MEDFIELD WATER DEPARTMENT
WATER SYSTEM MASTER PLAN

Prepared for:
Town of Medfield, Massachusetts

January 2024

ENVIRONMENTAL PARTNERS
— An Apex Company —

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LIST OF ABBREVIATIONS

AC	Asbestos Cement
ADD	Average Day Demand
AFF	Available Fire Flow
ASR	Annual Statistical Report
BPS	Booster Pump Station
CCI	Construction Cost Index
CI	Cast Iron
CIP	Capital Improvements Program
DI	Ductile Iron
EP	Environmental Partners
ENR	Engineering News-Record
GIS	Geographic Information Systems
gpm	Gallons per Minute
hp	Horsepower
ISO	Insurance Services Office
MassDEP	Massachusetts Department of Environmental Protection
MCL	Maximum Contaminant Level
MDD	Maximum Day Demand
MG	Million Gallons
MGD	Million Gallons per Day
NaOH	Sodium Hydroxide
NaOCl	Sodium Hypochlorite
NAVD88	North American Vertical Datum of 1988
NFF	Needed Fire Flow
OPPC	Opinion of Probable Project Cost
PFAS6	Per- and Polyfluoroalkyl Substances (group of six)
PHD	Peak Hour Demand
ppt	Parts per Trillion

psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
RAA	Risk and Resiliency Assessment
RGPCD	Residential Gallons per Capita per Day
SCADA	Supervisory Control and Data Acquisition
TDH	Total Dynamic Head
UAW	Unaccounted for Water
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VFD	Variable Frequency Drive
VOC	Volatile Organic Compounds
WSMP	Water System Master Plan
WTP	Water Treatment Plant

EXECUTIVE SUMMARY

Environmental Partners Group, LLC (EP) contracted with the Town of Medfield (Town) Department of Public Works Water Department (Department) to prepare this Water System Master Plan (WSMP) update. The Department's existing WSMP was completed by Polaris Consultants, LLC in 2016. The primary goals of this WSMP update were as follows:

- Update the status and condition of water system infrastructure;
- Create and calibrate a town-wide water system hydraulic model;
- Use the hydraulic model to assess system deficiencies and recommend supplementary improvements projects; and
- Update the existing recommendations to remove completed items, add newly identified items, assign current opinions of probable project costs (OPPCs), and integrate all outstanding recommendations into a comprehensive Capital Improvements Program (CIP).

EP has provided a complete and detailed explanation of our findings, conclusions, and recommendations in the following WSMP report.

REPORT CONTENTS

To properly document our work and address the project tasks and goals listed above, EP has prepared and organized the Department's WSMP report in sections as described below.

- Section 1 includes an introduction to the report and background on the project history.

- Section 2 describes the Department's water supply system, including the raw water wells and piping, treatment facilities, storage facilities, finished water piping, booster pump station (BPS), back-up power, and supervisory control and data acquisition (SCADA) system. Water distribution maps are included in Appendix A.

- Section 3 provides an overview of the water system hydraulic model creation and calibration process and presents the results of a water system hydraulic assessment on the basis of service pressures and fire flow availability. A full report of the hydraulic model creation and calibration is included in Appendix B of this report.

- Section 4 recommends improvements and presents an implementation schedule and OPPC for the recommended CIP through the 2045 planning period.

Water System Overview

The Medfield Water Department supplies approximately 1.4 million gallons per day (MGD) of drinking water to over 13,000 residents. The system includes five groundwater wells, two elevated storage tanks, one booster pump station (BPS), and one water treatment plant (WTP). There are no pressure reducing valves or permanent interconnections with neighboring water systems. The distribution system is connected by approximately 83 miles of water main, ranging in diameter from 4” to 16”. Water distribution maps are included in Appendix A.

All wells are treated with sodium hydroxide (NaOH) for pH adjustment and sodium hypochlorite (NaOCl) for disinfection. Wells 3a and 4 are treated at the WTP that was constructed in 2023, which also includes pressure filtration for removal of iron and manganese.

