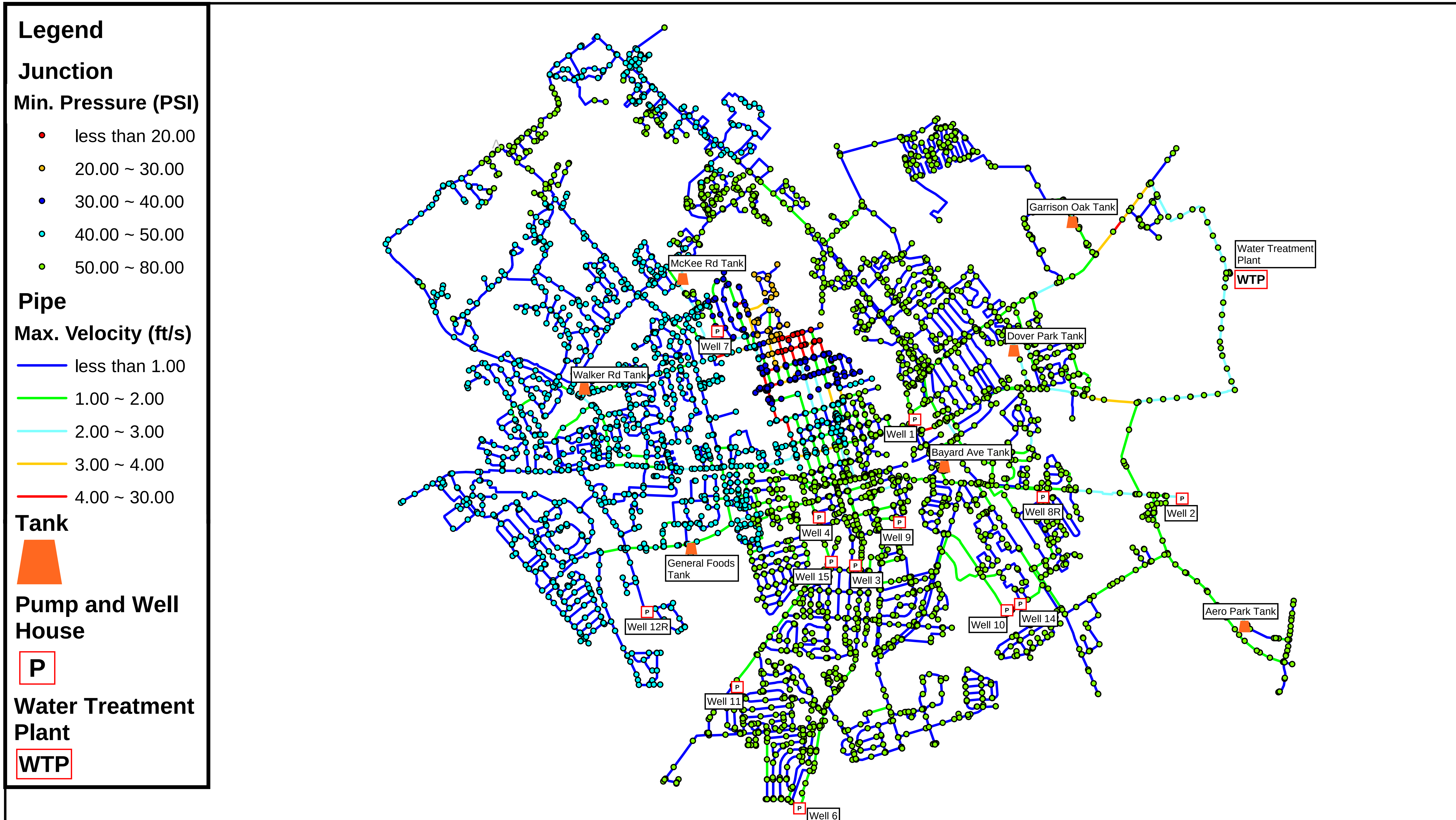
WTP

Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

0 0.25 0.5 1 1.5 2 Miles

City of Dover, Delaware
Water System Master Plan

Appendix F.4
2019 J15662 Fire Flow
Minimum Pressure and
Maximum Water Velocity

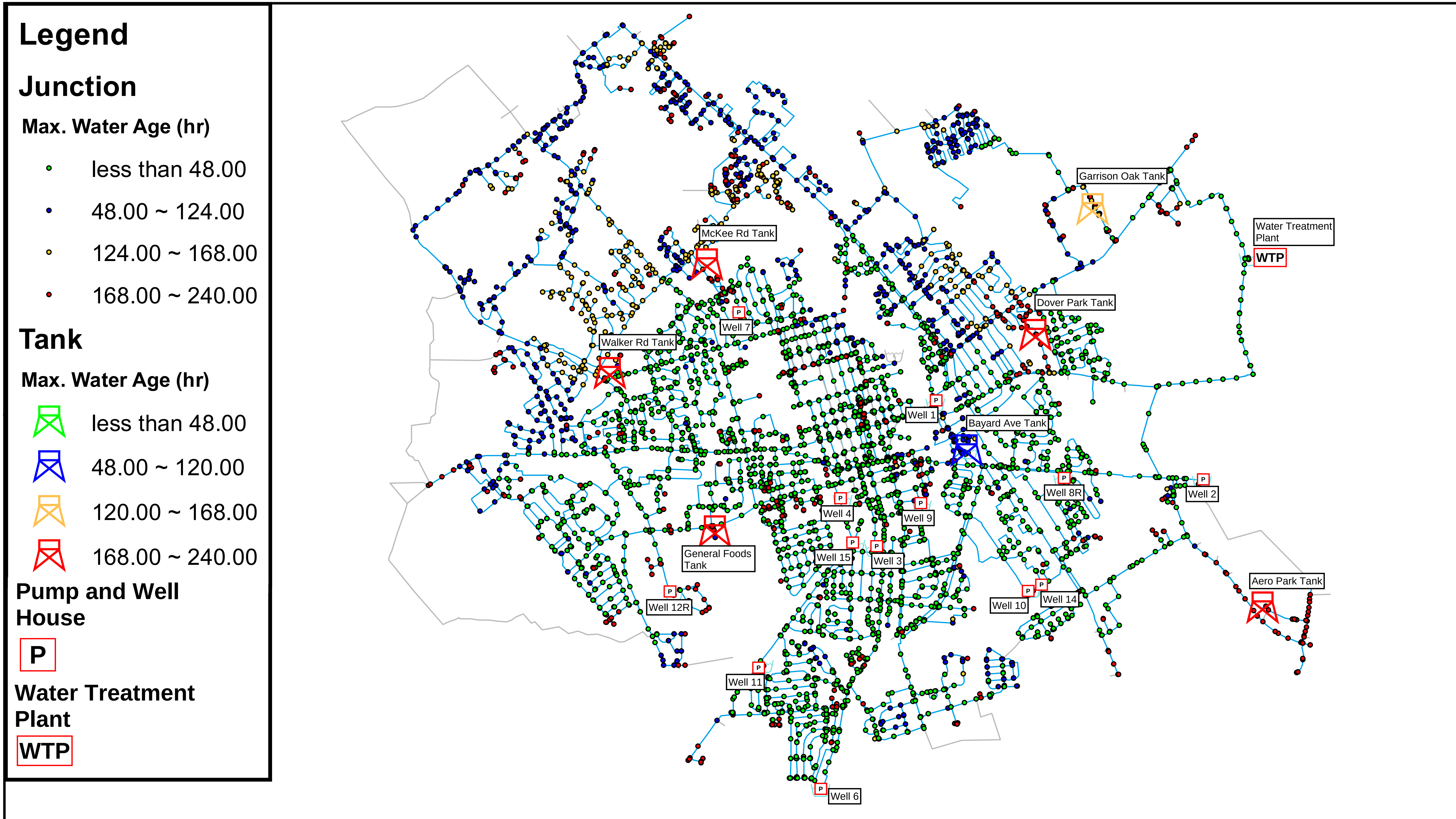


Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

The City of Dover Delaware

City of Dover, Delaware
Water System Master Plan

Appendix F.5
2019 J11512 Fire Flow
Minimum Pressure and
Maximum Water Velocity



Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

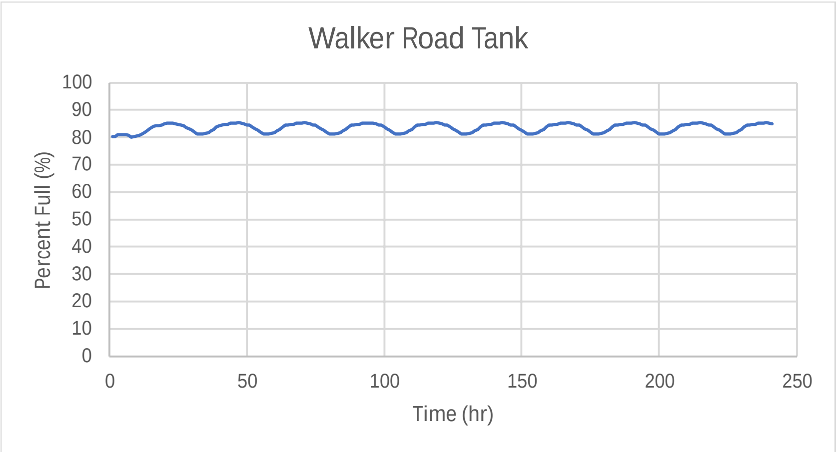
City of Dover, Delaware
Water System Master Plan

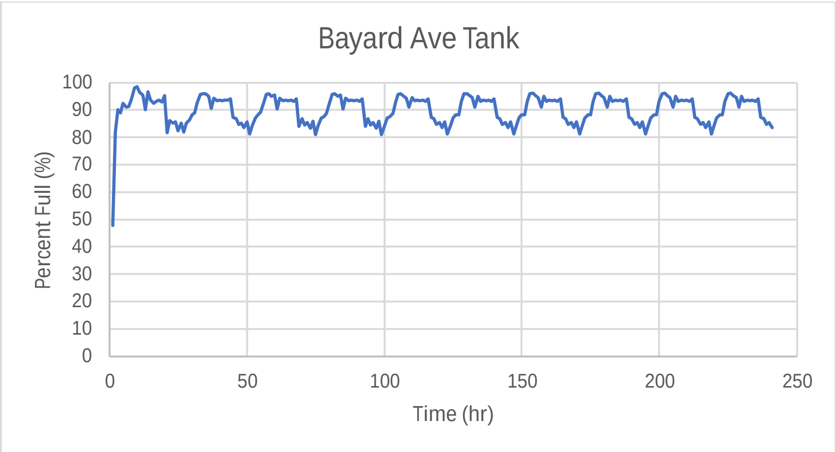
Appendix F.6
2019 System Water Age

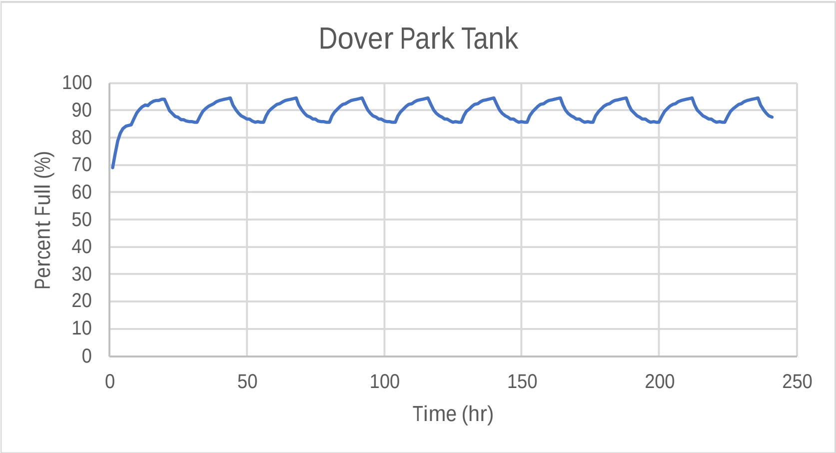
2019 ADD TANK LEVELS

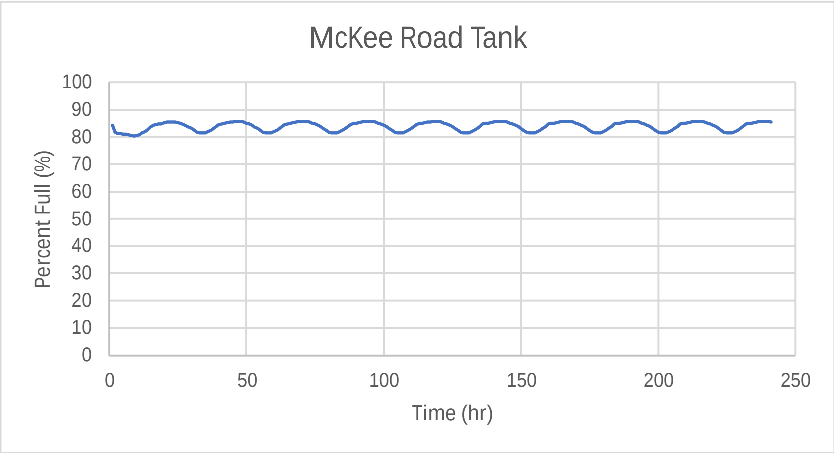
City of Dover, DE
Water Master Plan Draft

Appendix F
June 2021





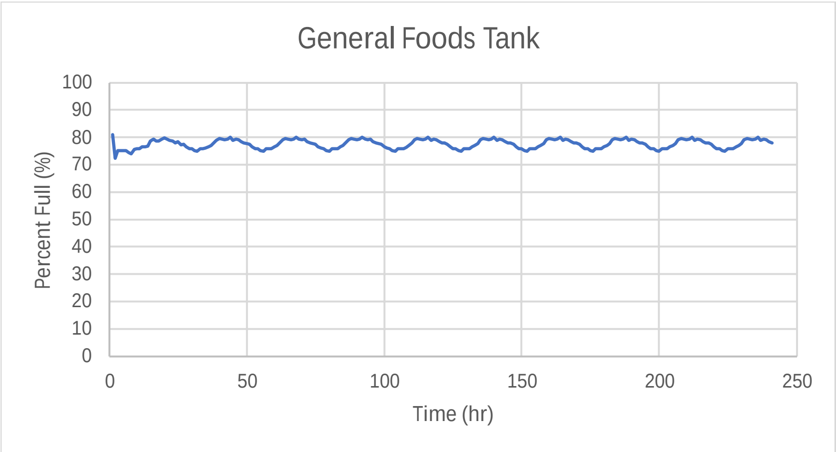


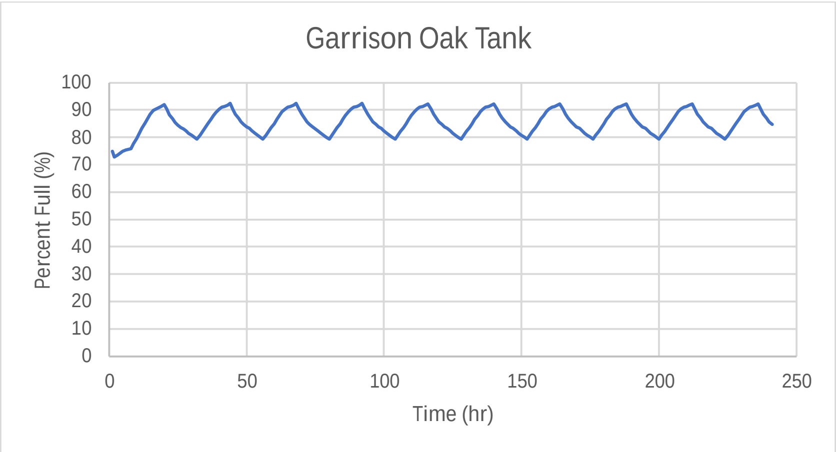


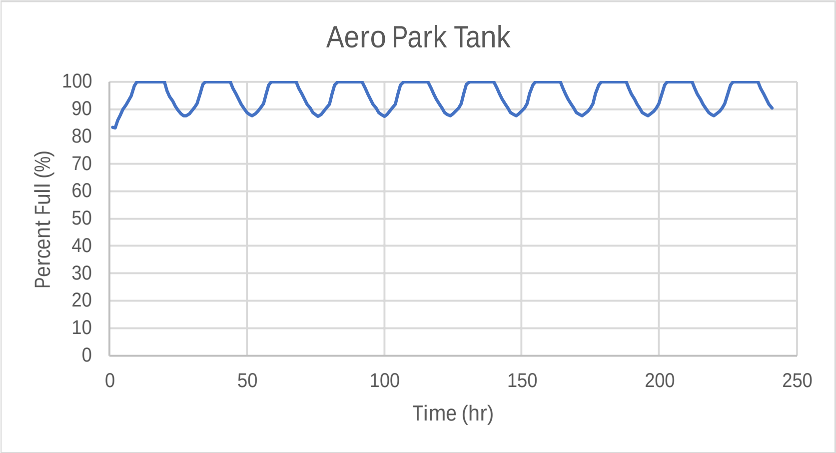
2019 ADD TANK LEVELS

City of Dover, DE
Water Master Plan Draft

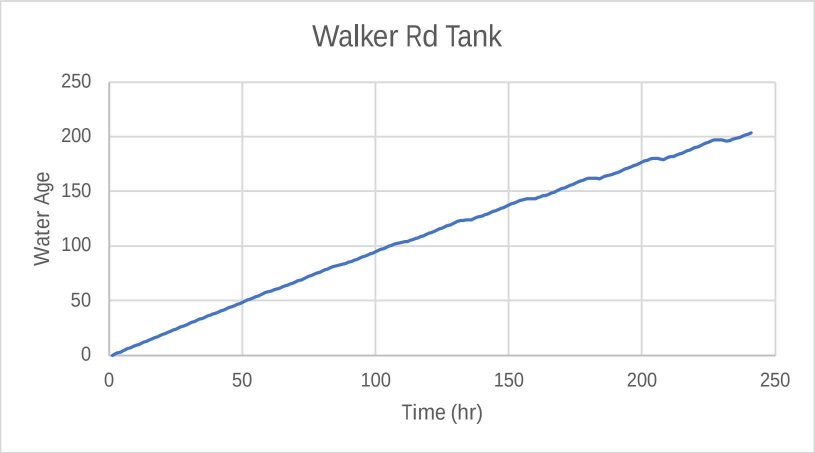
Appendix F
June 2021

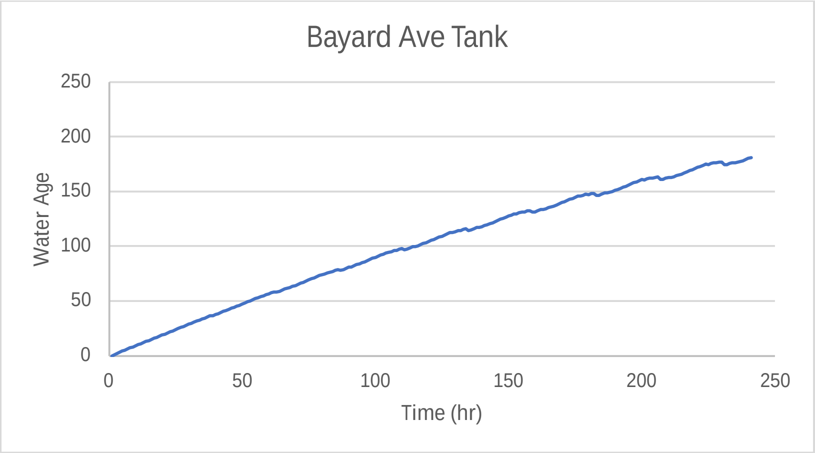


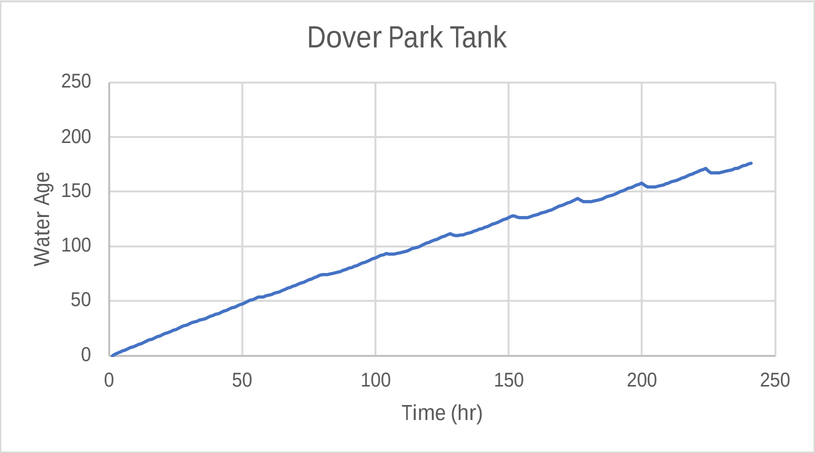


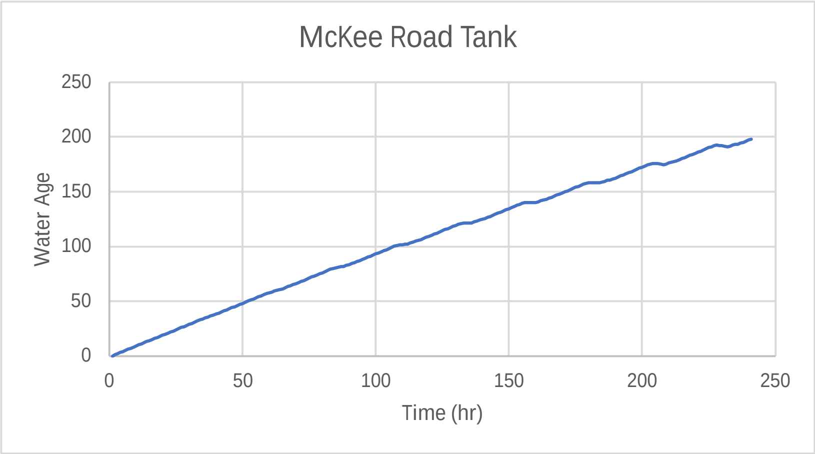


2019 ADD TANK WATER AGE

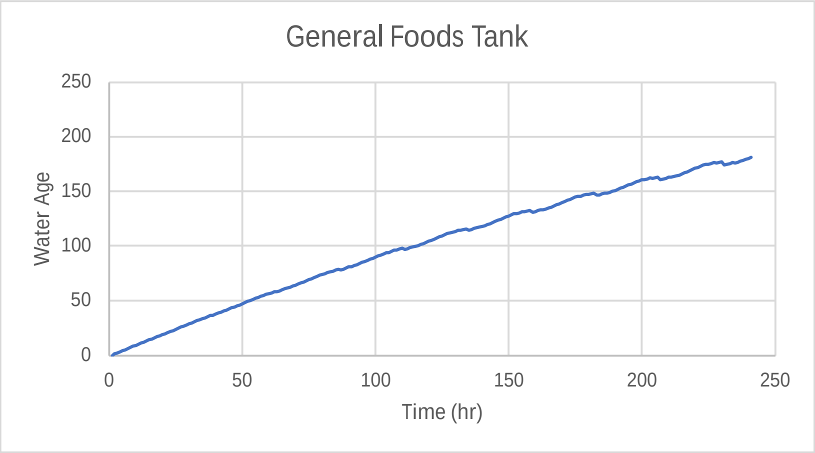


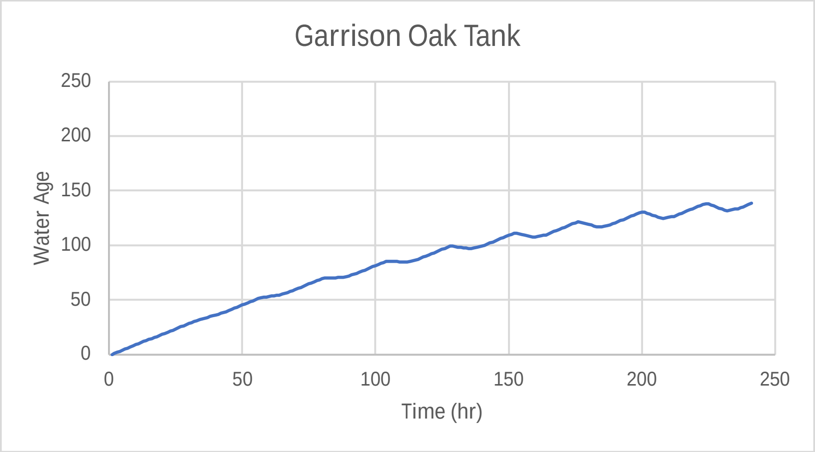






2019 ADD TANK WATER AGE





Legend

Pipe

Max. Velocity (ft/s)

- less than 1.00
- 1.00 ~ 2.00
- 2.00 ~ 3.00
- 3.00 ~ 4.00
- 4.00 ~ 5.00

Junction

Min. Pressure (PSI)

- less than 20.00
- 20.00 ~ 35.00
- 35.00 ~ 40.00
- 40.00 ~ 50.00
- 50.00 ~ 70.00

Water Treatment Plant

WTP

Pump and Well House

P

Tank

0 0.25 0.5 1 1.5 2 Miles

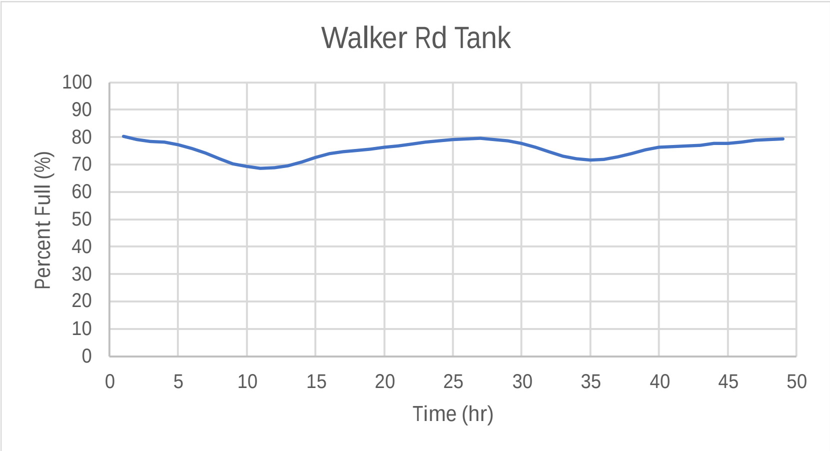
City of Dover, Delaware
Water System Master Plan

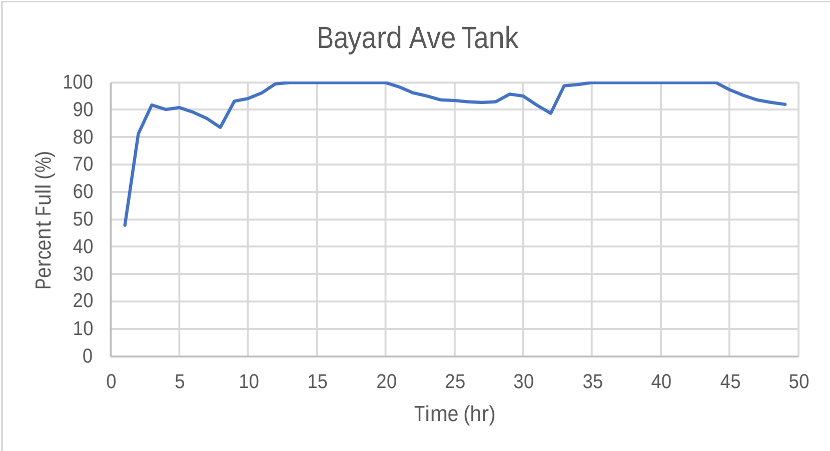
Appendix F.7
2025 System Minimum Pressure and Maximum Water Velocity