The Town completed an initial screening for Per- and Polyfluoroalkyl Substances at their active public water supply wells in January 2021 in response to the Massachusetts drinking water standard for the sum of 6 PFAS compounds (PFAS6). The PFAS6 results from Well 1 and Well 2 were above 10 parts per trillion (ppt), which required the Town to continue monthly PFAS screening. The PFAS6 levels at Well 1 and Well 2 have remained consistently above 10 ppt, but below the current Massachusetts Department of Environmental Protection (MassDEP) PFAS6 maximum contaminant level (MCL) of 20 ppt. Wells 3, 3A, 4, and 6 have consistently been below 10 ppt since 2021 screening began.

Distribution system storage for the Medfield water system is provided by two storage tanks: Mount Nebo Water Storage Tank and the State Hospital Storage Tank. The Mount Nebo storage tank is a 2.4 million gallon (MG) standpipe that was constructed in 1983 and is 97 feet high. The tank was partially rehabilitated in 2020. The 1.25 MG State Hospital Tank was replaced in 2016. The new tank is a composite elevated pedestal tank that sits atop a concrete circular pedestal that is 50 feet in diameter and approximately 97 feet high.

The Town’s water system has one boosted pressure zone in the northeast corner of the Town. This pressure zone is serviced by the Hawthorne Village BPS. The pump station is comprised of three closed impeller pumps that service the high pressure zone; with one duty pump, one standby pump, and one pump dedicated for fire flow.

The Town’s water system is connected through approximately 83 miles of distribution piping. This piping is a combination of cast iron (CI), ductile iron (DI), polyvinyl chloride (PVC), and asbestos cement (AC), with DI and CI being the most common. Distribution piping diameters range from 4-inch to 16-inch.

Distribution System Assessment

The Town provided EP with Geographic Information Systems (GIS) shapefiles of the water system infrastructure. The Town also assisted EP in performing 28 hydrant flow tests and four C-factor tests in April 2023, and provided supplementary supervisory control and data acquisition (SCADA) data to accompany the tests. EP created the hydraulic model using WaterCAD CONNECT Edition Update 4 (version 10.04.00.108) by Bentley Systems, Inc. EP then simulated each of the field tests and adjusted the interior pipe roughness to simulate the headloss observed in the field. A full account of the hydraulic model and calibration is included in Appendix B.

EP utilized the hydraulic model to analyze the distribution system, simulating existing and future proposed supply and demand conditions. EP used the 2030 average day demand (ADD) presented in the 2016 WSMP (1.656 MGD).

Distribution System Findings

According to MassDEP Guidelines for Public Water Systems Chapter 9: Distribution System Piping & Appurtenances, the ideal pressure range for the distribution system is 60-80 pounds per square inch (psi) and not less than 35 psi under normal operation conditions. Additionally, the Department must maintain a minimum residual water pressure of 20 psi during a fire event.

EP completed model simulations for ADD, maximum day demand (MDD), and available fire flow (AFF) scenarios under current conditions and using the 2030 demand projections. For ADD and MDD conditions, EP identified low pressures below 35 psi, high pressures above 80 psi, and additionally flagged elevated pressures above 100 psi. These elevated pressures represent a higher risk of developing leaks or breaks during transient pressure events such as pump or valve operations. For the fire flow analysis, EP used the model to determine the maximum AFF at each point in the distribution system before a residual pressure of 20 psi is reached at any point in the system.

The pressure analysis revealed two areas in the system with pressures below 35 psi during typical operations: Mohave Road and Main Street in the northeast corner of town. These low pressures are due to higher elevations at these locations as compared to the tank levels. EP recommends the Town verify the presence of household booster pumps in these areas, and evaluate the need for a local BPS for these higher elevation areas.

The pressure analysis also revealed that there are three areas of high pressure: Main Street near Well 1 and Well 2, Causeway Street where it crosses the Stop River, and North Meadows Road near Well 6. Given the location of these areas and the small degree of the exceedance, EP does not advise creating new pressure zones. EP recommends prioritizing old cast iron water mains within high pressure areas for replacement early in the replacement program, and suggests the Town verify the presence of pressure reducing valves to protect against damage to plumbing fixtures.

AFF is determined by the Insurance Services Office (ISO) at select locations based on construction materials, spacing, and other factors. In addition, typical residential requirements can be approximated based on house spacing, ranging from a minimum of 500 gallons per minute (gpm) to a maximum of 1,500 gpm. The analysis indicates the following areas do not meet ISO fire flow requirements:

- North Street from Winter Street to Hunt Drive;
- Farm Street from North Street to Townline;
- Dover Farm Road;
- Hartford Street from Main Street to end of water main;
- Westview Street from South Street to end of water main;

- Nebo Street at Main Street;
- South Street at Metacomet Street;
- Elm Street at Steven Lane;
- Main Street at Spring Street; and
- Main Street at Hatters Hill Road.

A figure showing the fire flow deficient areas is provided in Appendix C. EP recommends several improvements projects to address these deficiencies. The recommended fire flow improvement projects are outlined in Section 4 of this report.

Water age is also an important design parameter for distribution systems. Excessive water age can lead to reduced chlorine residual and formation of disinfection byproducts. EP did not directly evaluate distribution system water quality with the model. However, EP analyzed average water age based on total storage and average demand, which can be used as a surrogate for overall distribution water quality. EP calculated a bulk water age across the entire system of 4.5 days using current ADD, and 3.1 using the projected ADD. This falls within the MassDEP guidelines of 3-5 days for daily turnover for individual tanks. However, the water age may vary regionally based on operations and local demand.

RECOMMENDED IMPROVEMENTS AND CAPITAL IMPROVEMENTS PLAN

EP recommends water main replacements to address deficiencies, as well as a CI pipe replacement program to phase out aging CI pipe in the system. EP has divided the CI pipe into replacement phases, detailed in Section 5. EP recommends the Town complete Phases 1 and 2 within the 2045 planning period. This amounts to approximately 9.4 miles of pipe. Phases 1 and 2 are shown in Appendix C.

EP anticipates the need to rehabilitate the water storage tanks toward the end of the 2045 planning period.

EP anticipates the Hawthorne BPS will be in need of rehabilitation or equipment replacement within the 2045 planning period. EP recommends the Town consider modifying the station to either include variable frequency drives (VFDs) or a hydropneumatics tank as a means of controlling pressure fluctuations in response to rapid changes in customer demands.

In addition, EP recommends assessing and rehabilitating (as required) one well annually, beginning with Well 6, followed by Wells 1 and 2.

There are a total of 10 recommended CIP projects. EP spaced the projects out every two years as a guideline. EP assumes tank rehabilitation and BPS improvements will not be required until the final years of the planning period.

For all recommended improvements, EP developed an OPPC that includes the construction cost, engineering fee, and contingencies. These costs represent the value of the project in 2023 dollars and should be compared to the Engineering News-Record (ENR) Construction Cost Index (CCI) from October 2023 of 13,497.97 when extrapolating to future value. For construction costs, EP included a 30% planning contingency, 25% for engineering design fees, 10% for resident project representative fees, and 2% for police details and traffic management, for a total of 67%.

A funding projection for the CIP projects is shown in the table below.

Table ES-1: CIP Sequence

Year	Project Name	Project Cost	Annual Well Rehabilitation	Total
2025	Main Street Water Main Replacement	$3,744,000	$25,000	$3,769,000
2026	CI Replacement, Phase 1 Part 1	$2,841,880	$25,000	$2,866,880
2027	Elm St Water Main Replacement	$3,000,000	$25,000	$3,025,000
2028	CI Replacement, Phase 1 Part 2	$2,841,880	$25,000	$2,866,880
2029	Nebo St Water Main Replacement	$2,522,000	$25,000	$2,547,000
2030	CI Replacement, Phase 1 Part 3	$2,841,880	$25,000	$2,866,880
2031	North St Water Main Replacement	$4,317,000	$25,000	$4,342,000
2032	CI Replacement, Phase 1 Part 4	$2,841,880	$25,000	$2,866,880
2033	Farm St Water Main Replacement	$1,724,000	$25,000	$1,749,000
2034	CI Replacement, Phase 1 Part 5	$2,841,880	$25,000	$2,866,880
2035	Hartford St Water Main Replacement	$1,210,000	$25,000	$1,235,000
2036	CI Replacement, Phase 2 Part 1	$2,603,600	$25,000	$2,628,600
2037	Westview Rd Water Main Replacement	$1,385,000	$25,000	$1,410,000
2038	CI Replacement, Phase 2 Part 2	$2,603,600	$25,000	$2,628,600
2039	Mt. Nebo Tank Rehabilitation	$1,448,000	$25,000	$1,473,000
2040	CI Replacement, Phase 2 Part 3	$2,603,600	$25,000	$2,628,600
2041	State Hospital Tank Rehabilitation	$1,008,000	$25,000	$1,033,000
2042	CI Replacement, Phase 2 Part 4	$2,603,600	$25,000	$2,628,600
2043	Hawthorne BPS Improvements	$150,000	$25,000	$175,000
2044	CI Replacement, Phase 2 Part 5	$2,603,600	$25,000	$2,628,600
			Total	**$48,235,400**