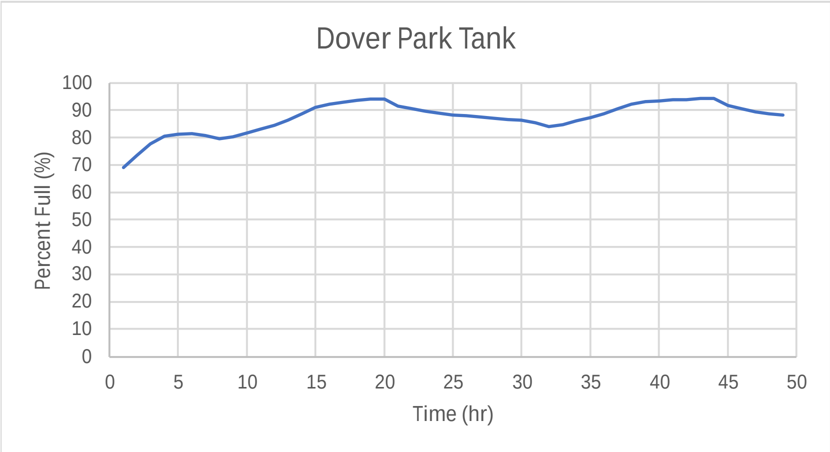
2025 MDD TANK LEVELS

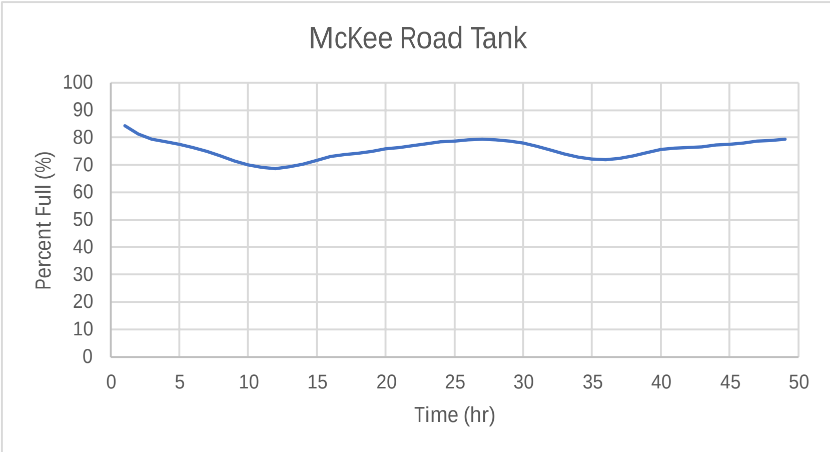
City of Dover, DE
Water Master Plan Draft

Appendix F
June 2021





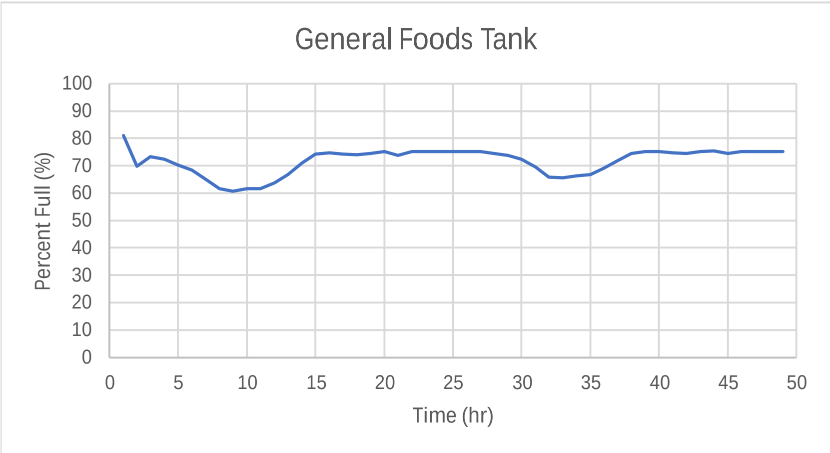


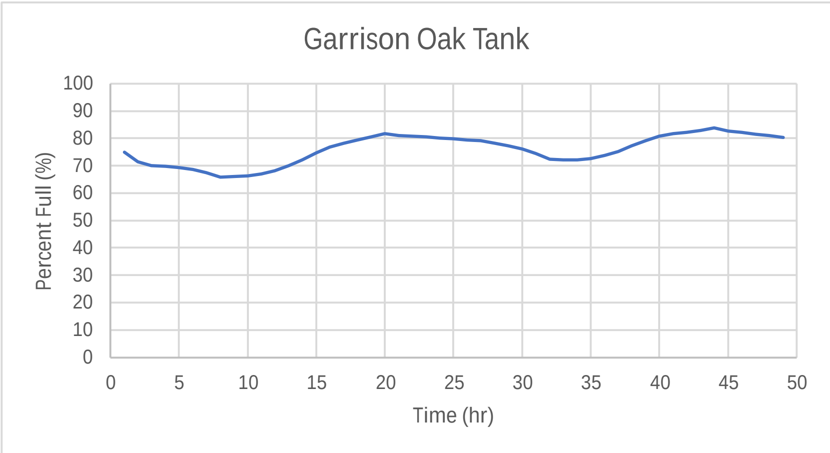


2025 MDD TANK LEVELS

City of Dover, DE
Water Master Plan Draft

Appendix F
June 2021





Legend

Junction

Hydrant Flow Available (gpm)

- less than 2,000.00
- 2,000.00 ~ 10,000.00

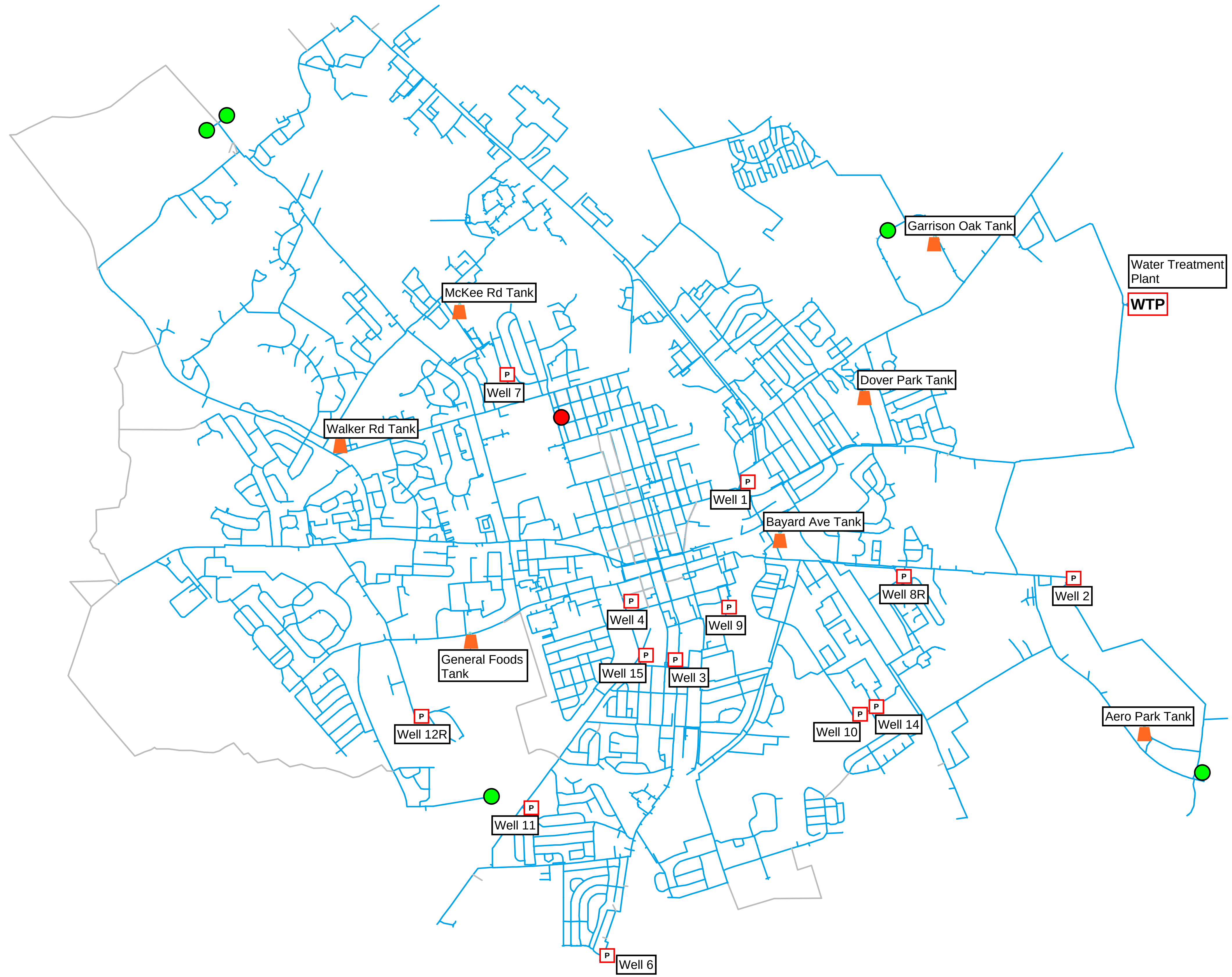
Tank

Pump and Well House

P

Water Treatment Plant

WTP



0 0.25 0.5 1 1.5 2 Miles

Whitman, Requardt & Associates, LLP 1915 100 YEARS 2015

City of Dover, Delaware
Water System Master Plan

Appendix F.8
2025 Max. Day Steady State Fire Flow (6 ft/s)

ID	Static Demand (gpm)	Static Pressure (psi)	Static Head (ft)	Fire-Flow Demand (gpm)	Residual Pressure (psi)	Hydrant Available Flow (gpm)	Hydrant Pressure at Available Flow (psi)	Critical Pipe ID at Available Flow	Critical Pipe Velocity at Available Flow (ft/s)
J19862	0.00	56.36	145.06	2,000.00	54.71	5,704.96	48.15	3775	5.98
J24268	0.56	49.39	146.98	2,000.00	43.93	1,679.23	45.23	P12653	6.01
J26518	4.09	56.87	150.24	2,000.00	44.12	2,115.07	42.85	P12439	6
J26524	7.87	49.19	144.54	2,000.00	24.64	2,115.07	22.2	P13021	6
J26530	28.46	61.45	141.82	2,000.00	47.52	2,115.07	46.49	P12451	6
J26532	41.01	61.45	141.82	2,000.00	47.76	2,115.07	46.91	P12449	6

ID	Static Demand (gpm)	Static Pressure (psi)	Static Head (ft)	Fire-Flow Demand (gpm)	Residual Pressure (psi)	Hydrant Available Flow (gpm)	Hydrant Pressure at Available Flow (psi)	Critical Pipe ID at Available Flow	Critical Pipe Velocity at Available Flow (ft/s)
J19862	0	56.36	145.06	2,000.00	54.71	3,878.92	52	3775	3.97
J24268	0.56	49.39	146.98	2,000.00	43.93	1,119.49	46.93	P12653	4.03
J26518	4.09	56.87	150.24	2,000.00	44.12	1,410.04	49.92	P12439	4
J26524	7.87	49.19	144.54	2,000.00	24.64	1,410.04	36.22	P13021	4
J26530	28.46	61.45	141.82	2,000.00	47.52	1,410.04	53.87	P12451	4
J26532	41.01	61.45	141.82	2,000.00	47.76	1,410.04	54.1	P12449	4

Legend

Junction

Min. Pressure (PSI)

- less than 20.00
- 20.00 ~ 35.00
- 35.00 ~ 40.00
- 40.00 ~ 50.00
- 50.00 ~ 70.00

Pipe

Max. Velocity (ft/s)

- less than 1.00
- 1.00 ~ 2.00
- 2.00 ~ 3.00
- 3.00 ~ 4.00
- 4.00 ~ 30.00

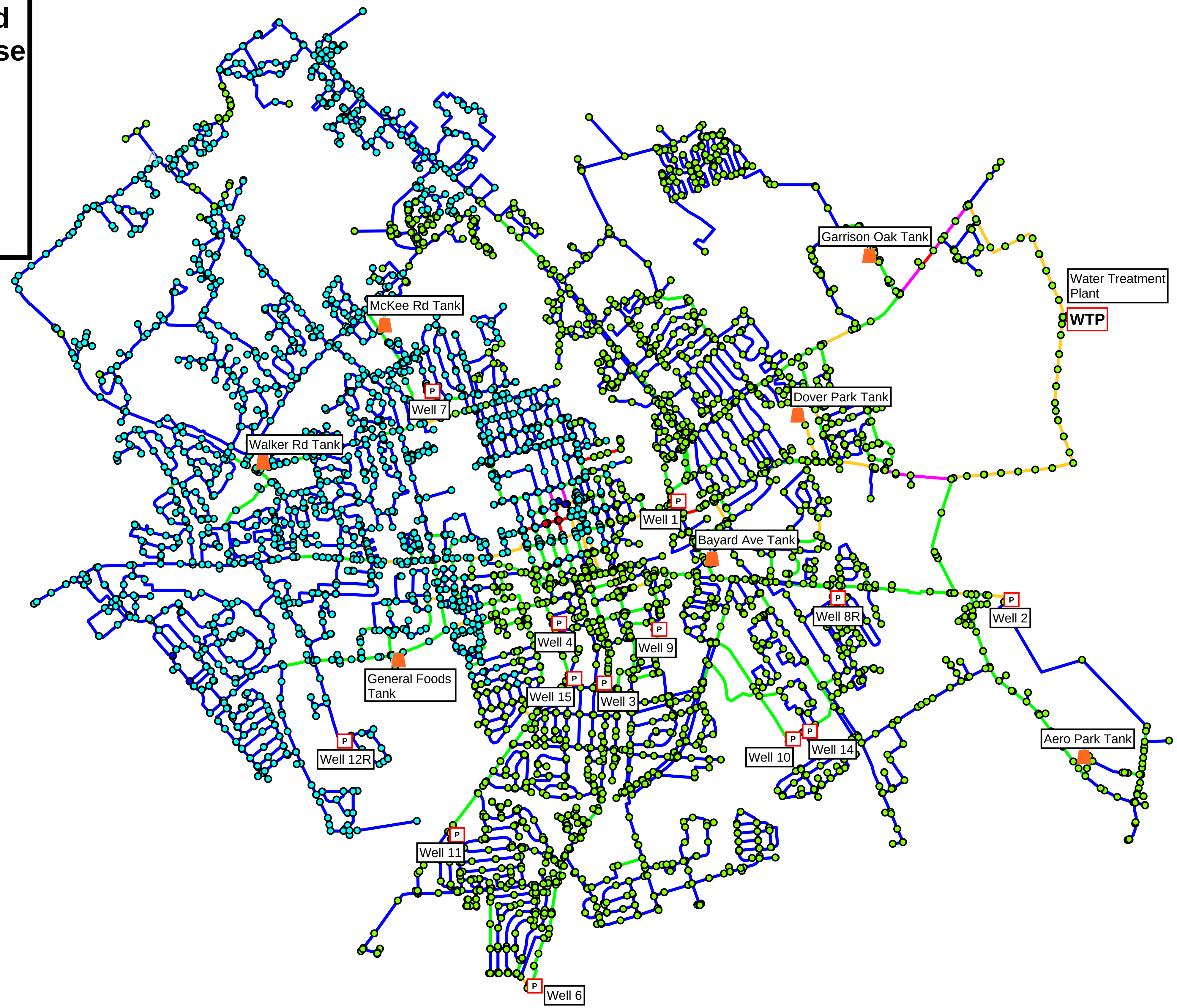
Water Treatment Plant

WTP

Pump and Well House

P

Tank



0 0.25 0.5 1 1.5 2 Miles

Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

City of Dover, Delaware
Water System Master Plan

Appendix F.9
2025 J15662 Fire Flow
Minimum Pressure and
Maximum Water Velocity

Legend

Junction

Min. Pressure (PSI)

- less than 20.00
- 20.00 ~ 35.00
- 35.00 ~ 40.00
- 40.00 ~ 50.00
- 50.00 ~ 70.00

Pipe

Max. Velocity (ft/s)

- less than 1.00
- 1.00 ~ 2.00
- 2.00 ~ 3.00
- 3.00 ~ 4.00
- 4.00 ~ 30.00

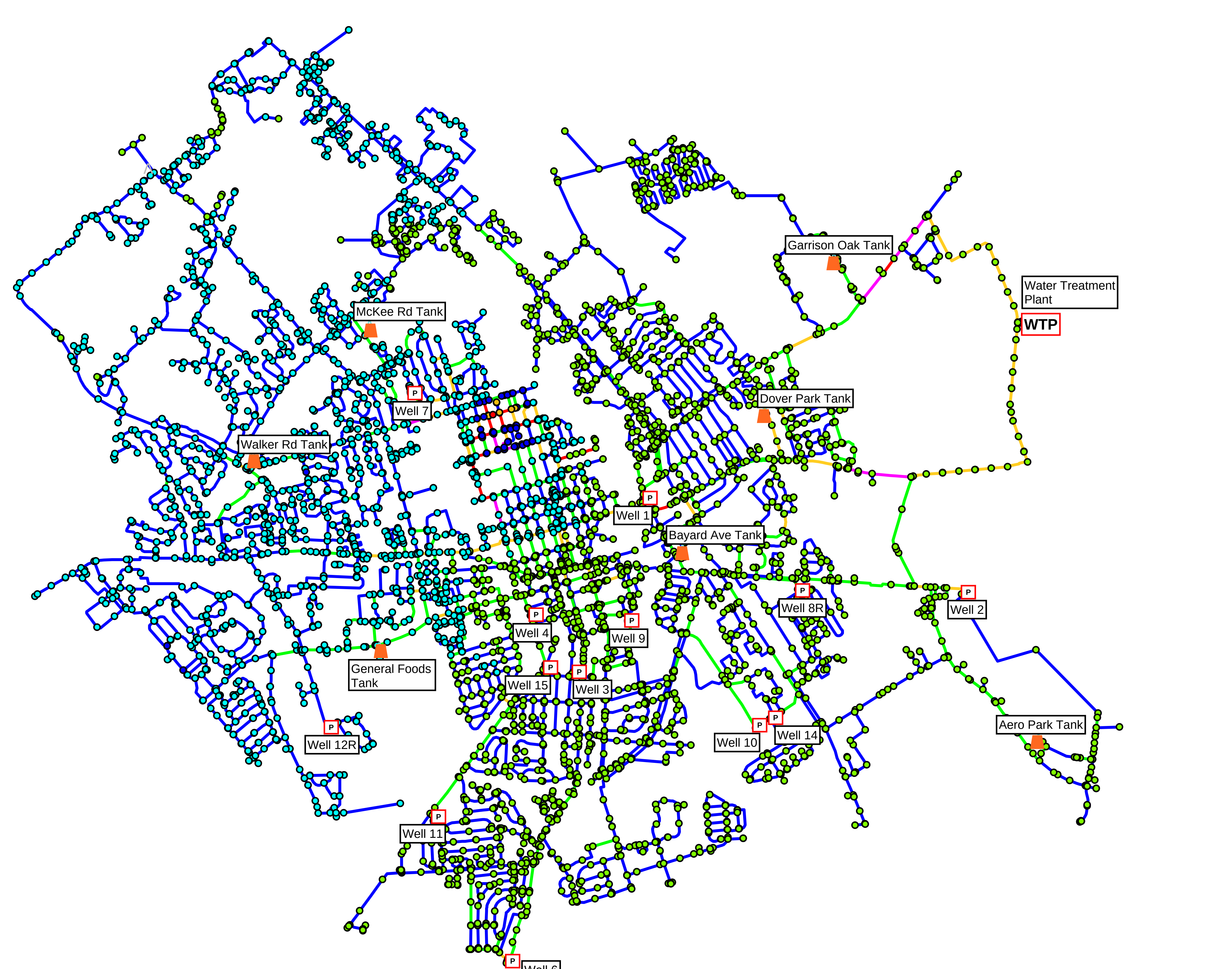
Water Treatment Plant

WTP

Pump and Well House

P

Tank



Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

0 0.25 0.5 1 1.5 2 Miles

City of Dover, Delaware
Water System Master Plan

Appendix F.10
2025 J11512 Fire Flow
Minimum Pressure and
Maximum Water Velocity

Legend

Junction

Min. Pressure (PSI)

- less than 20.00
- 20.00 ~ 35.00
- 35.00 ~ 40.00
- 40.00 ~ 50.00
- 50.00 ~ 70.00

Pipe

Max. Velocity (ft/s)

- less than 1.00
- 1.00 ~ 2.00
- 2.00 ~ 3.00
- 3.00 ~ 4.00
- 4.00 ~ 30.00

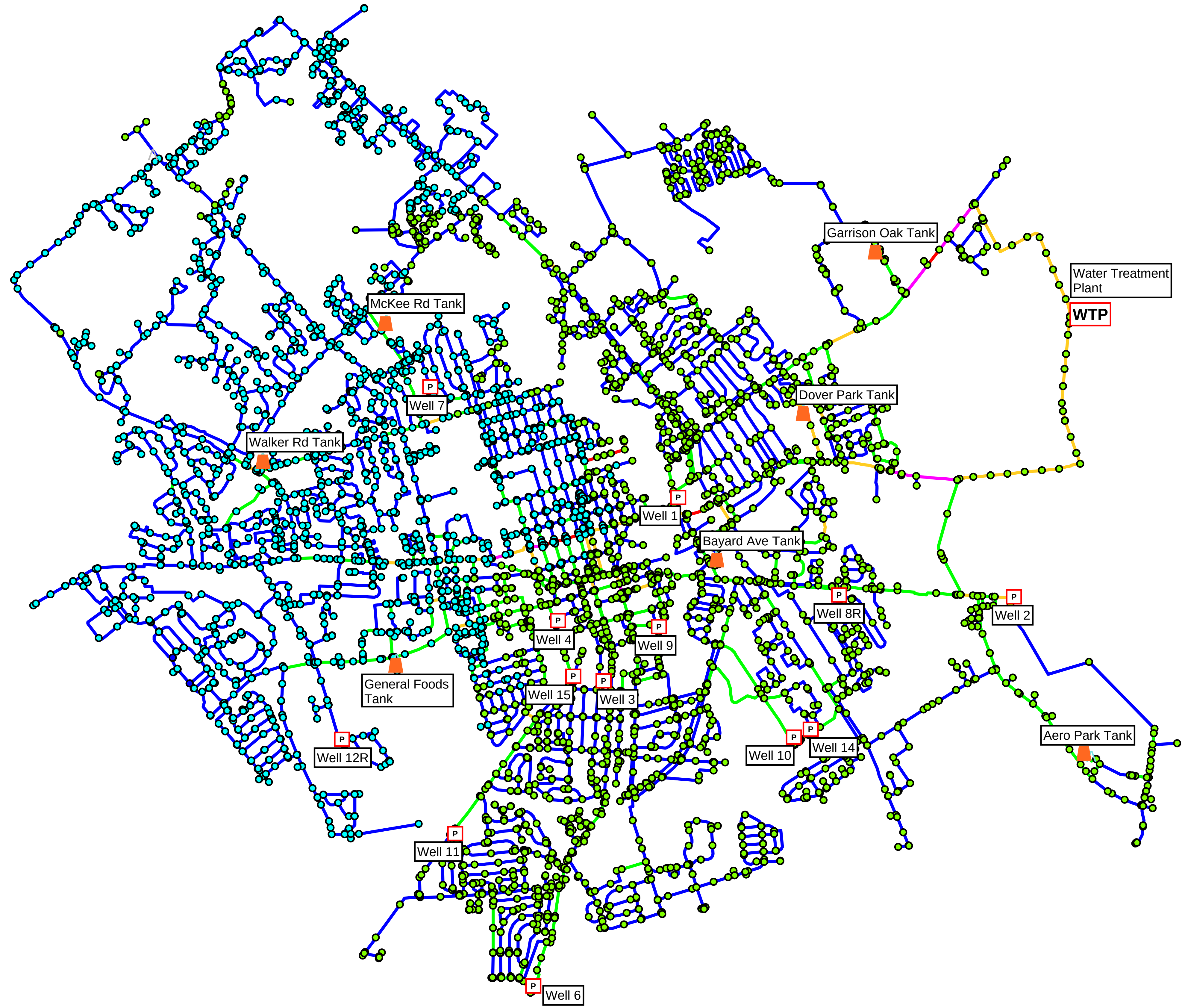
Water Treatment Plant

WTP

Pump and Well House

P

Tank

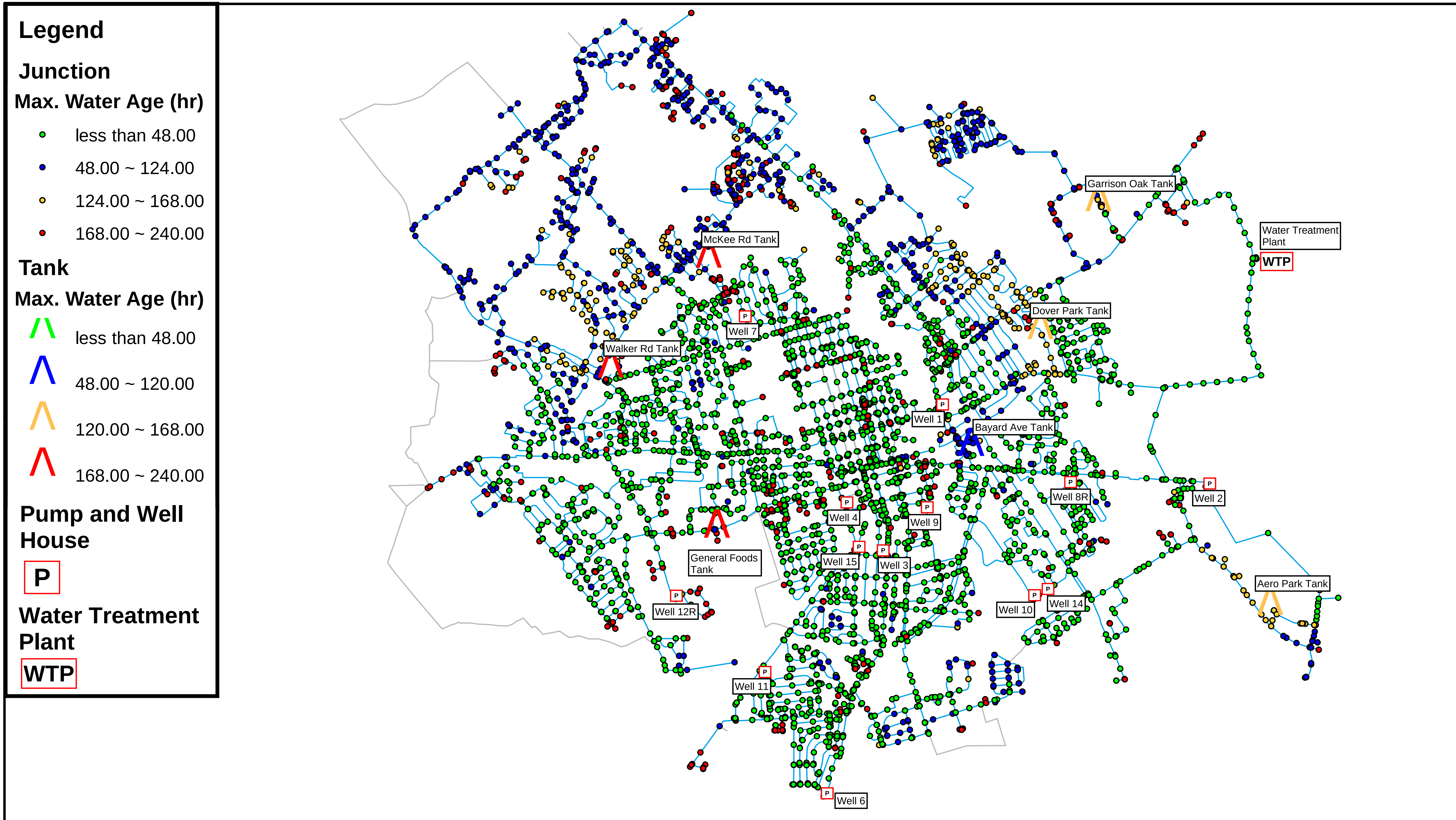


0 0.25 0.5 1 1.5 2 Miles

City of Dover, Delaware
Water System Master Plan

Appendix F.11
2025 J15534 Fire Flow
Minimum Pressure and
Maximum Water Velocity

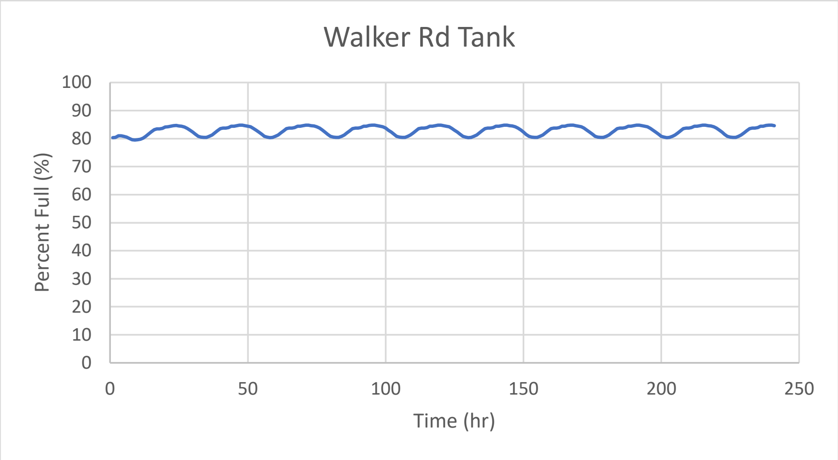
Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

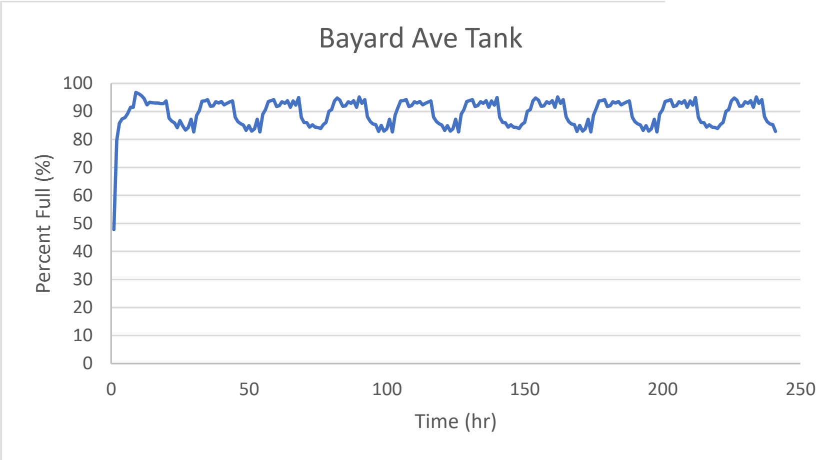


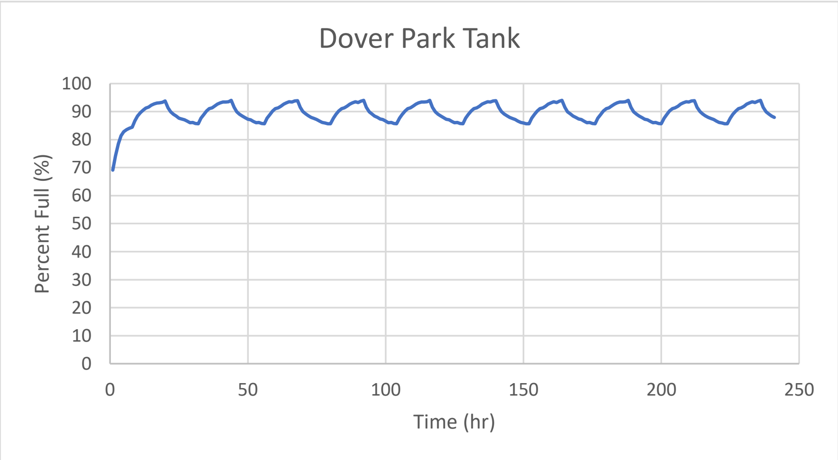
City of Dover, Delaware
Water System Master Plan

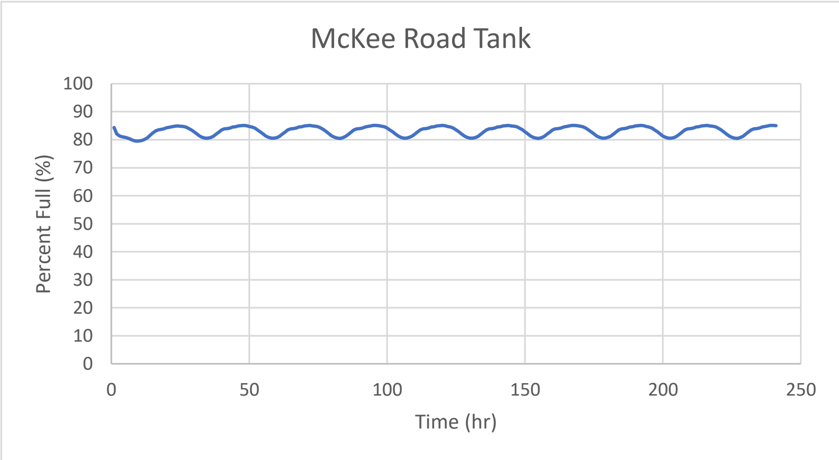
Figure 7.12
2025 System Water Age

2025 ADD TANK LEVELS





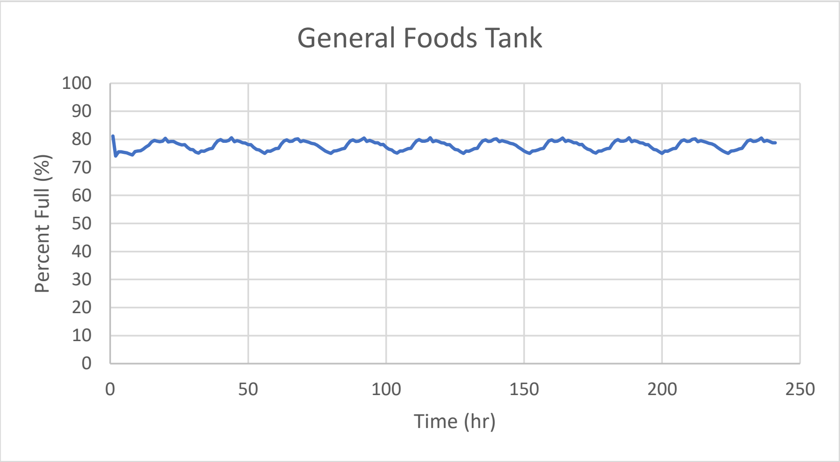


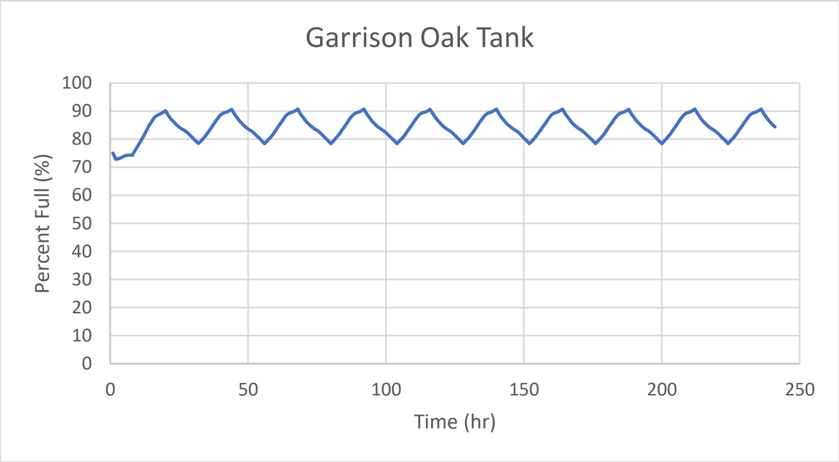


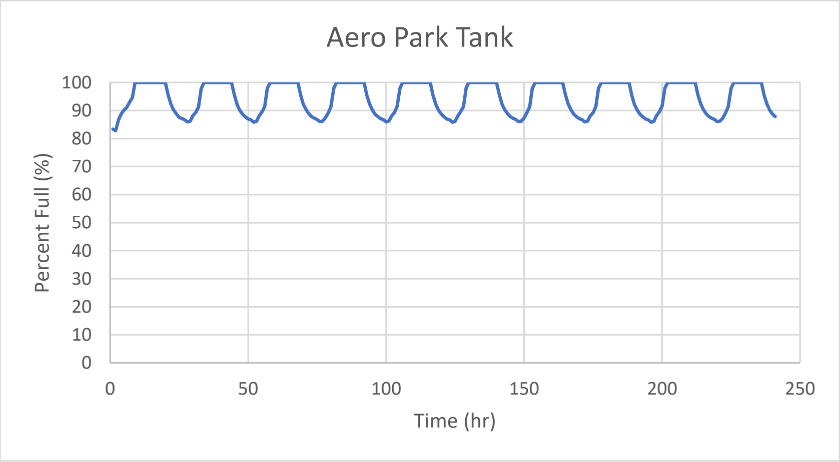
2025 ADD TANK LEVELS

City of Dover, DE
Water Master Plan Draft

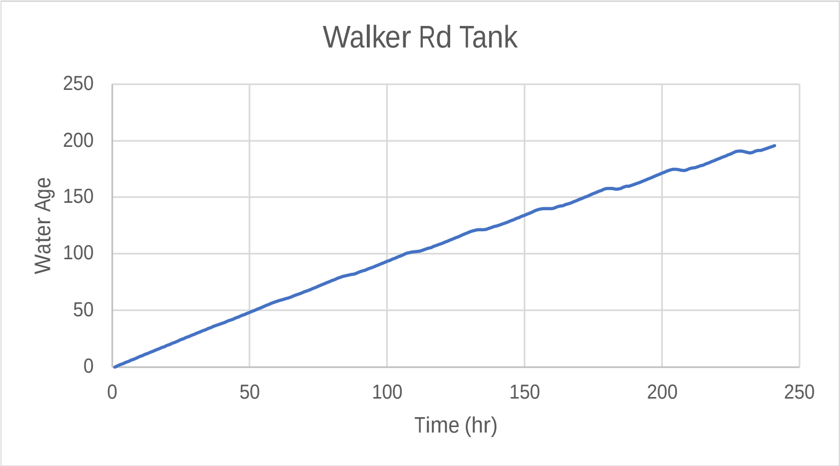
Appendix F
June 2021

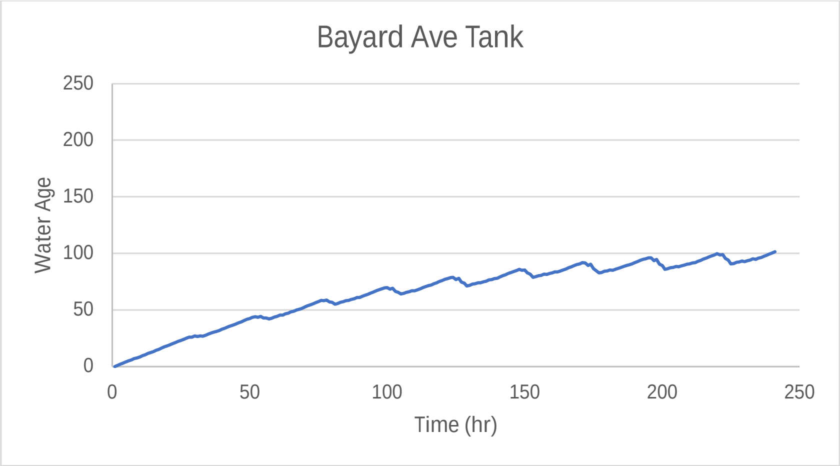


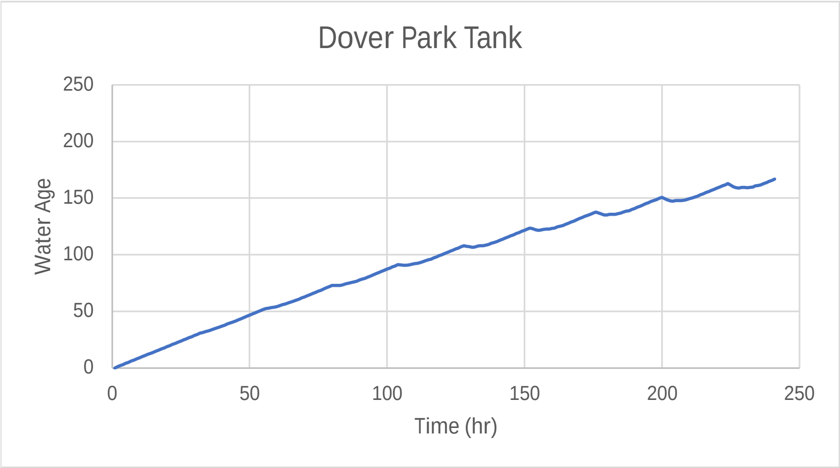


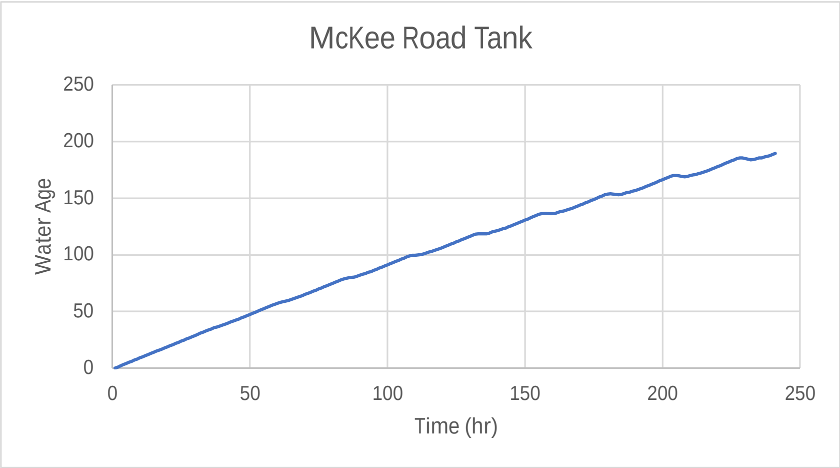


2025 ADD TANK WATER AGE

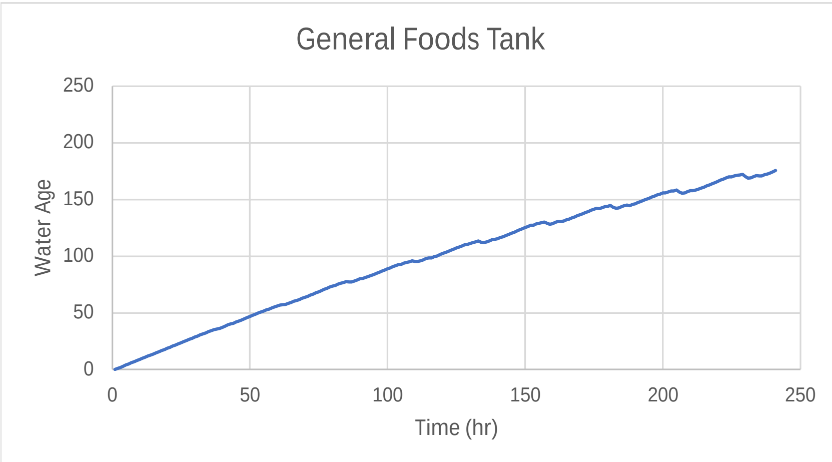


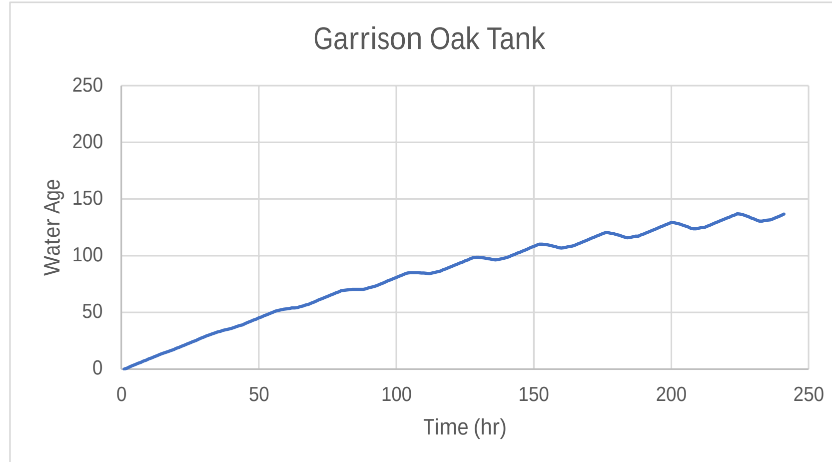






2025 ADD TANK WATER AGE





Legend

Pipe

Max. Velocity (ft/s)

- less than 1.00
- 1.00 ~ 2.00
- 2.00 ~ 3.00
- 3.00 ~ 4.00
- 4.00 ~ 5.00

Junction

Min. Pressure (PSI)

- less than 20.00
- 20.00 ~ 35.00
- 35.00 ~ 40.00
- 40.00 ~ 50.00
- 50.00 ~ 70.00

Water Treatment Plant

WTP

Pump and Well House

P

Tank

Whitman, Requardt & Associates, LLP 1915 100 YEARS 2015

0 0.25 0.5 1 1.5 2 Miles

City of Dover, Delaware
Water System Master Plan

Appendix F.13
2030 System Minimum Pressure and Maximum Water Velocity

2030 MDD TANK LEVELS

City of Dover, DE
Water Master Plan Draft

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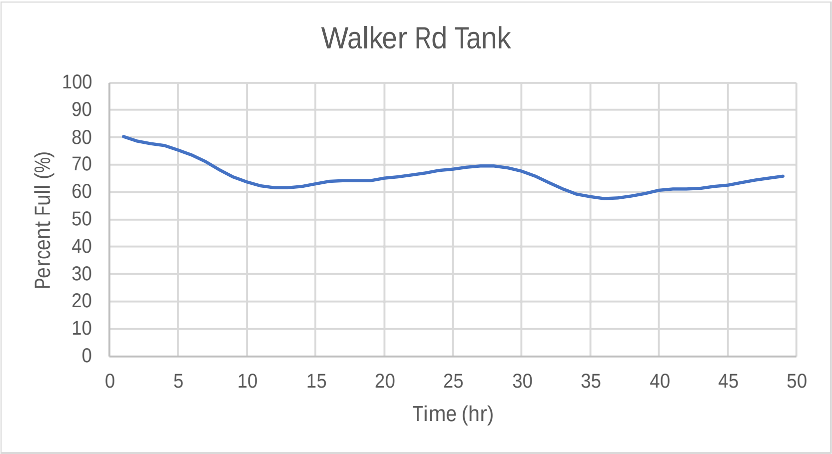
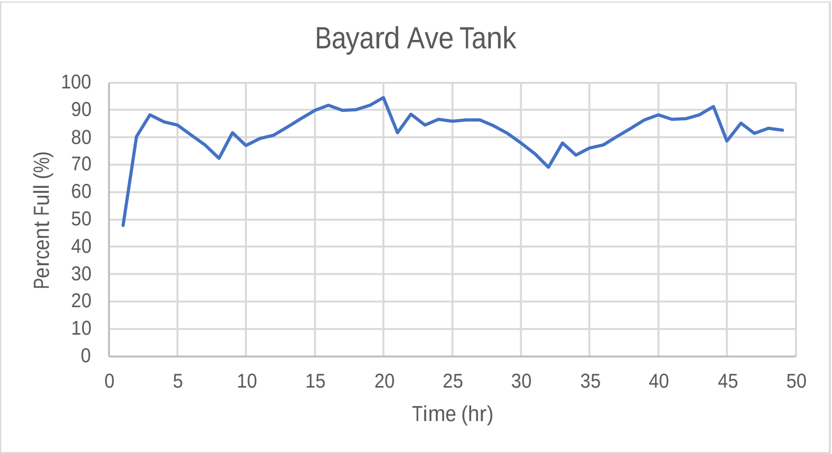
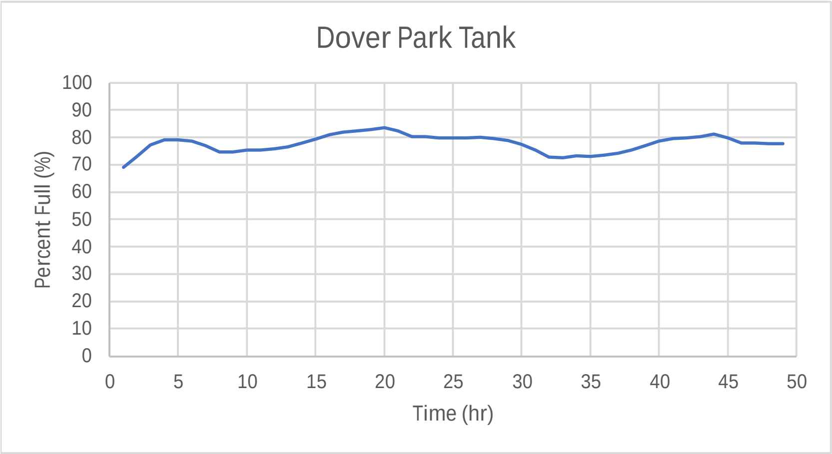
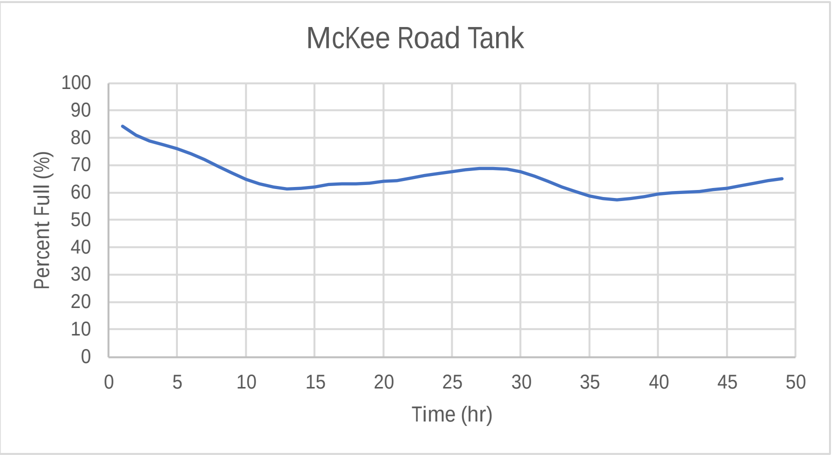
June 2021









2030 MDD TANK LEVELS

City of Dover, DE
Water Master Plan Draft

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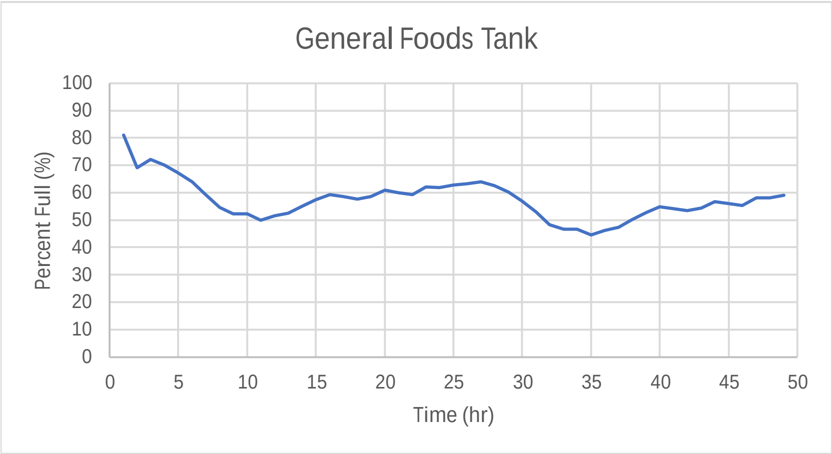
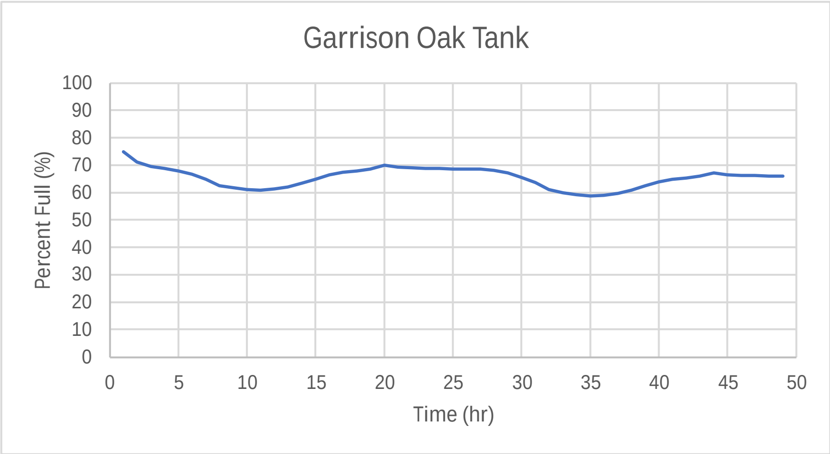
June 2021





Legend

Junction

Hydrant Flow Available (gpm)