Although this CIP represents a substantial investment in the Town's water system, significant infrastructure funding is being made available through the American Rescue Plan Act (ARPA) and Bipartisan Infrastructure Law. EP recommends evaluating funding opportunities further to support the Department's CIP.

SECTION 1 INTRODUCTION

Environmental Partners Group, LLC (EP) contracted with the Town of Medfield (Town) to prepare this WSMP update for the Department of Public Works (Department). The Department's existing WSMP was completed by Polaris Consultants LLC in 2016. The primary goals of this WSMP update were as follows:

- Update the status and condition of water system infrastructure;
- Create and calibrate a water system hydraulic model;
- Use the hydraulic model to assess system deficiencies and recommend supplementary improvements projects;
- Update the existing recommendations to remove completed items, add newly identified items, assign current opinions of probable project costs (OPPCs), and integrate water system recommendations into a comprehensive Capital Improvements Program (CIP).

This report details the methods and findings from each of the above tasks.

SECTION 2 WATER SYSTEM OVERVIEW

The Medfield Water Department is operated by the Town and is overseen by the Board of Water and Sewerage. The water system supplies approximately 1.4 MGD of drinking water to over 13,000 residents. The system includes five groundwater wells, two elevated storage tanks, one booster pump station, and one water treatment plant. There are no pressure reducing valves or permanent interconnections with neighboring water systems. The distribution system is connected by approximately 83 miles of water main, ranging in diameter from 4" to 16". Water distribution system maps are included in Appendix A.

SECTION 2.1 GROUND WATER WELLS

The drinking water supply for the Town of Medfield comes from three wellfields that have a total of five gravel packed wells (Wells 1, 2, 3A, 4, and 6). The wells are located along the Town's central west border (Wellfield A: Wells 1 and 2), the southeast corner (Wellfield B: Wells 3A and 4) and in the northwest corner (Wellfield C: Well 6). Wells 1, 2, and 6 have chemical addition of 50% $NaOH$ for pH adjustment and 13% $NaOCl$ for disinfection. Wells 3a and 4 are treated at the Well 3 & 4 WTP that was commissioned in 2023. A description of the WTP treatment is included in section 2.3. A summary of each well is provided in Table 2-1.

Table 2-1: Medfield Groundwater Supplies

Wellfield	Groundwater Supply	MassDEP Source ID	Construction Date	Pump Type	Horsepower (HP)	Status	Type
Wellfield A	Well #1	2175000-01G	1955	Vertical Turbine	40	Active	Gravel Packed
	Well #2	2175000-02G	1959	Submersible	75	Active	Gravel Packed
Wellfield B	Well #3	2175000-03G	1967	Vertical Turbine	75	Decommissioned (2023)	Gravel Packed
	Well #3A	N/A[1]	2023	Submersible	100	Active	Gravel Packed
	Well #4	2175000-04G	1976	Vertical Turbine	75	Active	Gravel Packed
	Well #5	N/A[2]	1982	Undeveloped			Undeveloped Gravel Packed
Wellfield C	Well #6	2175000-05G	1998	Submersible	75	Active	Gravel Packed
State Hospital Wellfield			1930	Water Rights Only (Offline)			Tubular Wellfield

1) Well 3A was recently commissioned and did not have a MassDEP Source ID designated at the time this report was prepared.
2) Well 5 is undeveloped and does not have a MassDEP Source ID designated at the time this report was prepared.

In addition to the production wells, two wells remain undeveloped or offline. These include the former Medfield State Hospital wellfield and Well 5. More detail is provided in the following sections about the wellfields and well station operations.

Section 2.1.1 Well Stations

The Town has two well stations, Main Street well station and Route 27 well station.

The Main Street well station is comprised of two groundwater wells, Well 1 and Well 2. Each of these wells have their own well pump building that includes a well pump, instrumentation and controls, and all associated piping. Well 1 pumps water to Well 2 building via an 8-inch CI main where the flow is combined with Well 2, chemically treated, and then sent to distribution via an 8-inch CI main. The wells are treated with 50% NaOH for pH adjustment and 13% NaOCl for disinfection. The combined treated water from Wells 1 and 2 is conveyed through an air stripping tower for VOC treatment before being collected in the clearwell at the Well 2 site. The treated water is then pumped from the clearwell into the distribution system through an 8-inch CI water main in Main Street via the Well 1 & 2 finished water pumps.

The Well 1 and 2 finished water pump configuration consists of three dry-pit centrifugal pumps. Two pumps are designed to operate at 600 gpm at 289 feet of total dynamic head (TDH) and are equipped with 60 horsepower (hp) motors and VFDs. The third pump is rated for 300 gpm at 255 feet TDH with a 30 hp motor and a VFD.

The Route 27 well station is comprised of one groundwater well, Well 6. This well station is comprised of one building with a pump, instrumentation and controls, all associated piping, and chemical treatment equipment. The well is treated with 50% NaOH for pH adjustment and 13% NaOCl for disinfection. The treated water enters the distribution system through a 12-inch DI water main in Route 27, also known as North Meadows Avenue.

SECTION 2.2 SOURCE WATER PROTECTION

Section 2.2.1 Wellfield A

Wellfield A is located in the central western part of the Town on a parcel owned by the Town within the Charles River Conservation Area. Withdrawals at Well 1 and Well 2 have been historically the second highest in the Town accounting for approximately 28.6% of the Town's total water supply prior to the commissioning of the Wells 3 and 4 WTP. In response to historic volatile organic compound (VOC) contamination, the Town performed the following improvements in 2010:

- Installed a bypass for the existing VOC treatment system, to be used if needed;
- Install a new 40 hp, 300 gpm vertical turbine pump at Well 1 to a depth of 73'7";
- Install a new 75 hp, 600 gpm submersible pump at Well 2 to a depth of 72 ft;
- Rehabilitation of the existing corrosion control facility at Well 1 for NaOH; and
- Installation of VFDs at each well for energy efficiency.

The Town completed an initial screening for Per- and Polyfluoroalkyl Substances at their active public water supply wells in January 2021 in response to the Massachusetts drinking water standard for PFAS6. The PFAS6 results from Well 1 and Well 2 were above 10 ppt, which required the Town to continue monthly PFAS screening. The PFAS6 levels at Well 1 and Well 2 have remained consistently above 10 ppt, but below the current MassDEP MCL of 20 ppt. Average concentrations from tests since 2021 are shown in , as reported on the Massachusetts Energy & Environmental Affairs Data Portal.

Table 2-2 below, as reported on the Massachusetts Energy & Environmental Affairs Data Portal.

Table 2-2: Wellfield A PFAS6 Concentration

Sample Location	Concentration (ppt)
Raw Water Well #1	15.8
Raw Water Well #2	18.7
Main Street Finished Water	17.8

These concentrations are currently under the MassDEP regulatory limit for PFAS6, but the Town is currently evaluating treatment options for PFAS at this wellfield.

Section 2.2.2 Wellfield B

Wellfield B is located in the southeast corner of Town on a parcel owned by the Town within the Mill Brook Conservation Area. In recent history, Well 4 has been offline due to elevated manganese and was only used during peak demand or emergencies. The Town recently completed the construction of a WTP at Wellfield B to treat iron and manganese from Wells 3A and 4. Details of this WTP are included in Section 3.1.3. Well 3 was abandoned as part of the WTP construction and a new well (Well 3A) was constructed to replace it. Well 3A was installed within 50 feet of Well 3 and was approved by MassDEP for the same yield.

Historically Wellfield B was investigated for another water supply well, Well 5. Well 5 was never developed due to elevated levels of manganese and organic color, potential wetland impacts, and concerns about Mine Brook permitting.