- less than 2,000.00
- 2,000.00 ~ 10,000.00

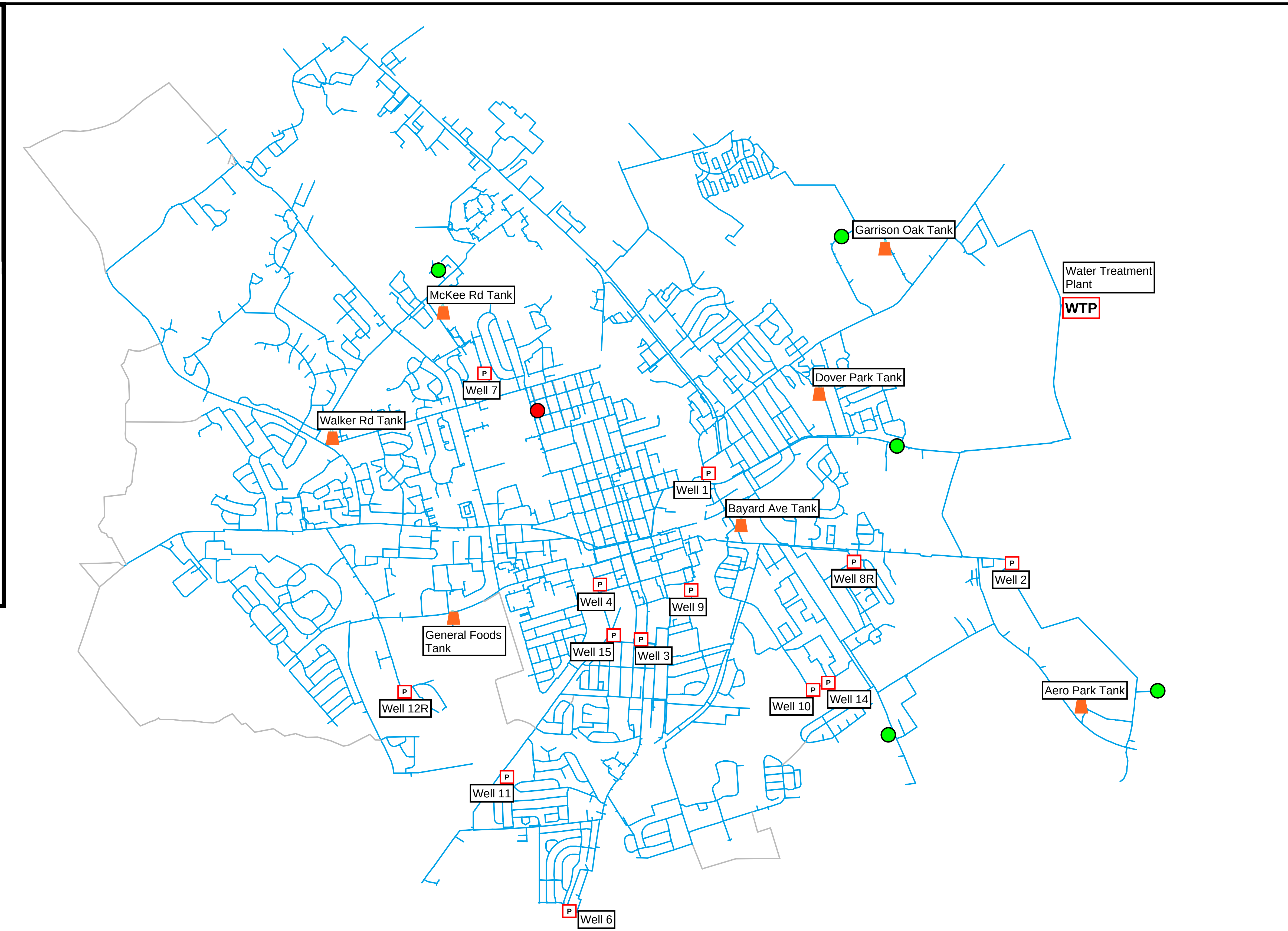
Tank

Pump and Well House

P

Water Treatment Plant

WTP



Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

0 0.25 0.5 1 1.5 2 Miles

City of Dover, Delaware
Water System Master Plan

Appendix F.14
2030 Max. Day
Steady State Fire Flow (6 ft/s)

ID	Static Demand (gpm)	Static Pressure (psi)	Static Head (ft)	Fire-Flow Demand (gpm)	Residual Pressure (psi)	Hydrant Available Flow (gpm)	Hydrant Pressure at Available Flow (psi)	Critical Pipe ID at Available Flow	Critical Pipe Velocity at Available Flow (ft/s)
J19862	0	56.29	144.92	2,000.00	54.61	5,627.47	48.16	3775	5.95
J24268	0.55	49.3	146.79	2,000.00	44.11	1,679.13	45.33	P12653	6.02
J26534	29.72	56.92	146.36	2,000.00	34.94	2,115.07	33.43	P12453	6
J26698	25.58	55.3	145.62	2,000.00	52.48	2,115.07	52.29	P12637	6
J26700	7.72	50.38	148.28	2,000.00	38.1	2,115.07	36.97	P12639	6
J26702	52.76	49.15	141.44	2,000.00	31.69	2,115.07	30.77	P12643	6

ID	Static Demand (gpm)	Static Pressure (psi)	Static Head (ft)	Fire-Flow Demand (gpm)	Residual Pressure (psi)	Hydrant Available Flow (gpm)	Hydrant Pressure at Available Flow (psi)	Critical Pipe ID at Available Flow	Critical Pipe Velocity at Available Flow (ft/s)
J19862	0	56.29	144.92	2,000.00	54.61	3,829.03	51.95	3775	3.98
J24268	0.55	49.3	146.79	2,000.00	44.11	1,119.42	46.96	P12653	4.04
J26534	29.72	56.92	146.36	2,000.00	34.94	1,410.04	44.5	P12453	4
J26698	25.58	55.3	145.62	2,000.00	52.48	1,410.04	53.6	P12637	4
J26700	7.72	50.38	148.28	2,000.00	38.1	1,410.04	43.57	P12639	4
J26702	52.76	49.15	141.44	2,000.00	31.69	1,410.04	39.96	P12643	4

Legend

Junction

Min. Pressure (PSI)

- less than 20.00
- 20.00 ~ 35.00
- 35.00 ~ 40.00
- 40.00 ~ 50.00
- 50.00 ~ 70.00

Pipe

Max. Velocity (ft/s)

- less than 1.00
- 1.00 ~ 2.00
- 2.00 ~ 3.00
- 3.00 ~ 4.00
- 4.00 ~ 30.00

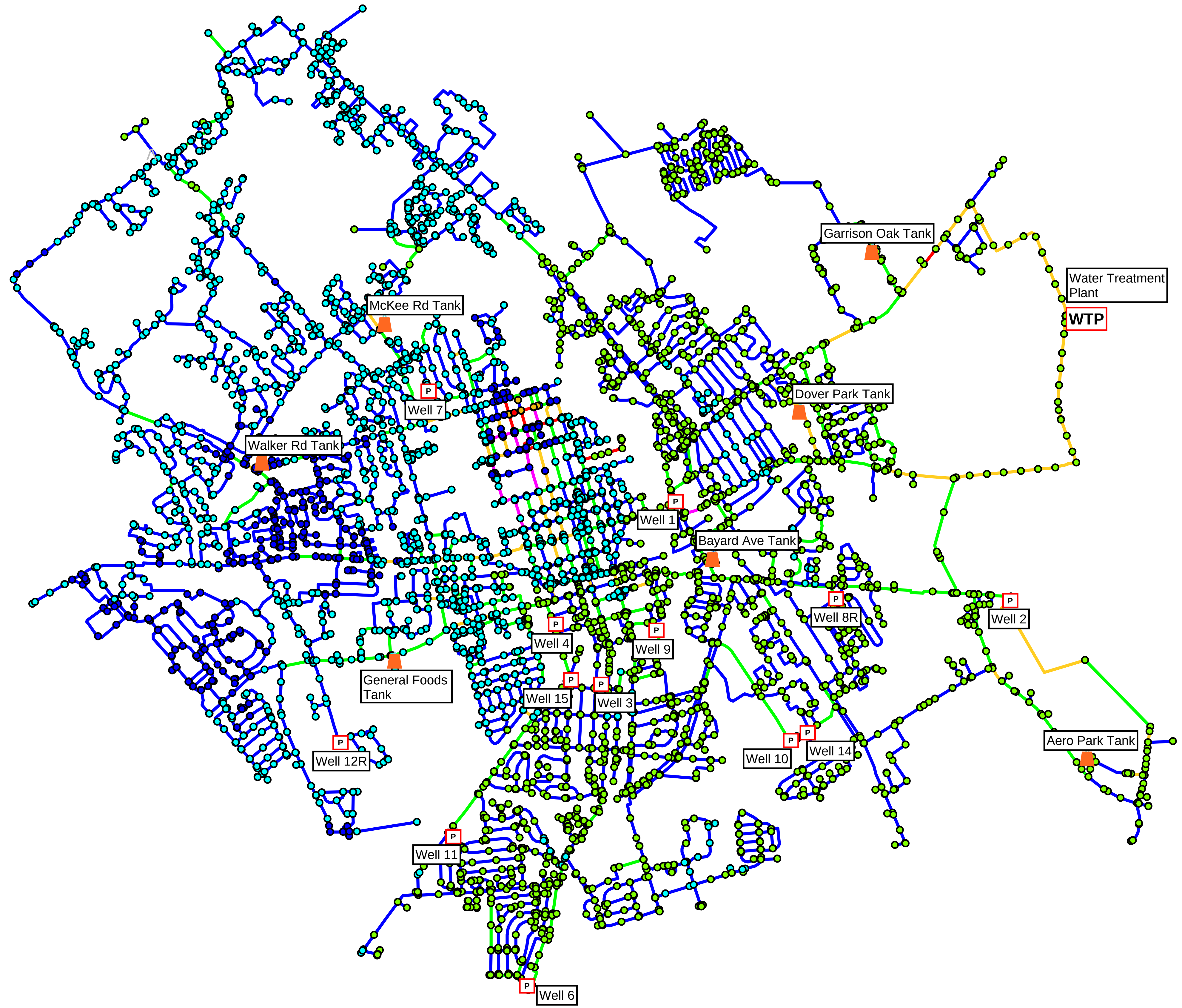
Water Treatment Plant

WTP

Pump and Well House

P

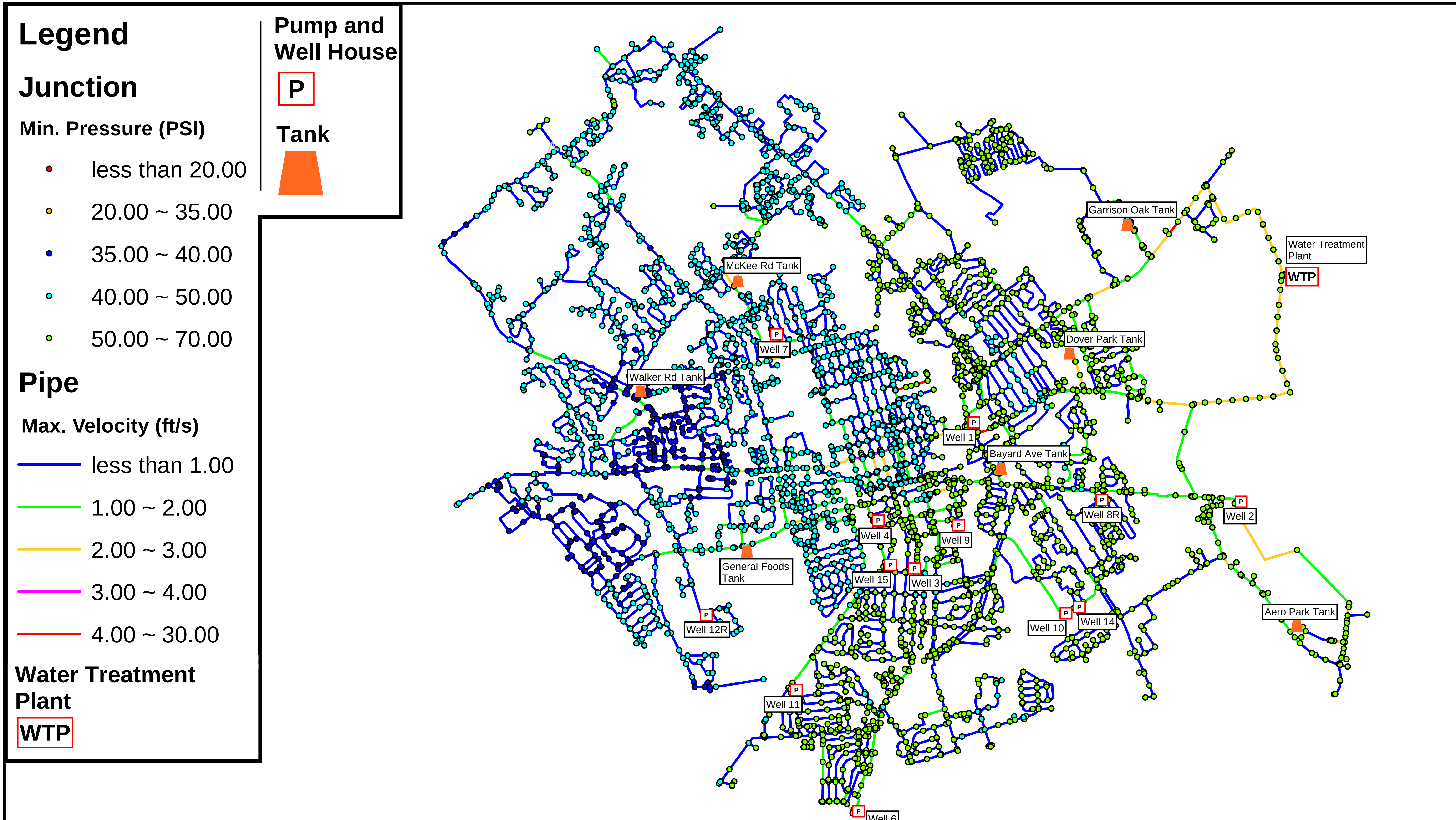
Tank



0 0.25 0.5 1 1.5 2 Miles

City of Dover, Delaware
Water System Master Plan

Appendix F.15
2030 J11512 Fire Flow
Minimum Pressure and
Maximum Water Velocity



City of Dover, Delaware
Water System Master Plan

Appendix F.16
2030 J15534 Fire Flow
Minimum Pressure and
Maximum Water Velocity

Legend

Junction

Min. Pressure (PSI)

- less than 20.00
- 20.00 ~ 35.00
- 35.00 ~ 40.00
- 40.00 ~ 50.00
- 50.00 ~ 70.00

Pipe

Max. Velocity (ft/s)

- less than 1.00
- 1.00 ~ 2.00
- 2.00 ~ 3.00
- 3.00 ~ 4.00
- 4.00 ~ 30.00

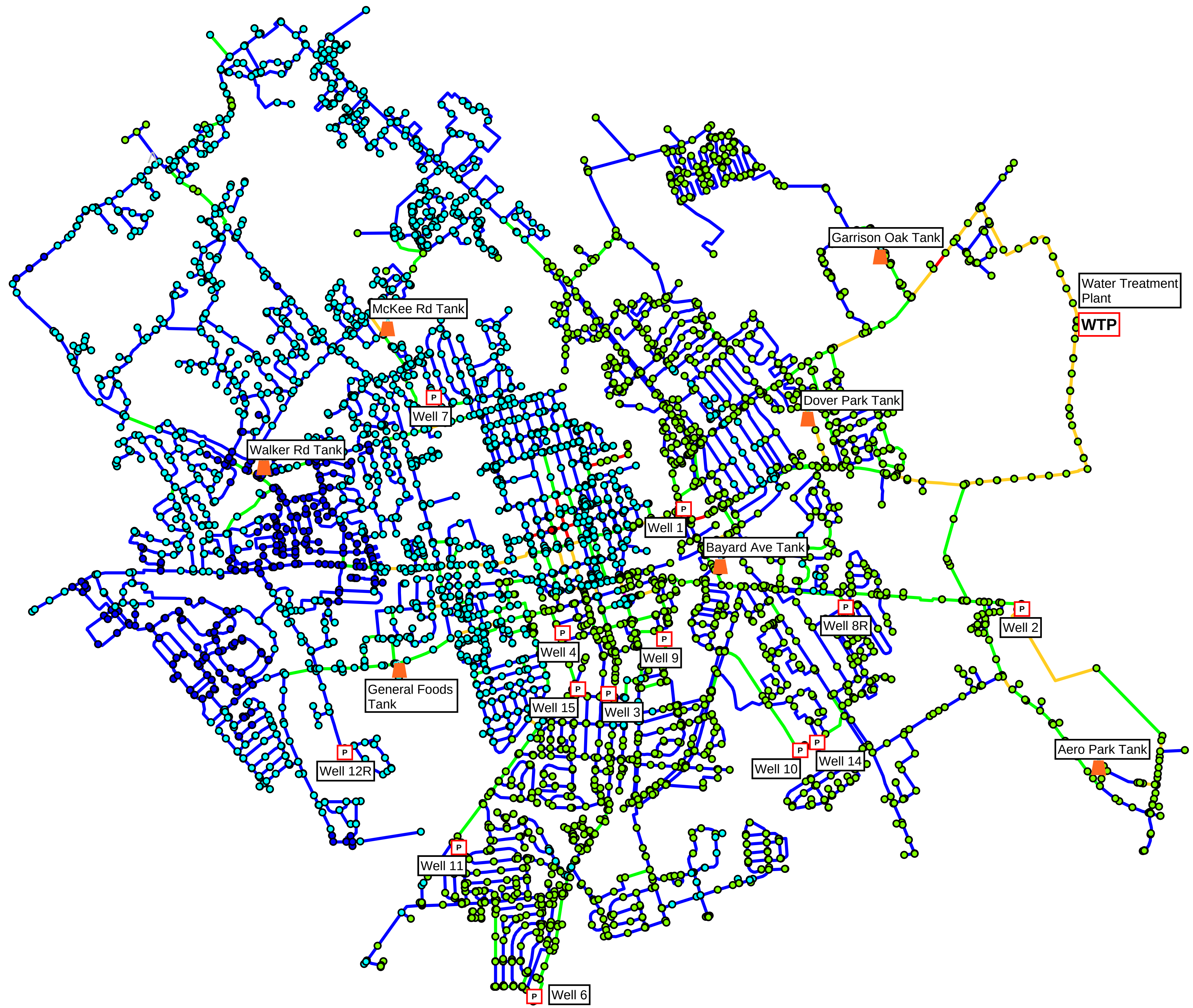
Water Treatment Plant

WTP

Pump and Well House

P

Tank

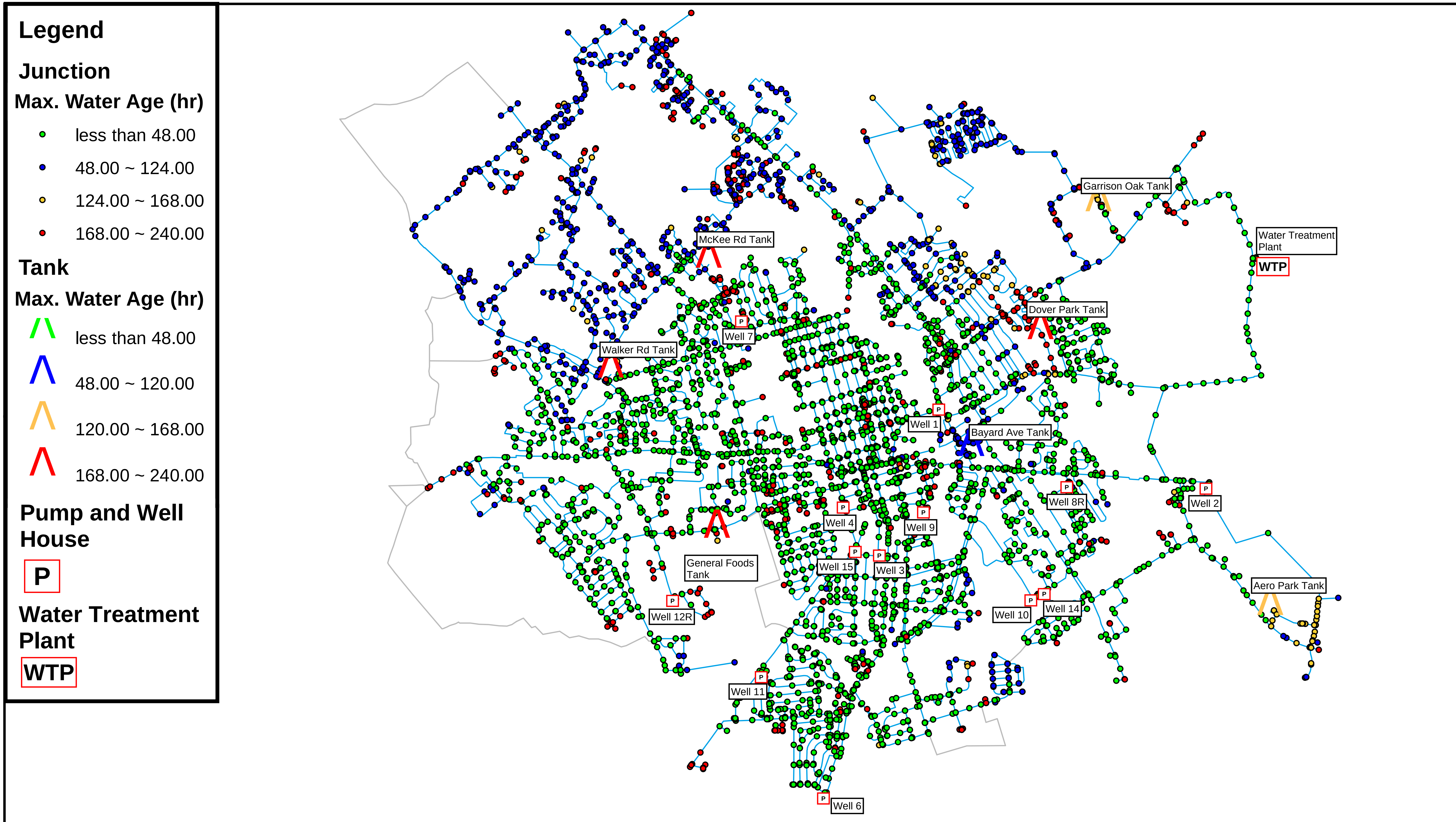


0 0.25 0.5 1 1.5 2 Miles

Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

City of Dover, Delaware
Water System Master Plan

Appendix F.17
2030 J15662 Fire Flow
Minimum Pressure and
Maximum Water Velocity



0 0.25 0.5 1 1.5 2 Miles

City of Dover, Delaware
Water System Master Plan

Appendix F.18
2030 System Water Age

2030 ADD TANK LEVELS

City of Dover, DE
Water Master Plan Draft

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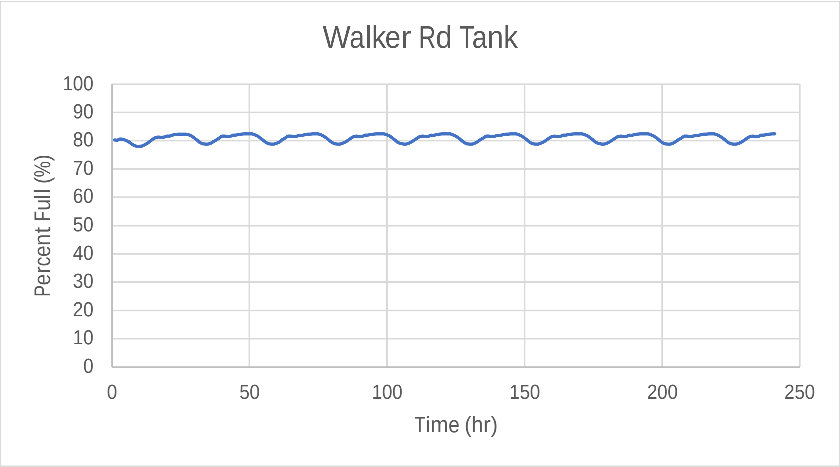
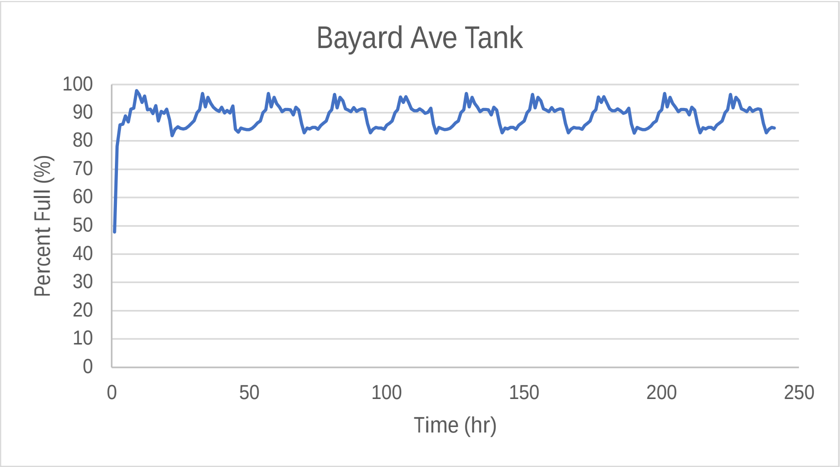
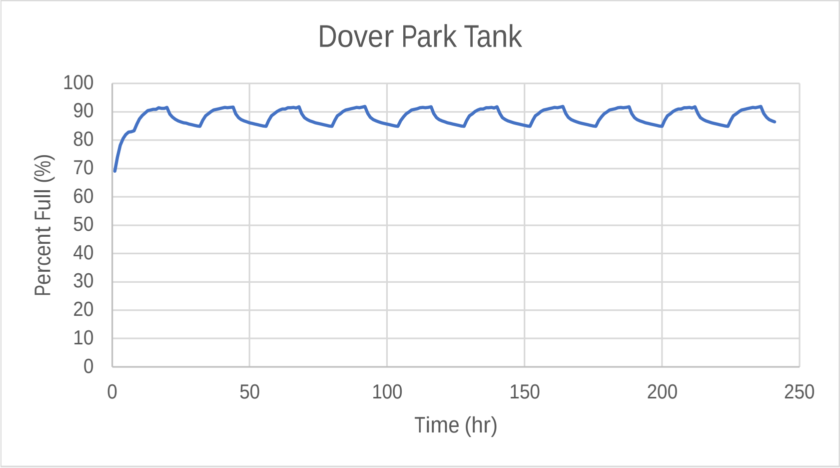
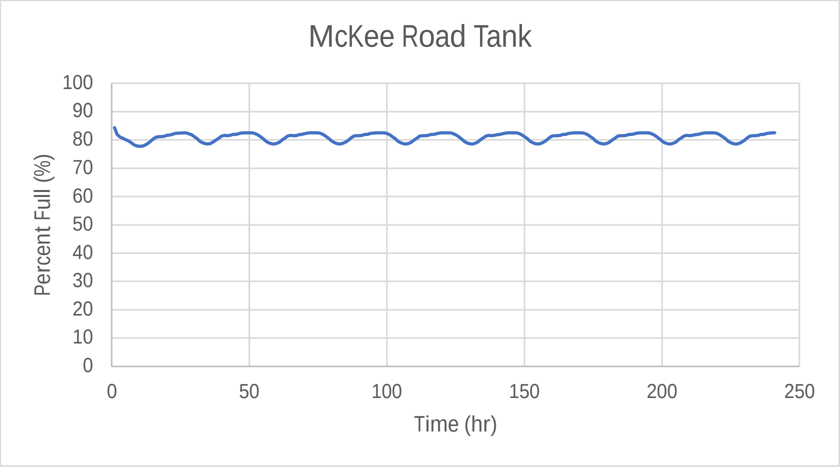
June 2021









2030 ADD TANK LEVELS

City of Dover, DE
Water Master Plan Draft

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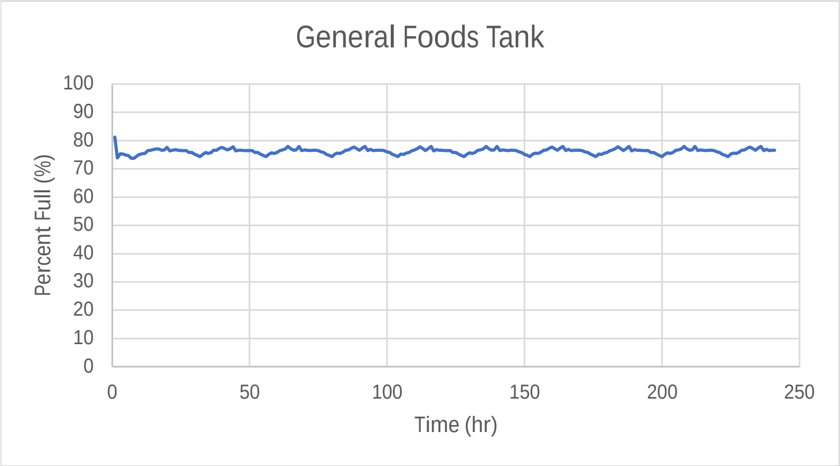
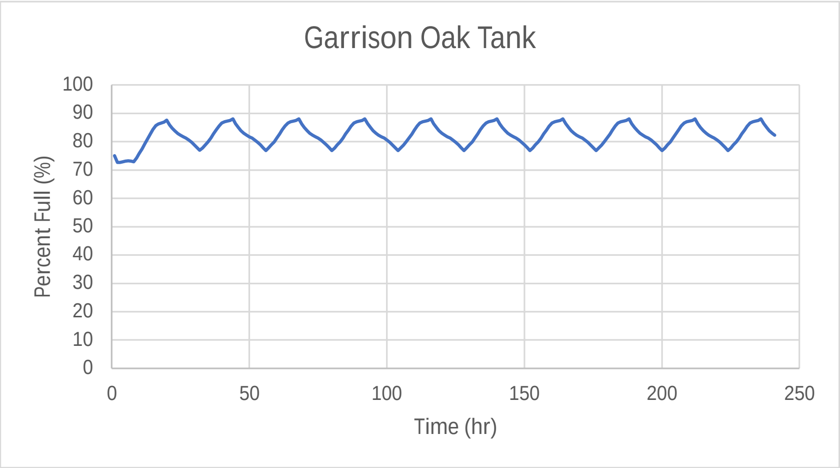
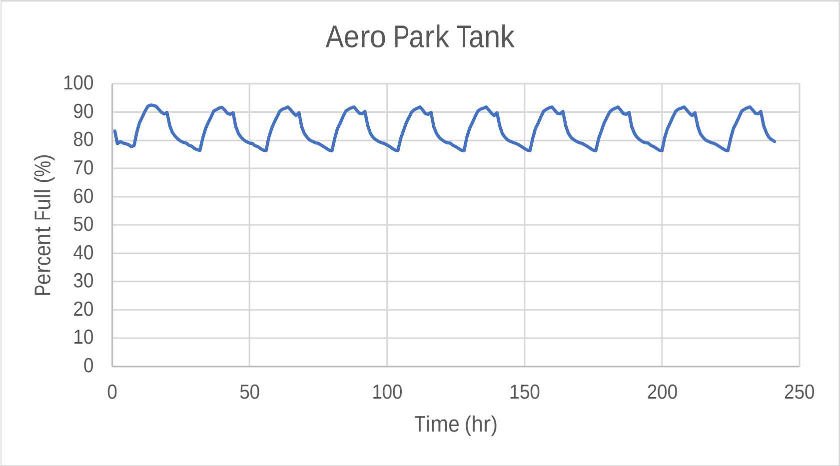
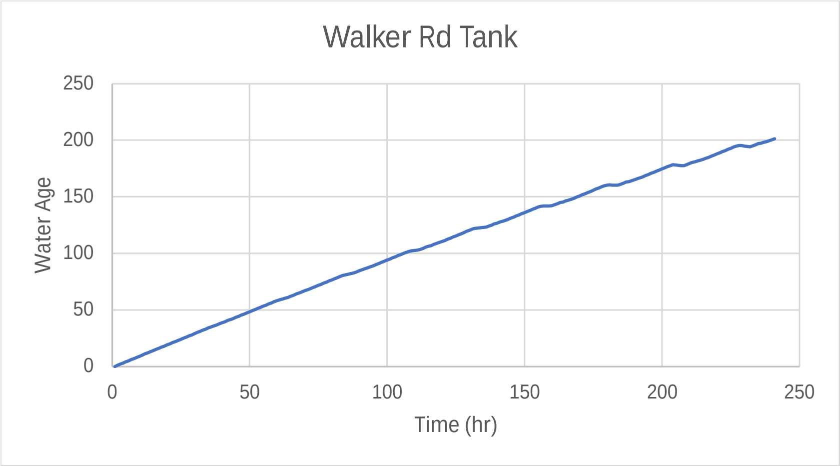
June 2021

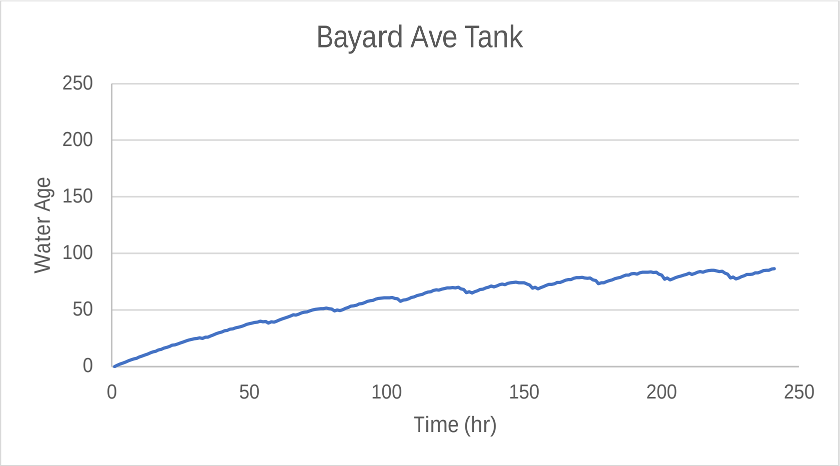


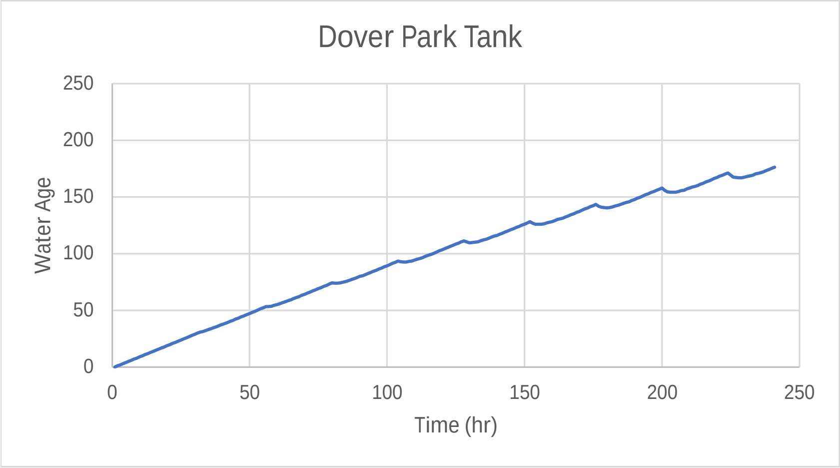


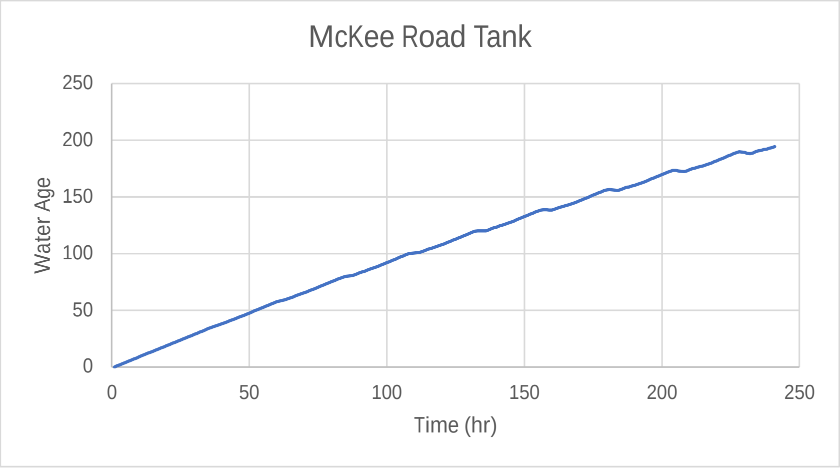


2030 ADD TANK WATER AGE

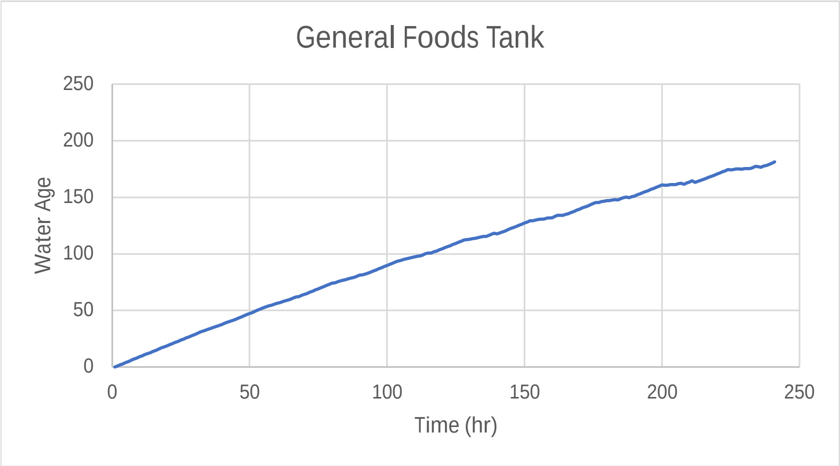


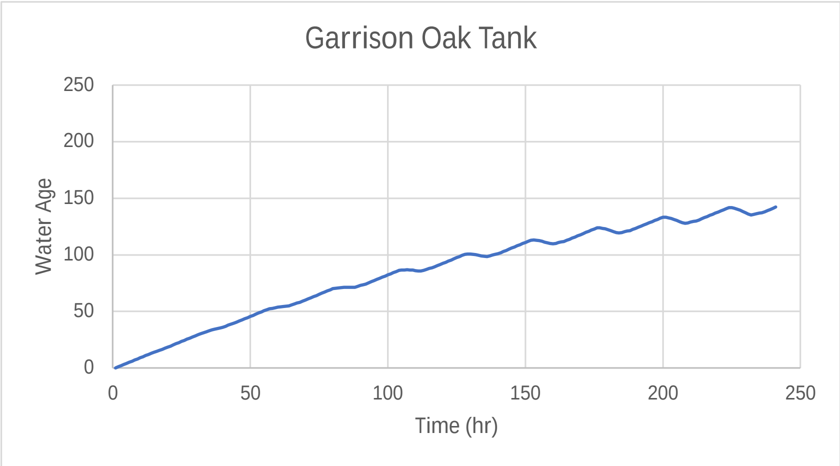






2030 ADD TANK WATER AGE





Legend

Junction
Min. Pressure (PSI)

- less than 20.00
- 20.00 ~ 35.00
- 35.00 ~ 40.00
- 40.00 ~ 50.00
- 50.00 ~ 70.00

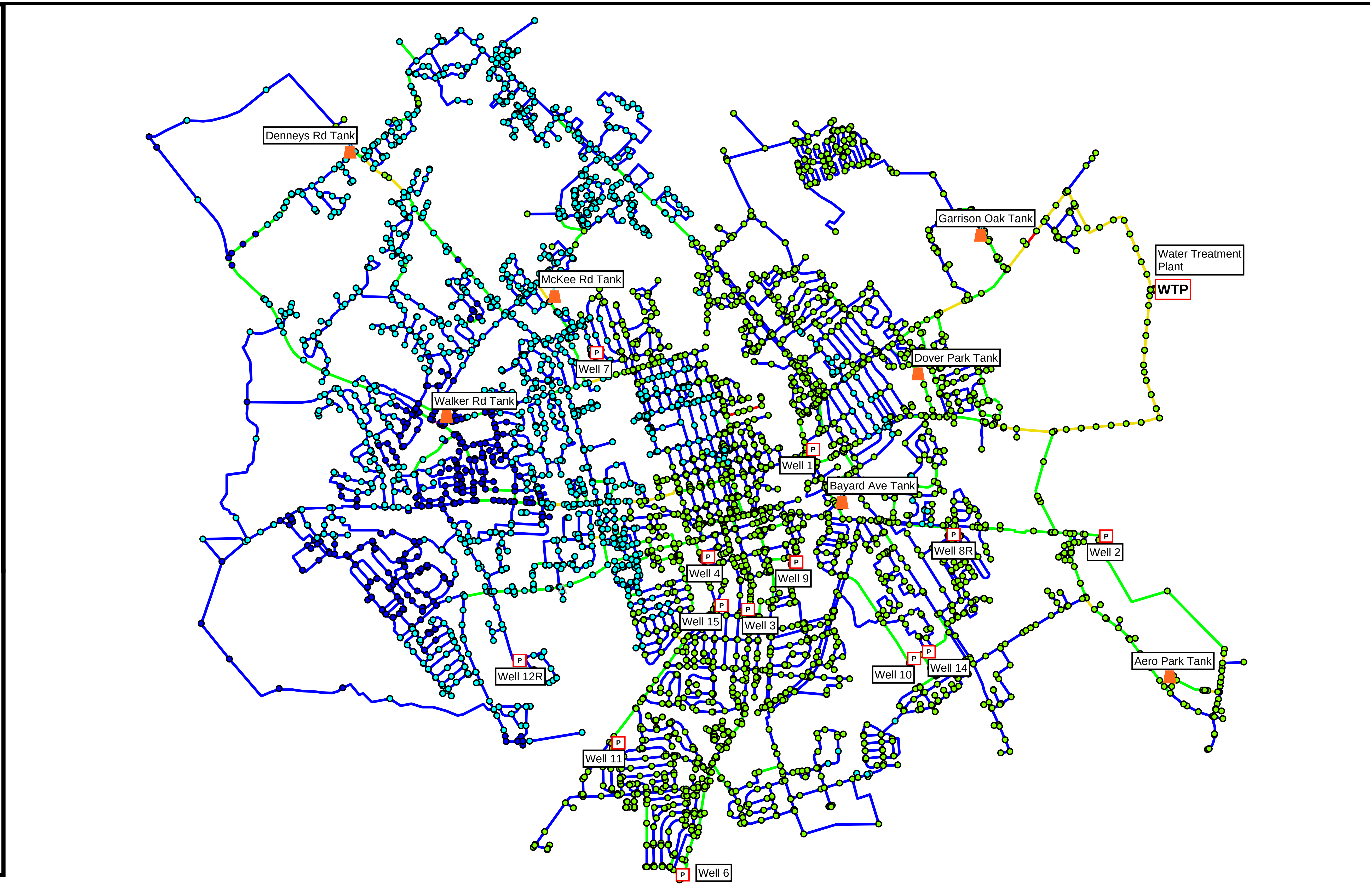
Pipe
Max. Velocity (ft/s)

- less than 1.00
- 1.00 ~ 2.00
- 2.00 ~ 3.00
- 3.00 ~ 4.00
- 4.00 ~ 5.00

Water Treatment Plant
WTP

Pump and Well House
P

Tank



0 0.25 0.5 1 1.5 2 Miles

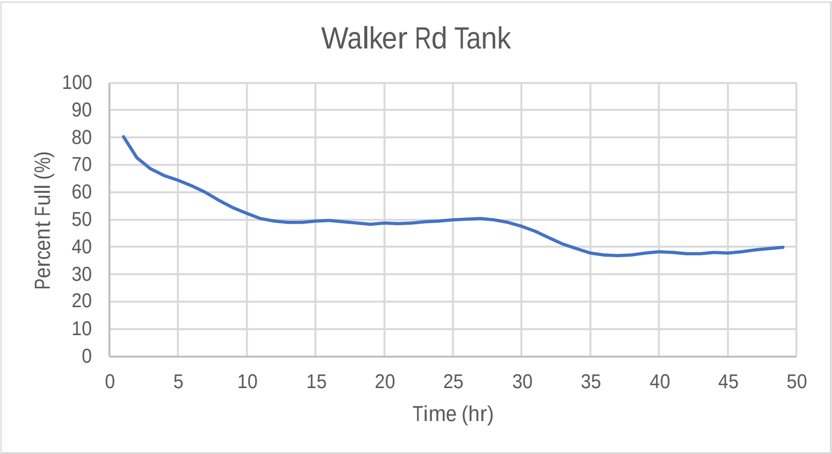
City of Dover, Delaware
Water System Master Plan

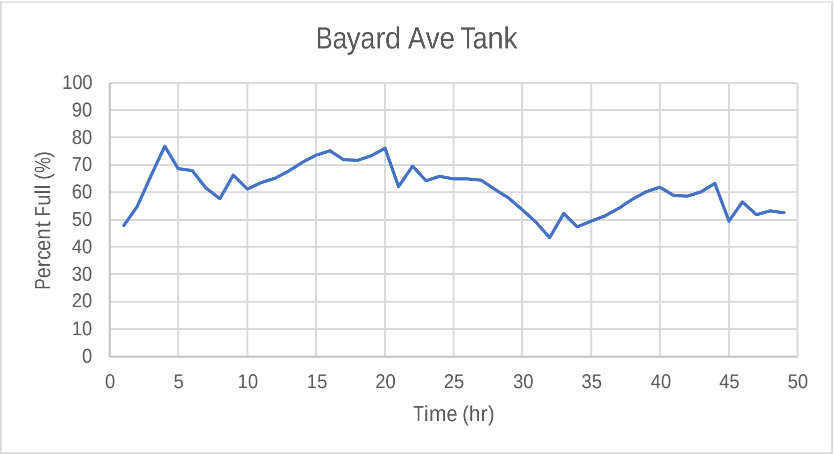
Appendix F.19
2035 System Minimum Pressure and Maximum Water Velocity

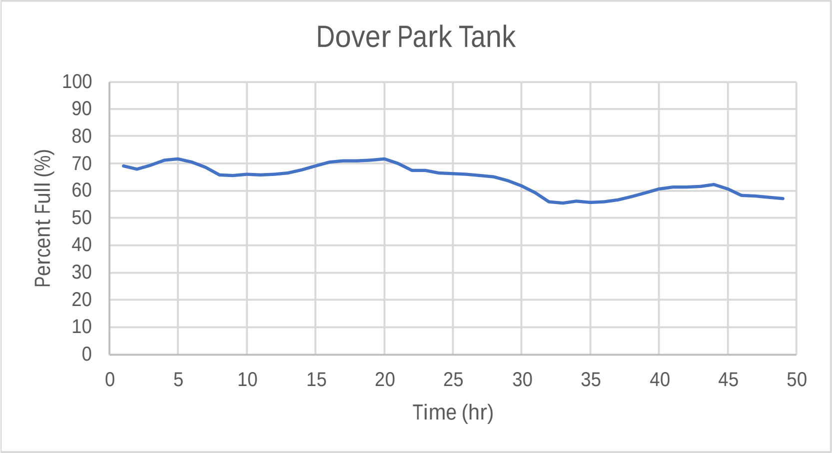
2035 MDD TANK LEVELS

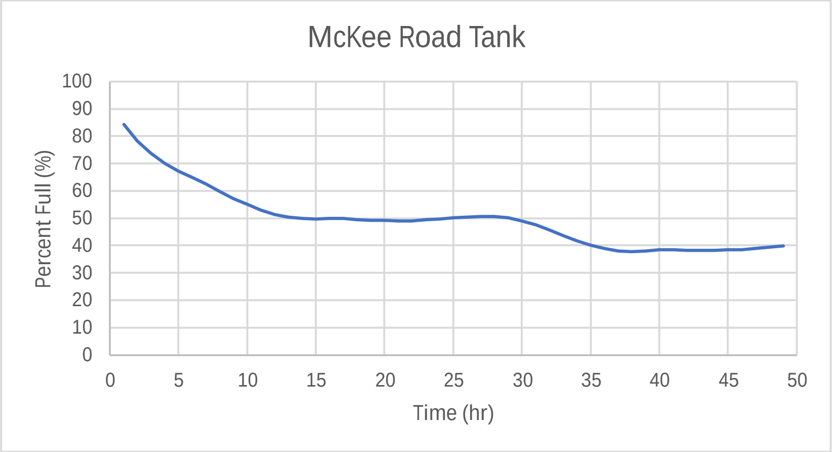
City of Dover, DE
Water Master Plan Draft

Appendix F
June 2021









2035 MDD TANK LEVELS

City of Dover, DE
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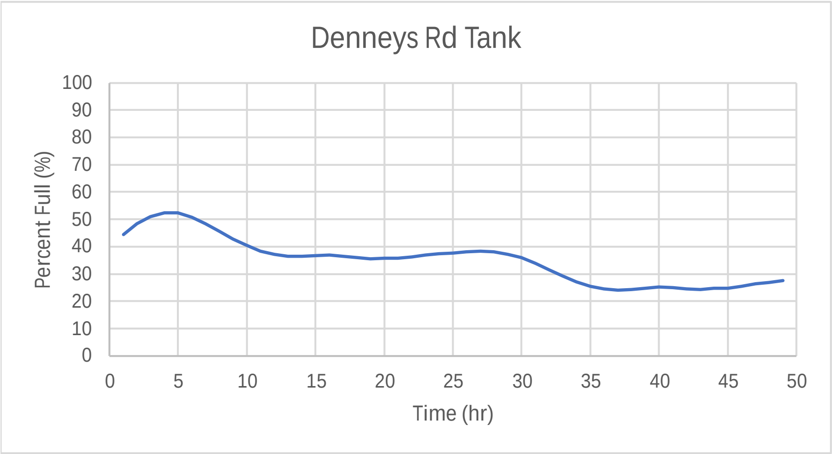
June 2021



Legend

Junction

Hydrant Flow Available (gpm)

- less than 2,000.00
- 2,000.00 ~ 10,000.00

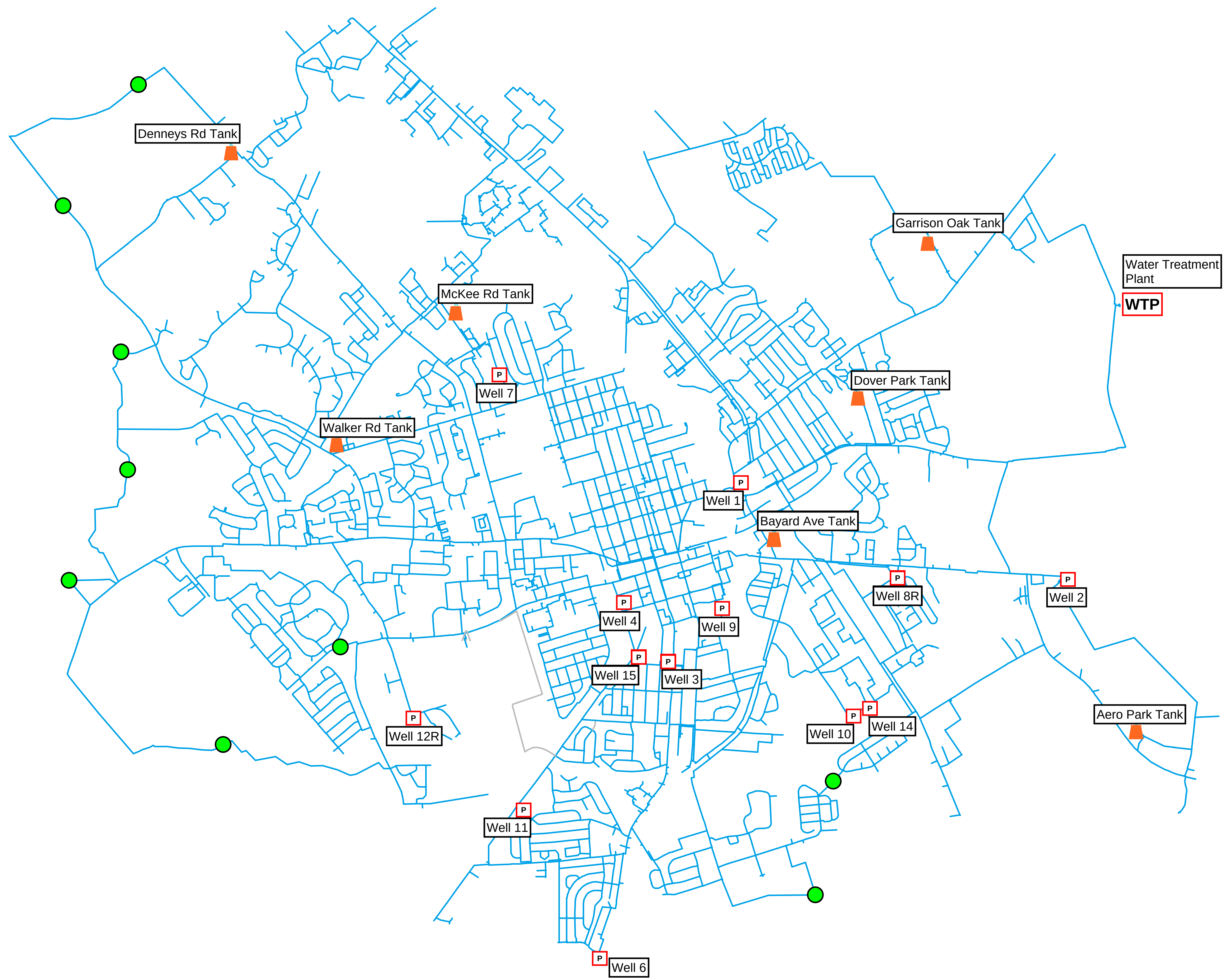
Tank

Pump and Well House

P

Water Treatment Plant

WTP



0 0.25 0.5 1 1.5 2 Miles

Whitman, Requardt & Associates, LLP 1915 100 YEARS 2015

City of Dover, Delaware
Water System Master Plan

Appendix F.20
2035 Max. Day
Steady State Fire Flow (6 ft/s)

ID	Static Demand (gpm)	Static Pressure (psi)	Static Head (ft)	Fire-Flow Demand (gpm)	Residual Pressure (psi)	Hydrant Available Flow (gpm)	Hydrant Pressure at Available Flow (psi)	Critical Pipe ID at Available Flow	Critical Pipe Velocity at Available Flow (ft/s)
J15118	1.5	43.26	143.83	2,000.00	39.33	3,818.85	31.31	P4243	6.05
J26724	30.35	48.04	143.87	2,000.00	39.78	3,396.40	27.45	P13003	6.02
J26732	38.9	44.06	143.68	2,000.00	36.7	3,167.17	27.96	P12993	6.03
J26734	38.9	43.9	143.31	2,000.00	39.5	3,445.96	32.69	P12991	6.04
J26738	38.9	44.74	143.26	2,000.00	38.73	3,486.42	29.16	P12985	6.02
J26742	5.71	46.04	143.26	2,000.00	39.08	4,190.30	20.81	P12975	6
J26752	64.4	40.4	143.24	2,000.00	27.3	2,649.95	20	P12965	3.93
J26758	72.3	56.56	147.54	2,000.00	37.89	3,072.02	20	P13009	4.67
J26760	72.3	47.89	147.51	2,000.00	20.97	2,115.18	20	P13027	3.56

ID	Static Demand (gpm)	Static Pressure (psi)	Static Head (ft)	Fire-Flow Demand (gpm)	Residual Pressure (psi)	Hydrant Available Flow (gpm)	Hydrant Pressure at Available Flow (psi)	Critical Pipe ID at Available Flow	Critical Pipe Velocity at Available Flow (ft/s)
J15118	1.5	43.26	143.83	2,000.00	39.33	2,493.68	37.54	P4243	4
J26724	30.35	48.04	143.87	2,000.00	39.78	2,234.61	38.26	P13003	4
J26732	38.9	44.06	143.68	2,000.00	36.7	2,081.99	36.42	P12993	4
J26734	38.9	43.9	143.31	2,000.00	39.5	2,261.51	38.61	P12991	4
J26738	38.9	44.74	143.26	2,000.00	38.73	2,324.28	37.17	P12985	4.03
J26742	5.71	46.04	143.26	2,000.00	39.08	2,793.54	33.68	P12975	3.98
J26752	64.4	40.4	143.24	2,000.00	27.3	2,649.95	20	P12965	3.93
J26758	72.3	56.56	147.54	2,000.00	37.89	2,628.59	28.62	P13009	4
J26760	72.3	47.89	147.51	2,000.00	20.97	2,115.18	20	P13027	3.56

Legend

Junction

Min. Pressure (PSI)

- less than 20.00
- 20.00 ~ 35.00
- 35.00 ~ 40.00
- 40.00 ~ 50.00
- 50.00 ~ 70.00

Pipe

Max. Velocity (ft/s)

- less than 1.00
- 1.00 ~ 2.00
- 2.00 ~ 3.00
- 3.00 ~ 4.00
- 4.00 ~ 30.00

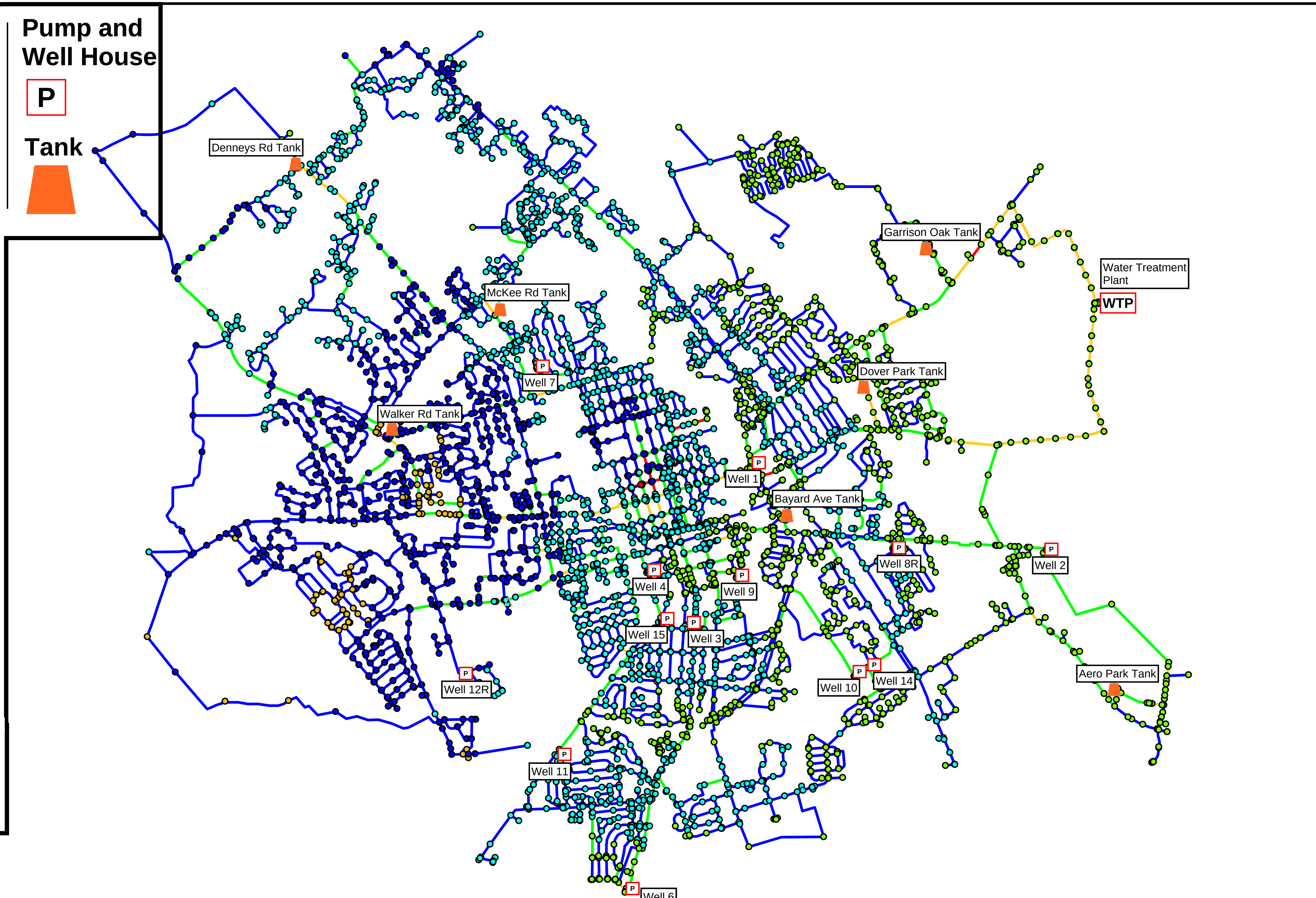
Water Treatment Plant

WTP

Pump and Well House

P

Tank

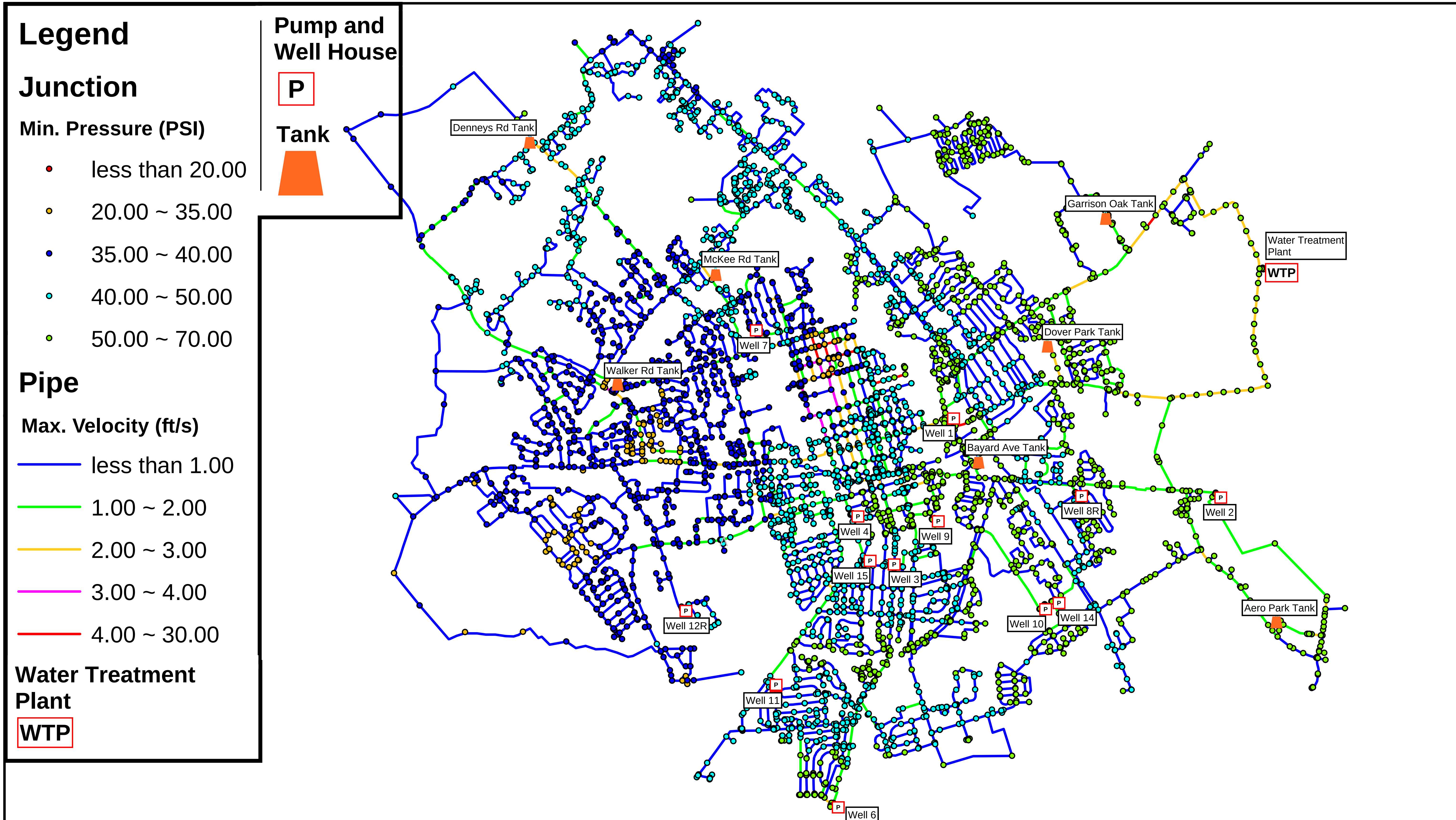


Whitman, Requardt & Associates, LLP 1915 100 YEARS 2015

0 0.25 0.5 1 1.5 2 Miles

City of Dover, Delaware
Water System Master Plan

Appendix F.21
2035 J15662 Fire Flow
Minimum Pressure and
Maximum Water Velocity

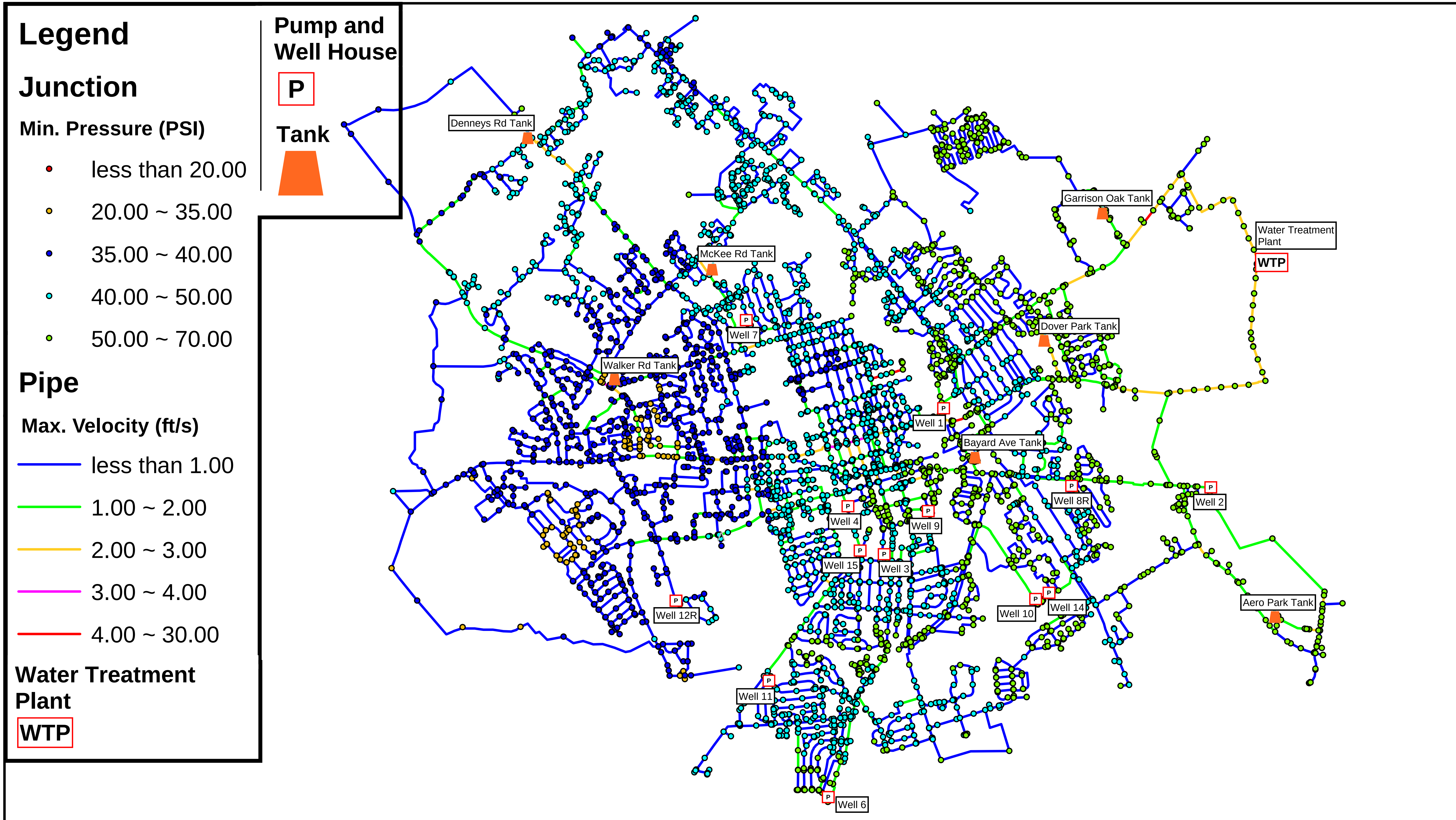


Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

0 0.25 0.5 1 1.5 2 Miles

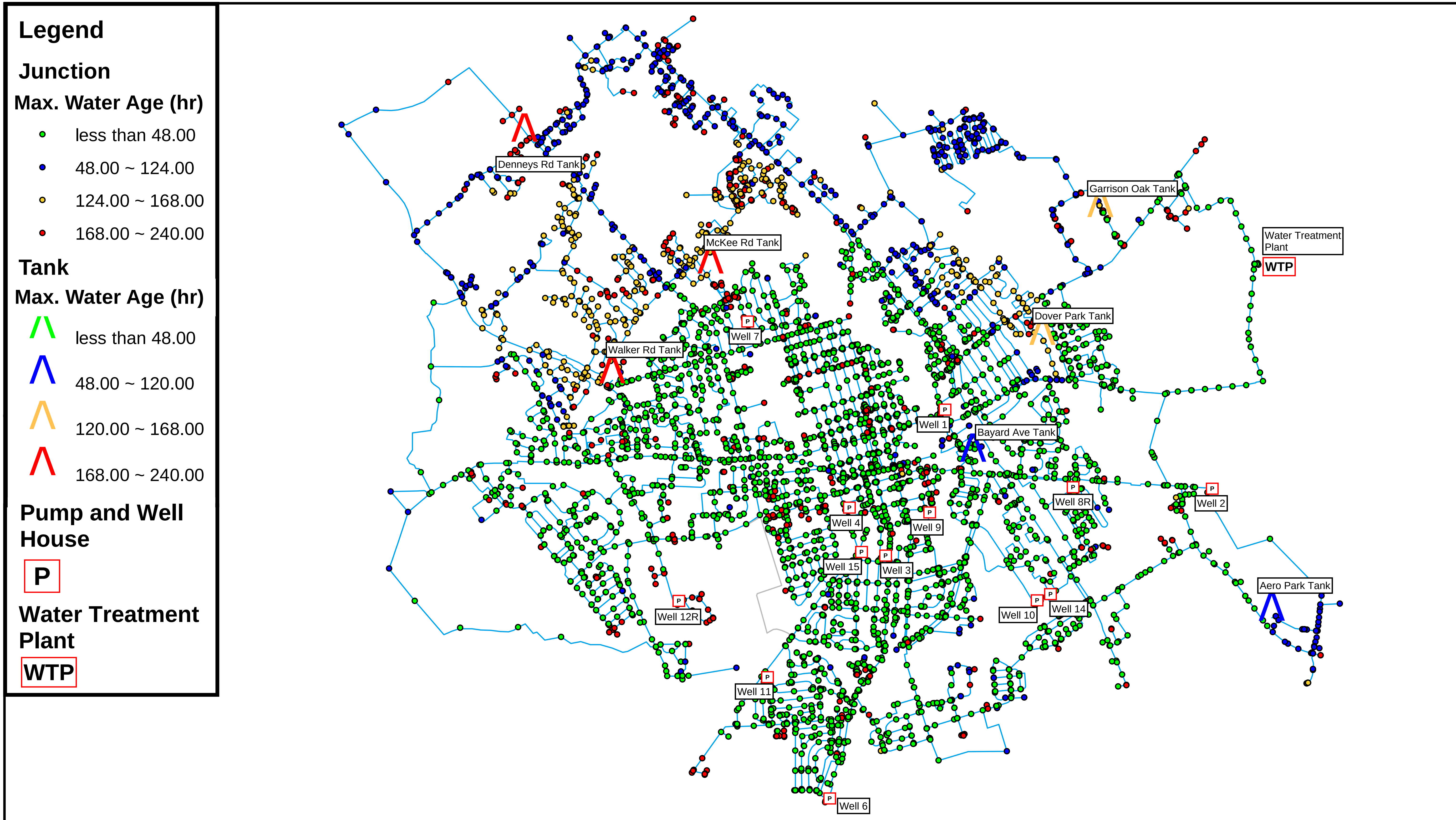
City of Dover, Delaware
Water System Master Plan

Appendix F.22
2035 J11512 Fire Flow
Minimum Pressure and
Maximum Water Velocity



City of Dover, Delaware
Water System Master Plan

Appendix F.23
2035 J15534 Fire Flow
Minimum Pressure and
Maximum Water Velocity



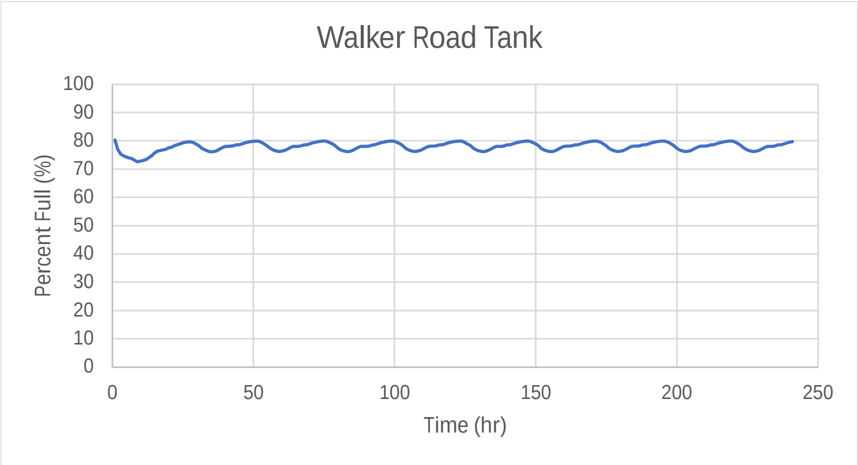
Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

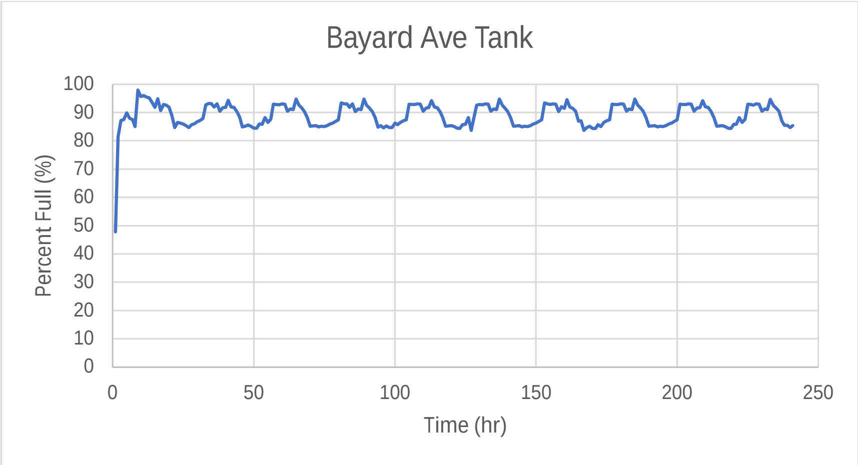
0 0.25 0.5 1 1.5 2
Miles

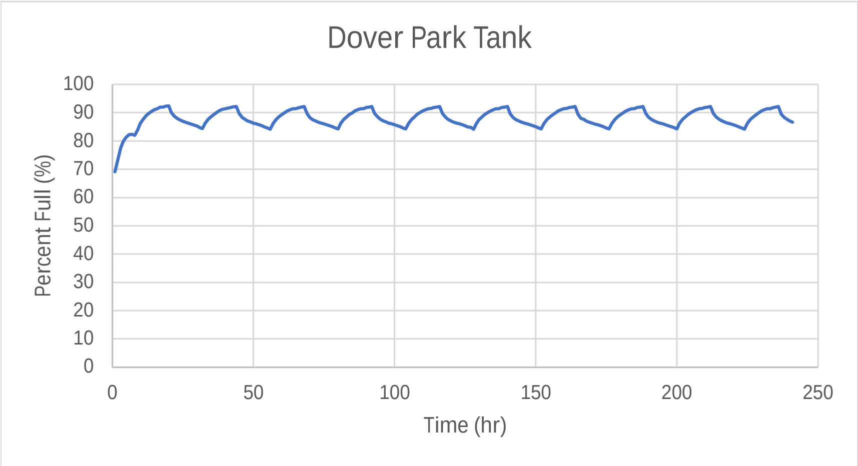
City of Dover, Delaware
Water System Master Plan

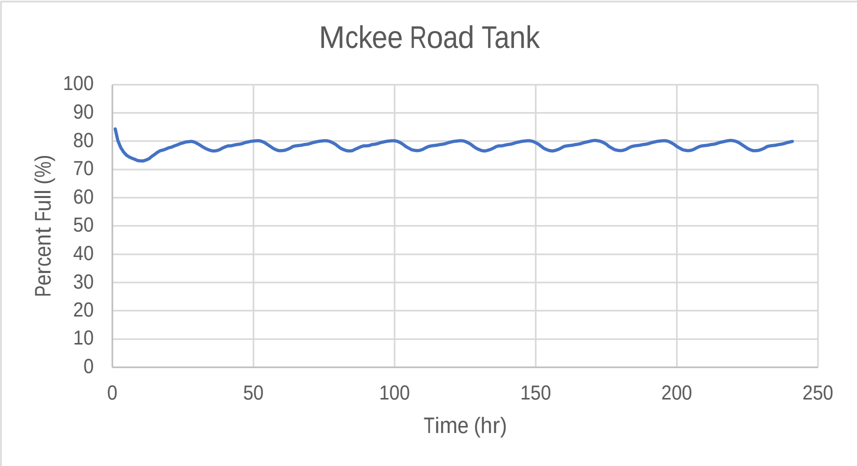
Appendix F.24
2035 System Water Age

2035 ADD TANK LEVELS

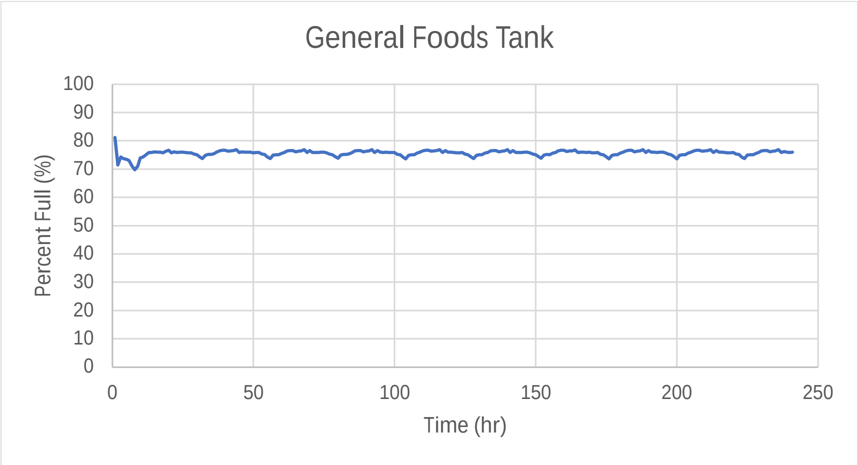


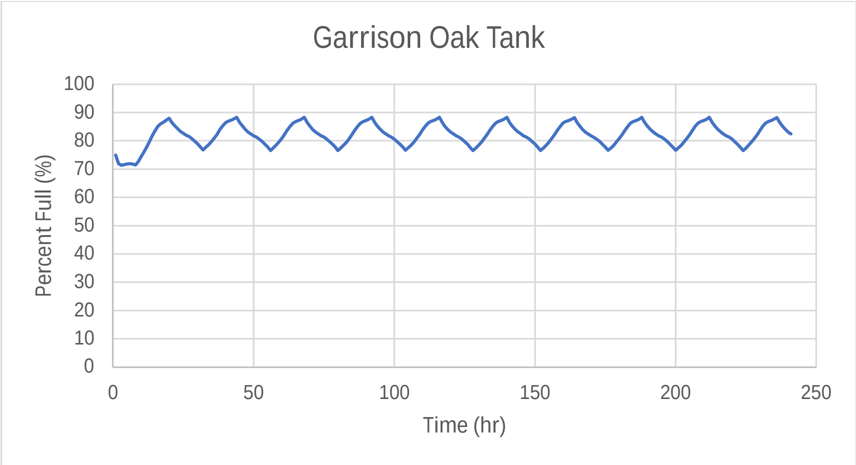


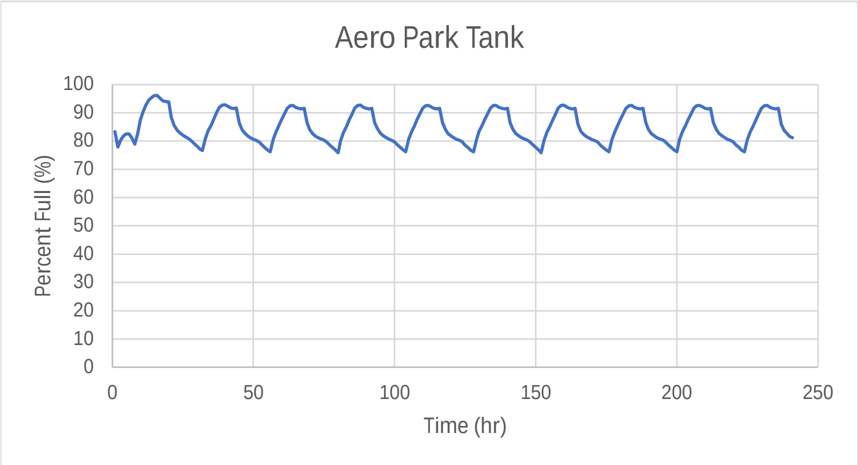


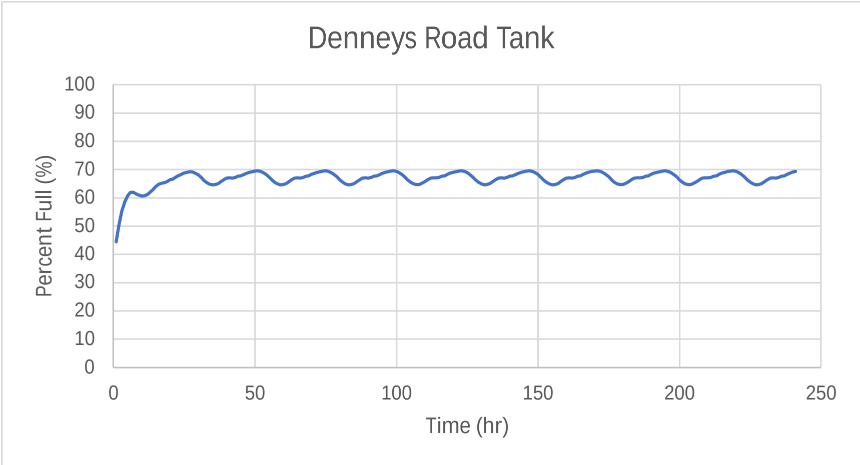


2035 ADD TANK LEVELS

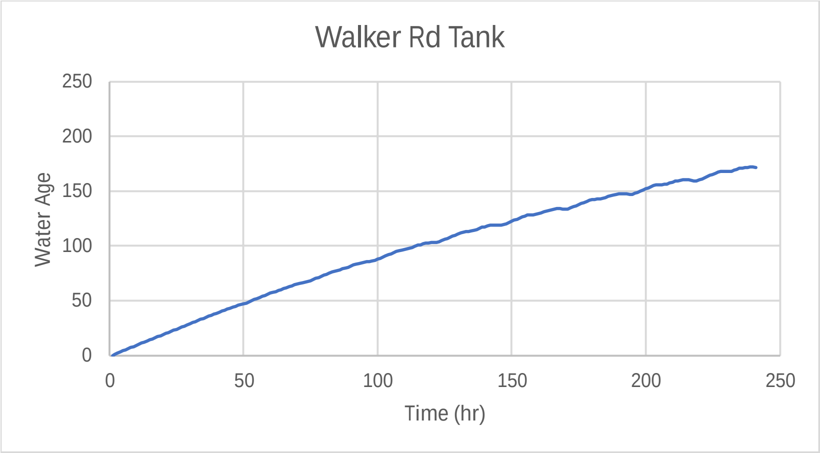


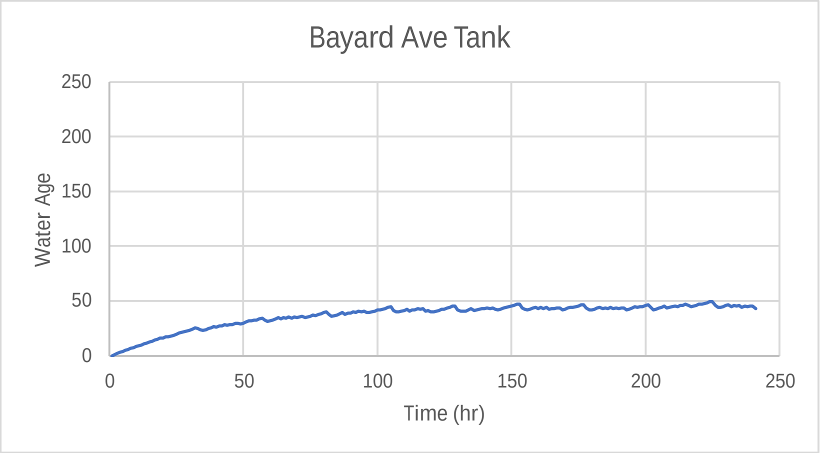


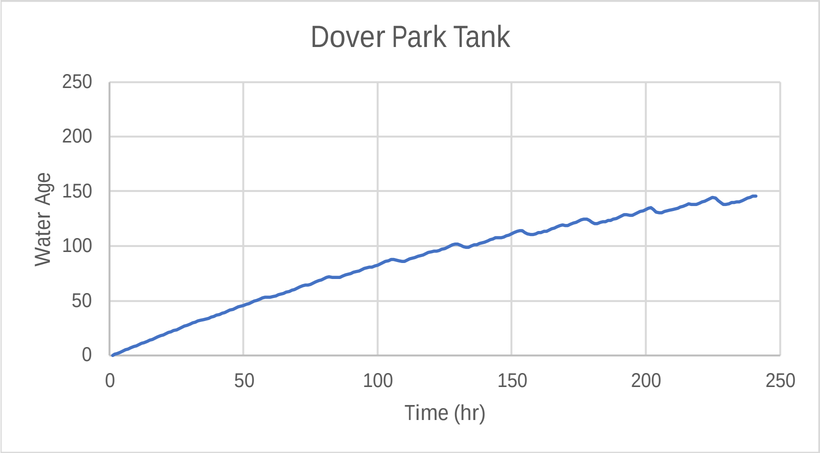


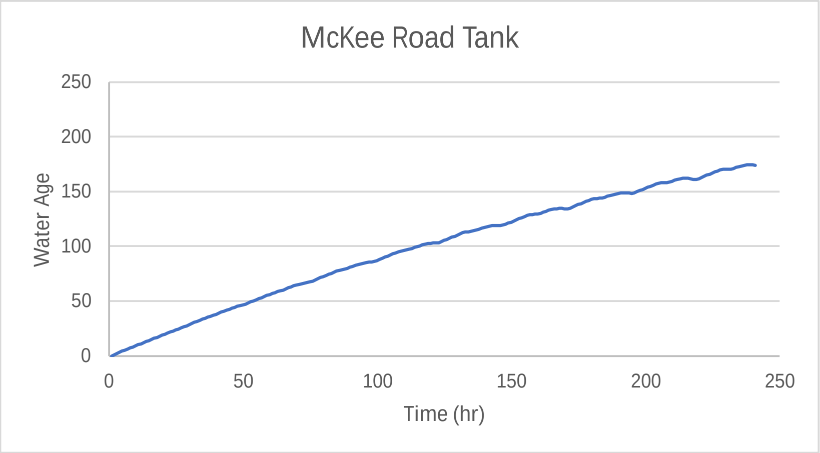


2035 ADD TANK WATER AGE

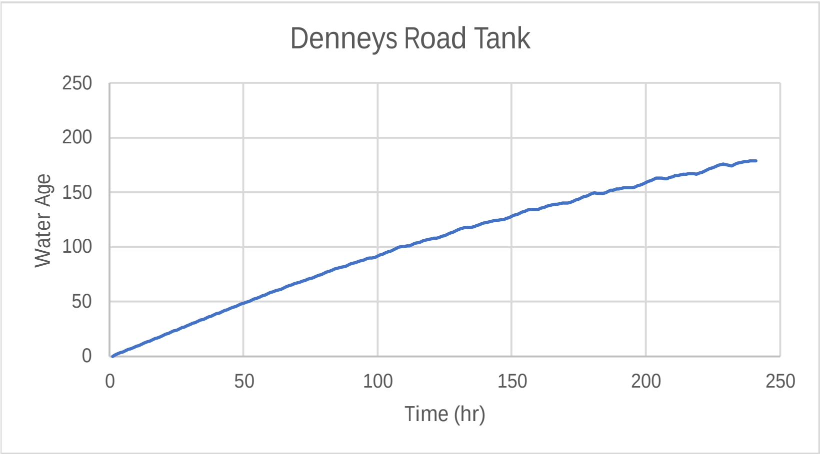


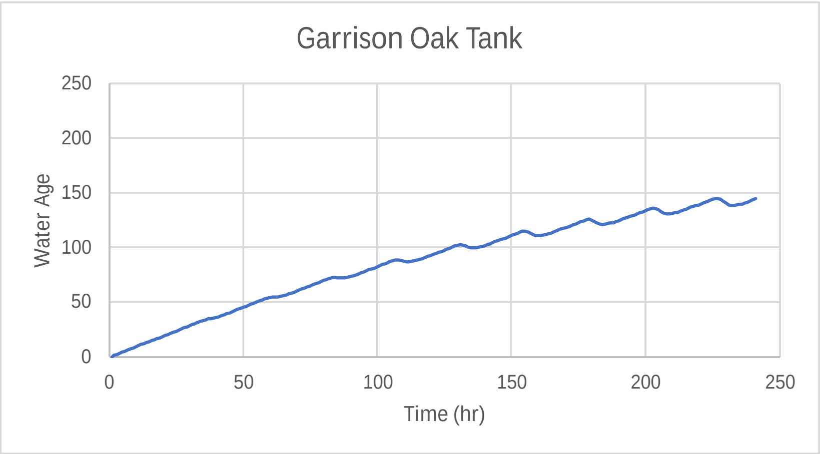






2035 ADD TANK WATER AGE





Legend

Junction
Min. Pressure (PSI)

- less than 20.00
- 20.00 ~ 35.00
- 35.00 ~ 40.00
- 40.00 ~ 50.00
- 50.00 ~ 70.00

Pipe
Max. Velocity (ft/s)

- less than 1.00
- 1.00 ~ 2.00
- 2.00 ~ 3.00
- 3.00 ~ 4.00
- 4.00 ~ 5.00

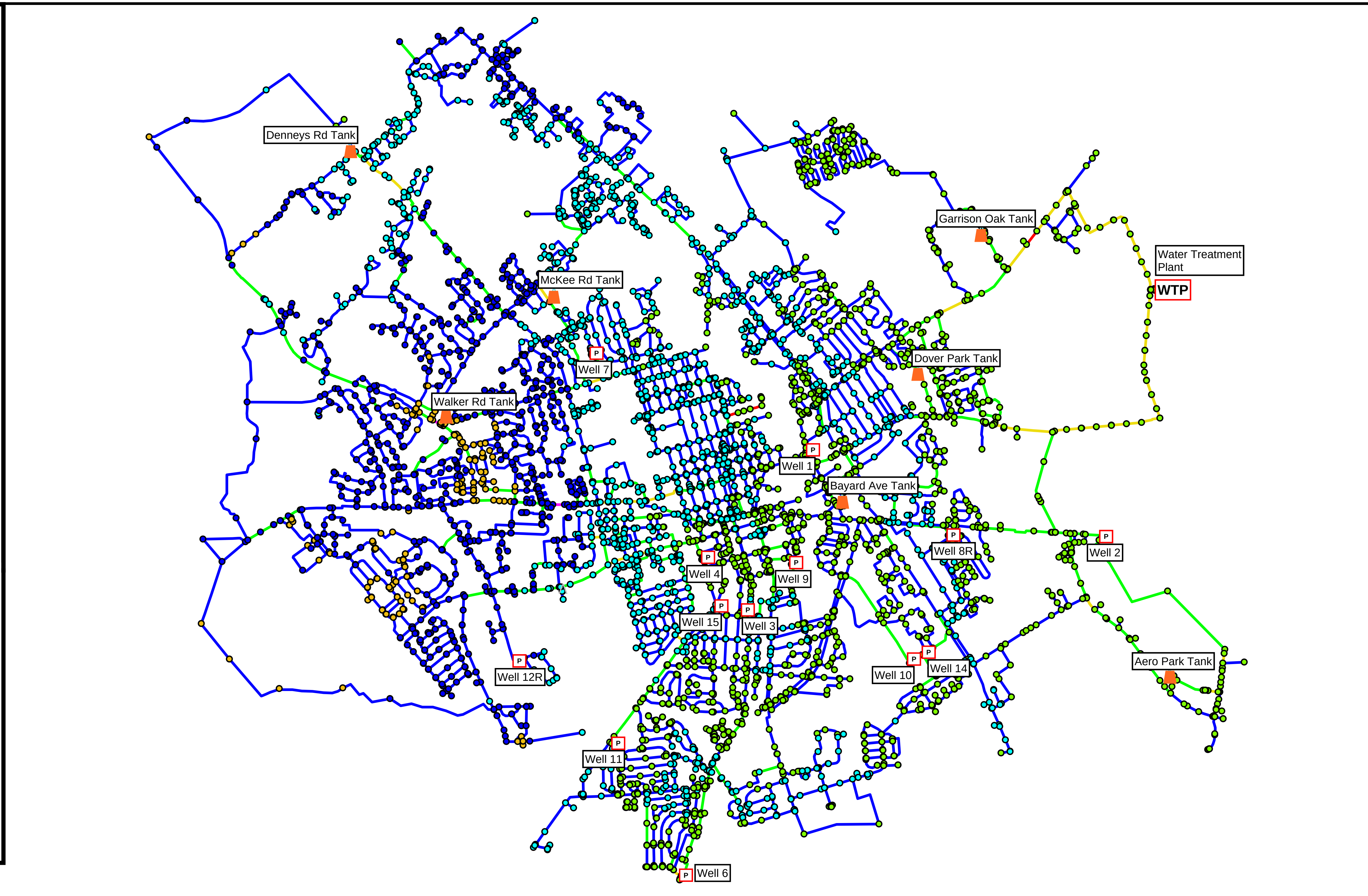
Water Treatment Plant

WTP

Pump and Well House

P

Tank



Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

0 0.25 0.5 1 1.5 2 Miles

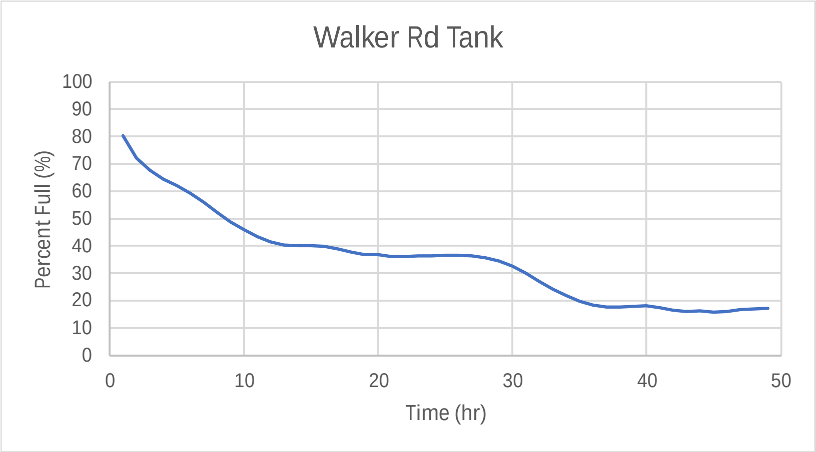
City of Dover, Delaware
Water System Master Plan

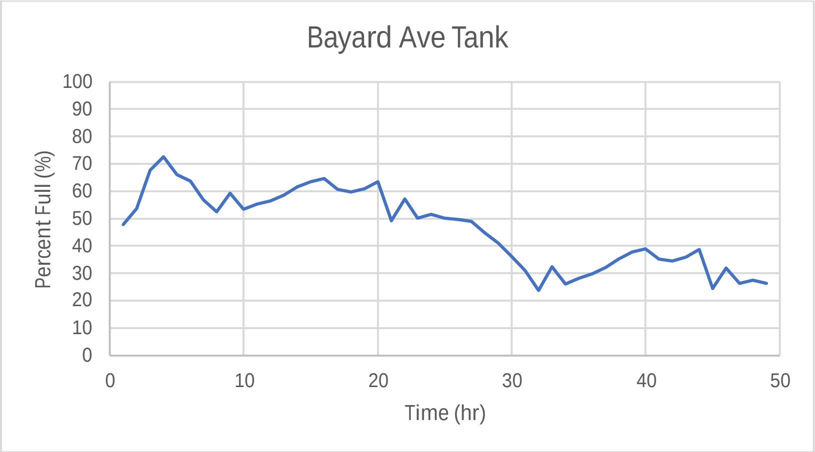
Appendix F.25
2040 System Minimum Pressure and Maximum Water Velocity

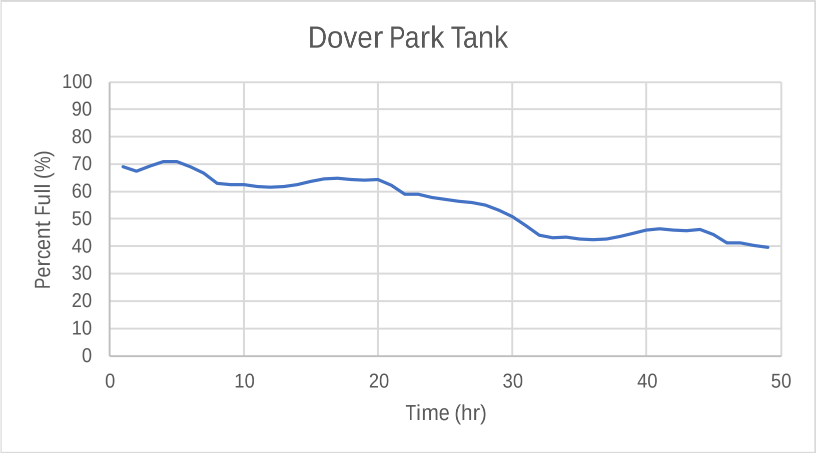
2040 MDD TANK LEVELS

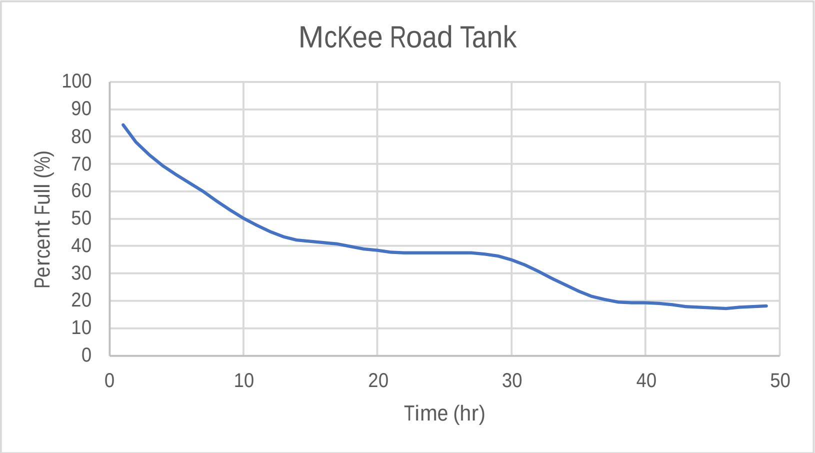
City of Dover, DE
Water Master Plan Draft

Appendix F
June 2021





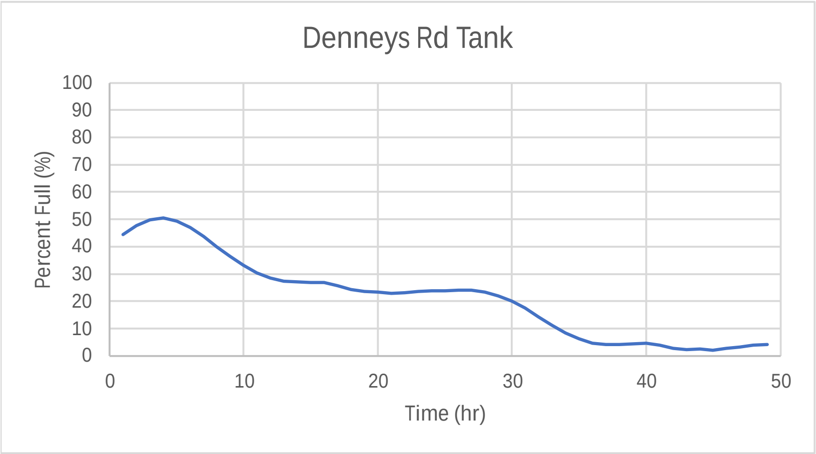




2040 MDD TANK LEVELS

City of Dover, DE
Water Master Plan Draft

Appendix F
June 2021



Legend

Junction

Hydrant Flow Available (gpm)

- less than 2,000.00
- 2,000.00 ~ 10,000.00

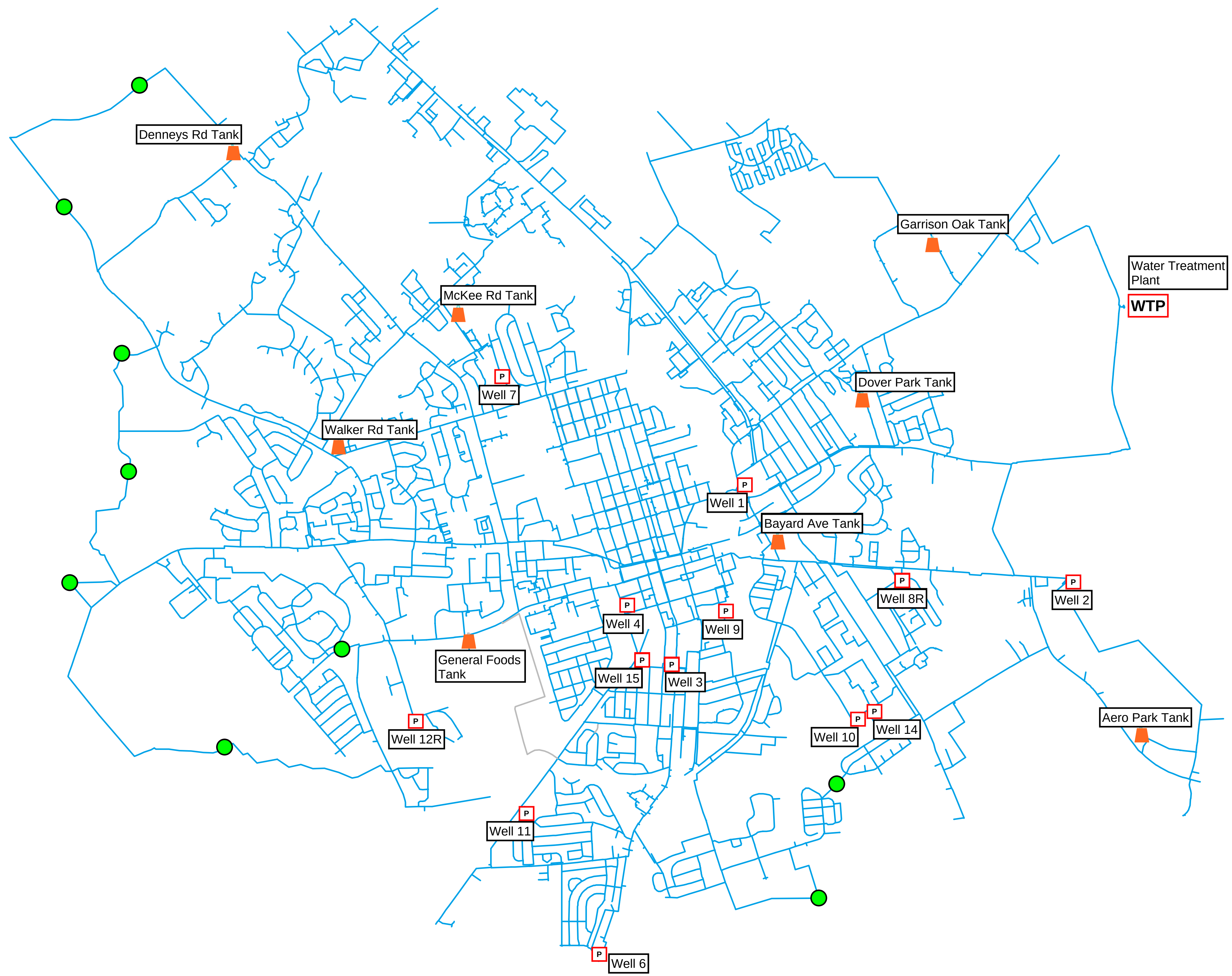
Tank

Pump and Well House

P

Water Treatment Plant

WTP

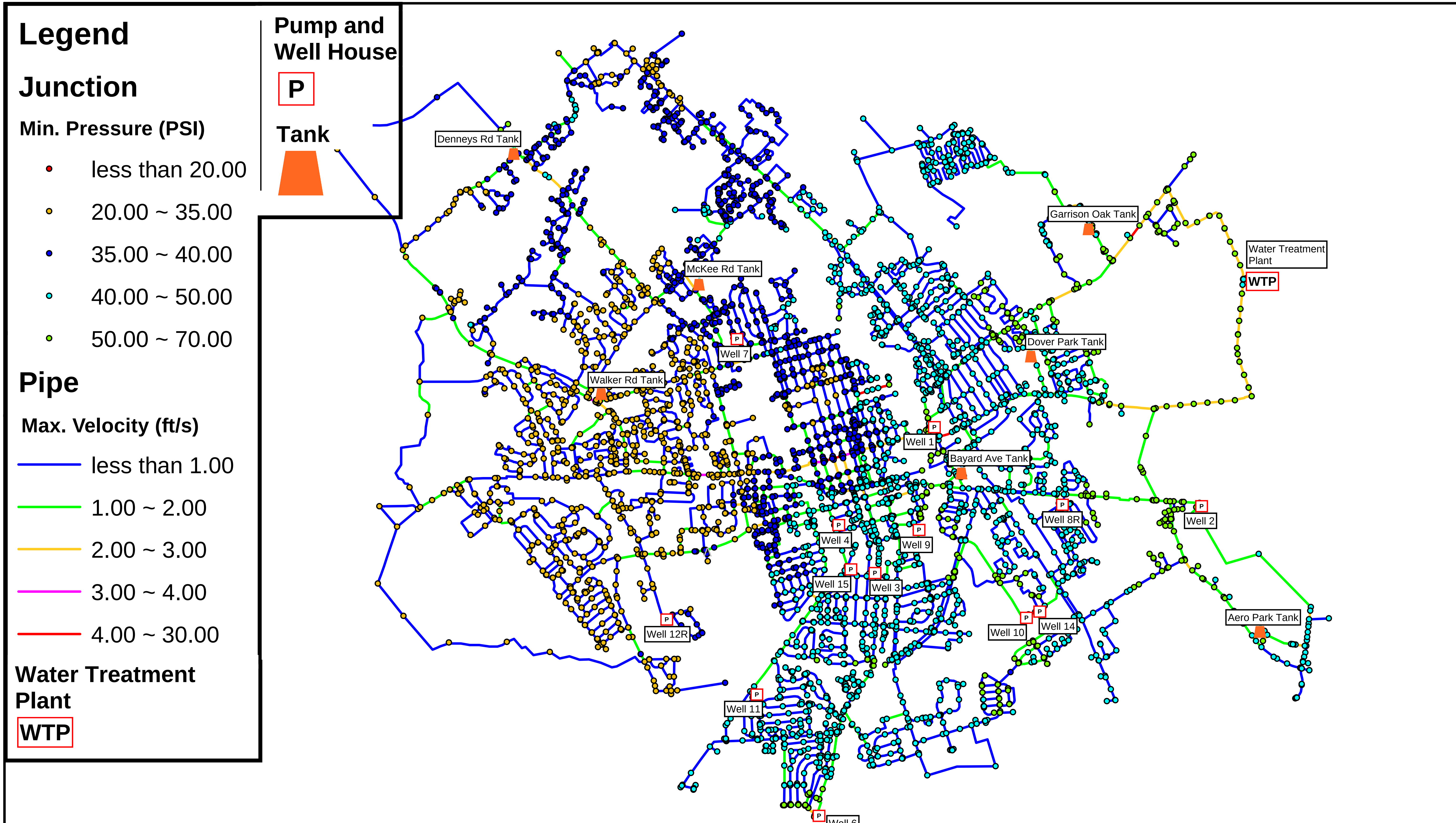


Whitman, Requardt & Associates, LLP 1915 100 YEARS 2015

0 0.25 0.5 1 1.5 2 Miles

City of Dover, Delaware
Water System Master Plan

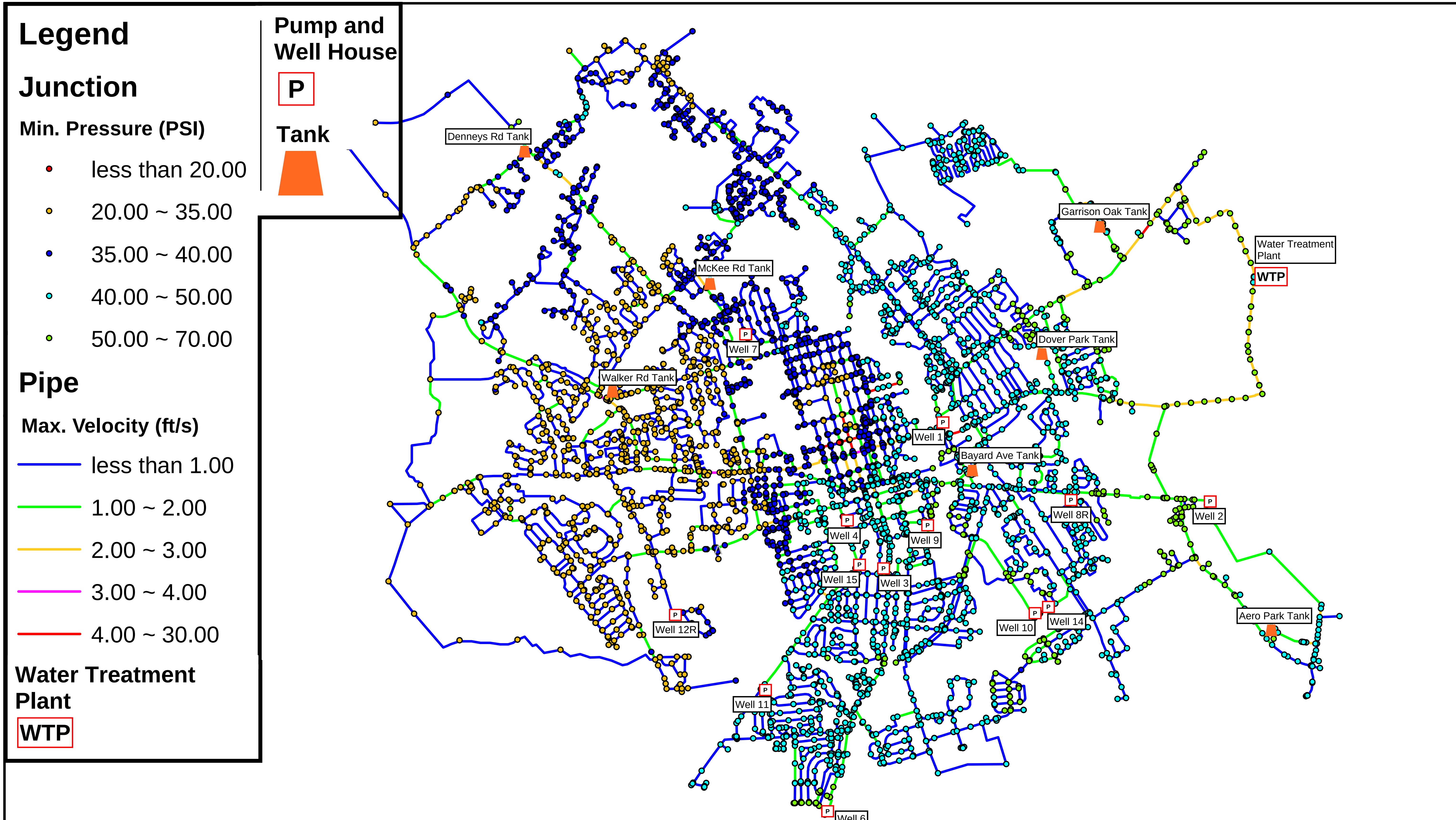
Appendix F.26
2040 Max. Day
Steady State Fire Flow (6 ft/s)



0 0.25 0.5 1 1.5 2 Miles

City of Dover, Delaware
Water System Master Plan

Appendix F.27
2040 J15534 Fire Flow
Minimum Pressure and
Maximum Water Velocity



0 0.25 0.5 1 1.5 2 Miles

City of Dover, Delaware
Water System Master Plan

Appendix F.28
2040 J15662 Fire Flow
Minimum Pressure and
Maximum Water Velocity

Legend

Junction

Min. Pressure (PSI)

- less than 20.00
- 20.00 ~ 35.00
- 35.00 ~ 40.00
- 40.00 ~ 50.00
- 50.00 ~ 70.00

Pipe

Max. Velocity (ft/s)

- less than 1.00
- 1.00 ~ 2.00
- 2.00 ~ 3.00
- 3.00 ~ 4.00
- 4.00 ~ 30.00

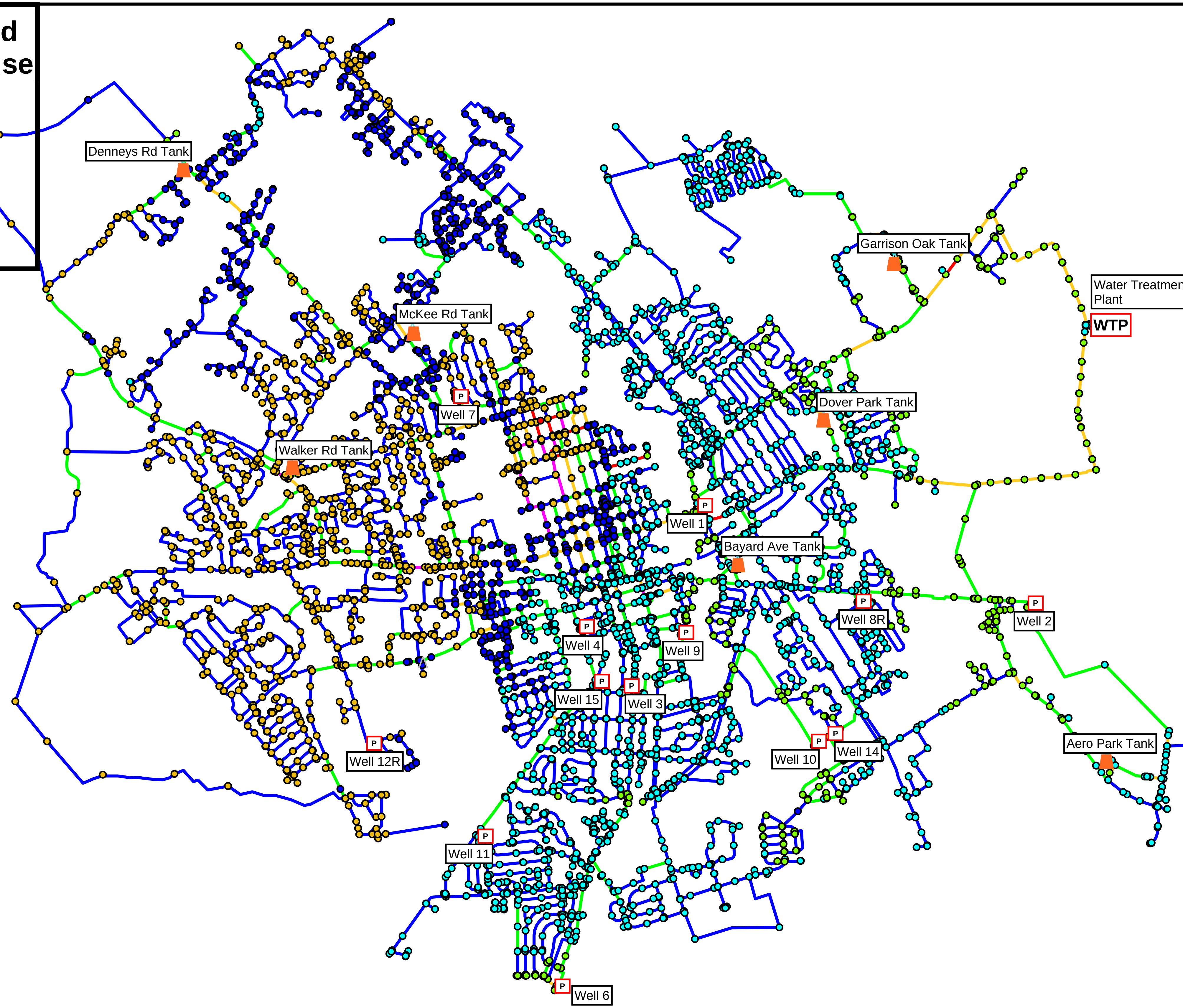
Water Treatment Plant

WTP

Pump and Well House

P

Tank

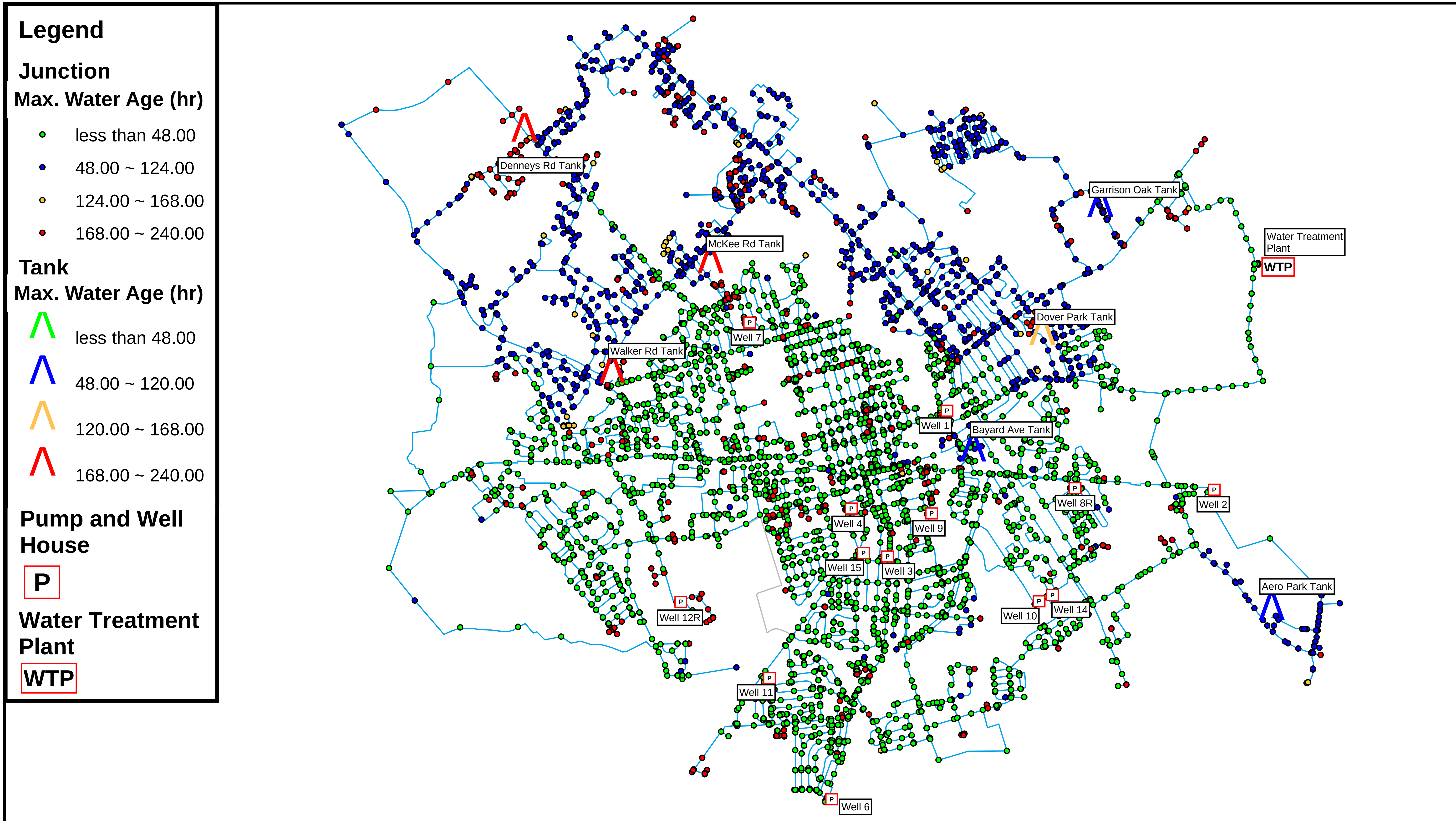


0 0.25 0.5 1 1.5 2 Miles

Whitman, Requardt & Associates, LLP
1915 100 YEARS 2015

City of Dover, Delaware
Water System Master Plan

Appendix F.29
2040 J11512 Fire Flow
Minimum Pressure and
Maximum Water Velocity



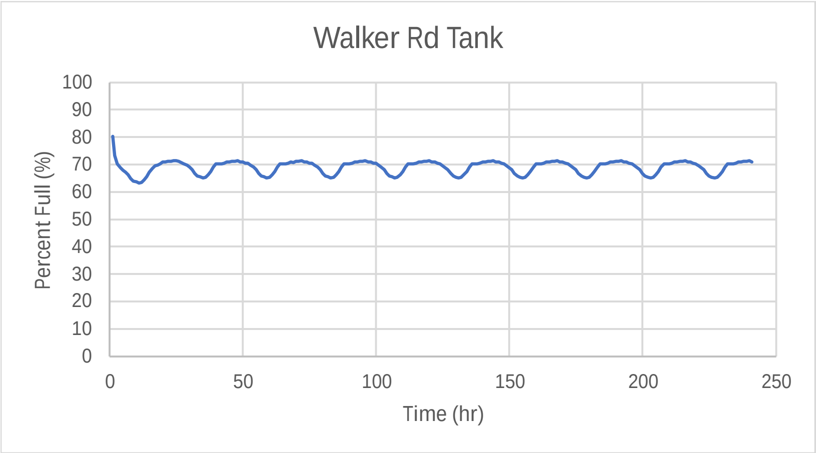
City of Dover, Delaware
Water System Master Plan

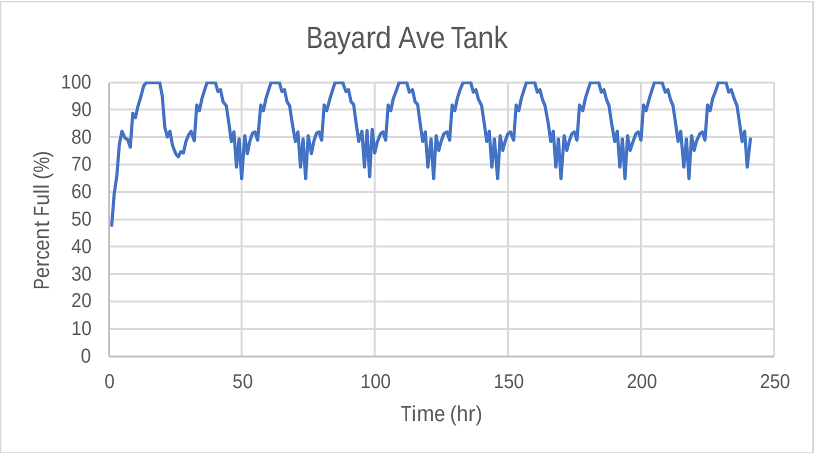
Appendix F.30
2040 System Water Age

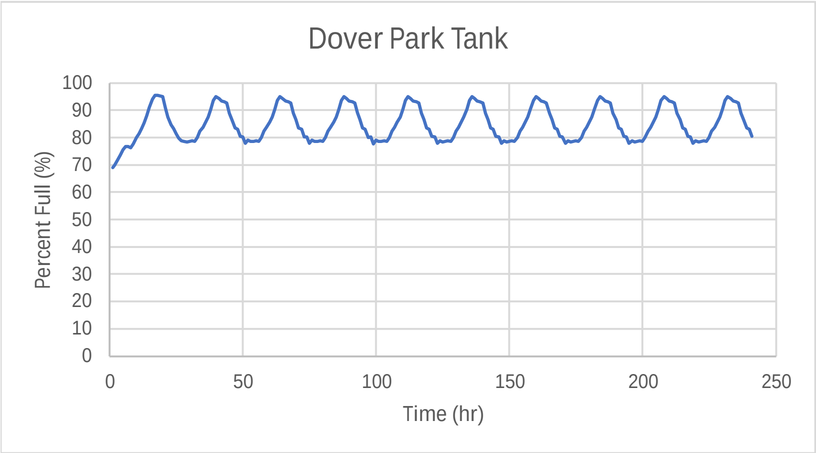
2040 ADD TANK LEVELS

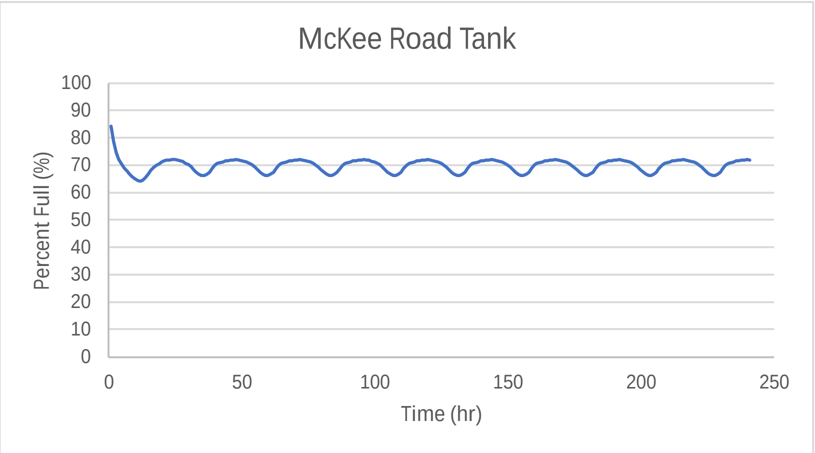
City of Dover, DE
Water Master Plan Draft

Appendix F
June 2021





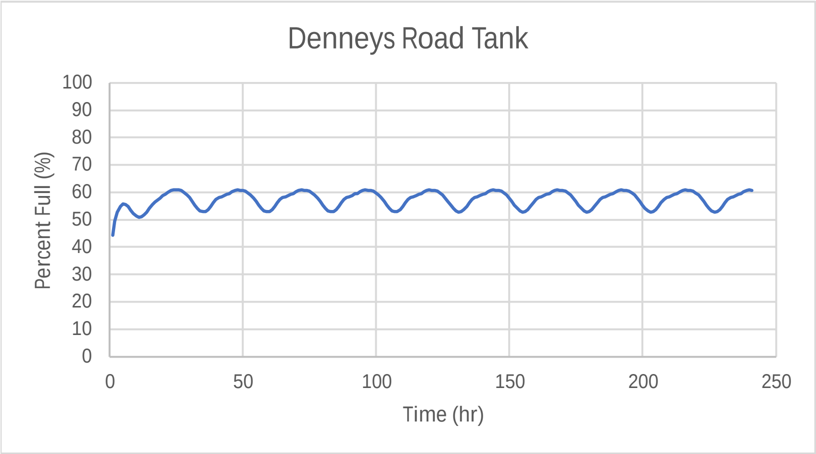


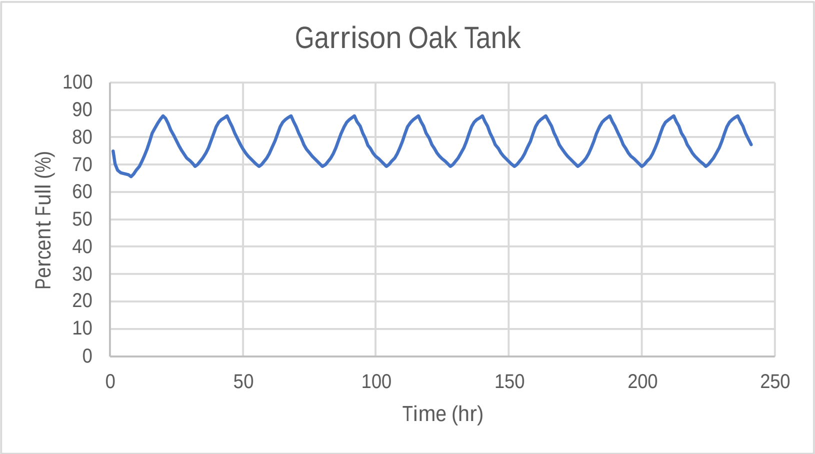


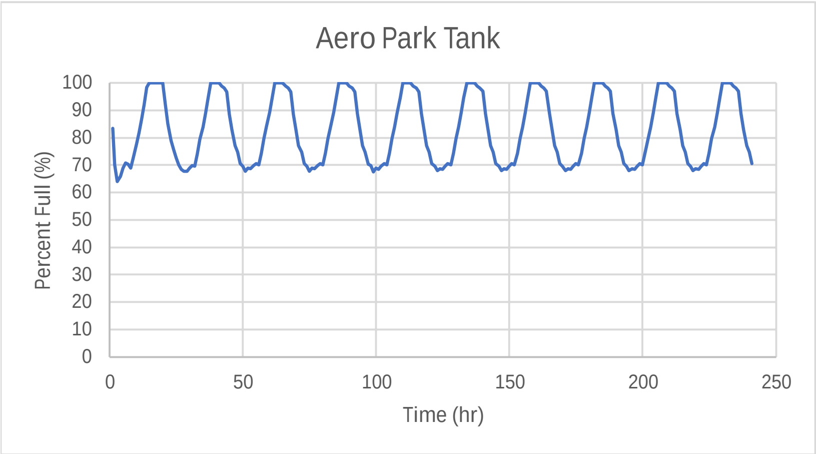
2040 ADD TANK LEVELS

City of Dover, DE
Water Master Plan Draft

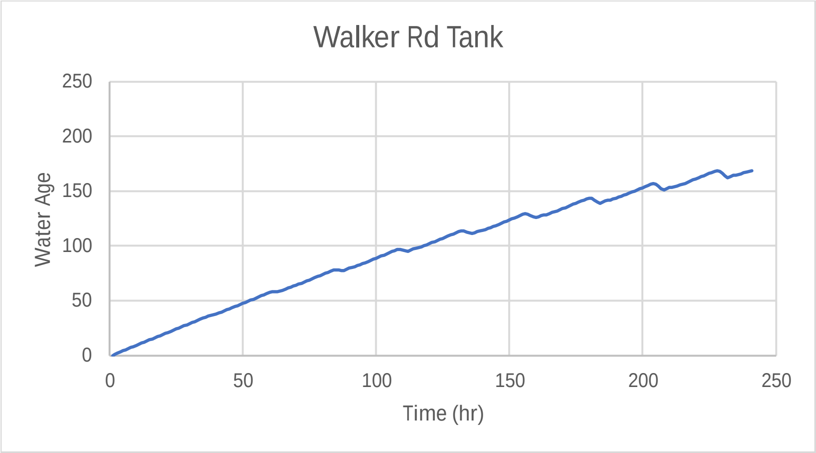
Appendix F
June 2021

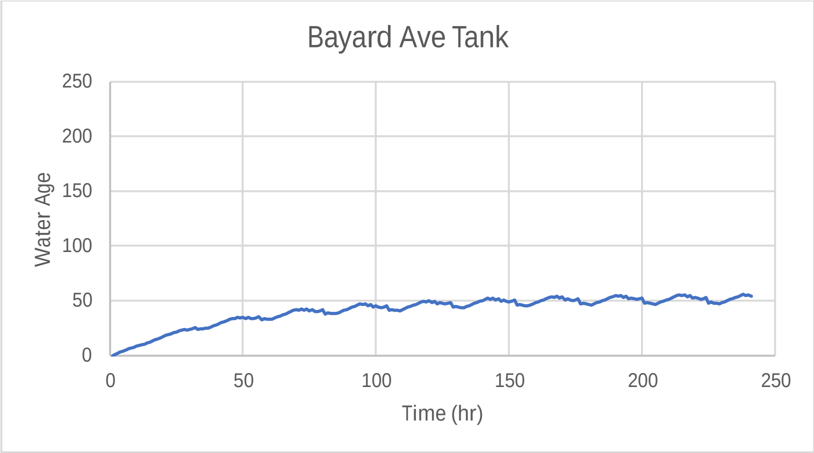


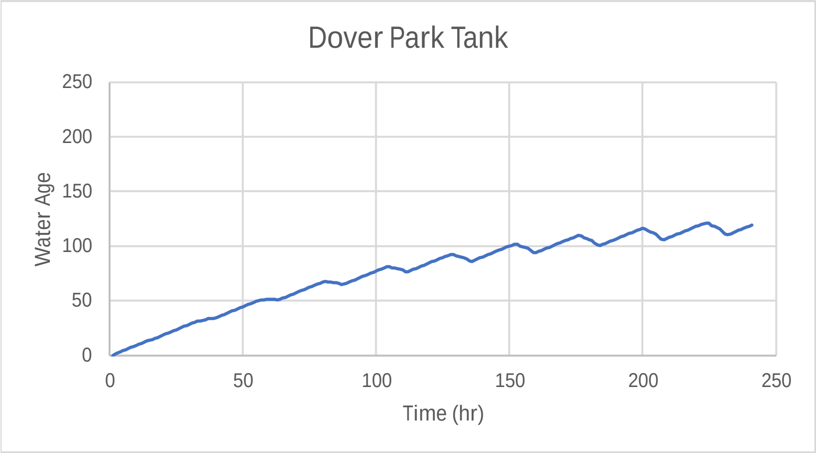


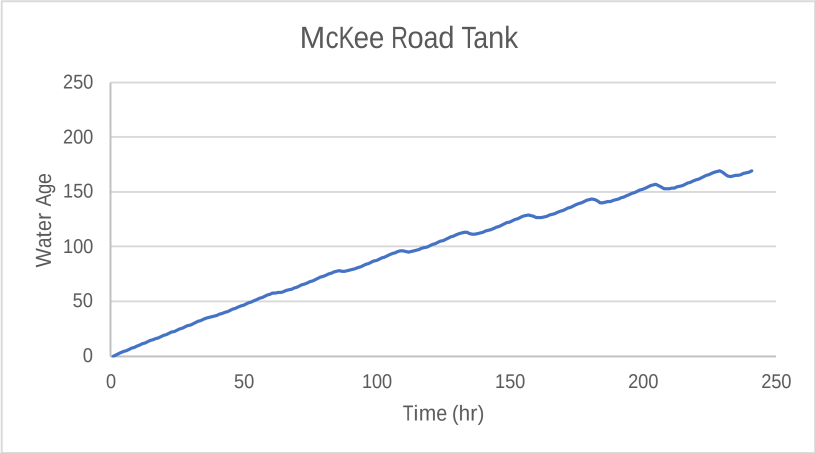


2040 ADD TANK WATER AGE









2040 ADD TANK WATER AGE