The Town has completed the required PFAS6 screening since 2021 and PFAS6 levels have been below the current MassDEP MCL as well as the 10 ppt threshold requiring monthly screening.

Section 2.2.3 Wellfield C

Wellfield C is located in the northwest corner of the Town on a parcel owned by the Massachusetts Department of Conservation and Recreation within the Medfield Charles River State Reservation. The Well 6 land has been leased from the State since 1993 under the terms of a 50-year lease. Historically withdrawals at Well 6 have accounted for 46.4% of the Town's total water supply prior to the recent WTP commissioning. The submersible pump at the well was replaced in 2022 and to date there are no present water quality concerns.

The Town has completed the required PFAS6 screening since 2021 and PFAS6 levels have been below the current MassDEP MCL as well as the 10 ppt threshold requiring monthly screening.

Section 2.2.4 State Hospital Wellfield

The Town acquired the water rights to the State Hospital Wellfield in 2001. The existing State Hospital water supply consists of sixty-three 2½” diameter wells and dates back to the 1930s. The Town is in the process of redeveloping the State Hospital property for residential, open space, and community uses.

SECTION 2.3 WATER TREATMENT PLANT

The WTP was commissioned in 2023 and is rated for an average flow of 0.9 MGD with a maximum flow capacity of 2.21 MGD. The facility is located northwest of Well 3/3A in a mainly wooded area owned by the Town adjacent to the Town soccer fields and Wheelock School. A new production well, Well 3A, was installed within 50 feet of Well 3. Raw water from Well 3A and Well 4 is pumped via 8-inch DI water main to the new facility. The two 8-inch raw water mains combine in the water treatment plant driveway and become a single 12-inch raw water main that enters at the southwest corner of the building.

Raw water enters the building and receives pre-filtration chemical treatment with NaOH for pH adjustment and NaOCl for disinfection and oxidation. The oxidized water is distributed to four vertical pressure filters containing anthracite, GreensandPlus™ media, and gravel for the removal of iron and manganese. Filter effluent water flows back through the process area before entering the distribution system. Provisions for post-filtration chemical treatment are available if needed with NaOH for pH adjustment and NaOCl for disinfection. Standard operational procedure for the WTP dictates that pH and chlorine residual carries through filtration and additional post-filtration chemical treatment typically will not be required.

The Well 3A and Well 4 pumps deliver pressurized water from the wells, through the facility, and into the distribution system with no intermediate pumping required. A 12-inch finished water pipe exits the facility and connects to the existing 12-inch finished water main at the intersection of the plant driveway and access road.

SECTION 2.4 DISTRIBUTION STORAGE FACILITIES

Distribution system storage for the Medfield water system is provided by two storage tanks: Mount Nebo Water Storage Tank and the State Hospital Storage Tank. EP estimates the highest customer in the main service zone is at approximately elevation 271.5 feet. This makes the minimum water elevation to provide 20 pounds psi of fire service pressure approximately 318 feet. The minimum water elevation to provide minimum 35 psi for typical service is approximately 352 feet. The tank details are summarized in Table 2-3 below.

Table 2-3: Water Storage Tank Summary

Location	Type	Date Constructed	Storage Base El. (ft)	Height (ft)	Dia. (ft)	Overflow El. (USGS Datum)	Tank Volume (MG)
Mount Nebo Storage Tank	Standpipe	1983	263.0	97.0	65	360.0	2.40

State Hospital Storage Tank	Composite Elevated	2016	320.0	137.5	84	360.0	1.25
						Total Volume	**3.65**

Section 2.4.1 Mount Nebo Standpipe

The Mount Nebo storage tank is a standpipe that was constructed in 1983 and is 97 feet high. The base of the tank is at approximately elevation 263 feet, putting the overflow pipe at approximate elevation of 360 feet in United States Geological Survey (USGS) North American Vertical Datum of 1988 (NAVD 88). Based on the key elevations outlined above, approximately 8.5 feet of storage is unusable for fire storage, and approximately 89 feet is unusable for typical service.

The 2018 inspection report noted generally good structural and sanitary condition, as well as very good interior coating condition. The report noted some degradation of the exterior coating system. The tank was partially rehabilitated in 2020, including the following:

- Exterior rehabilitation with high-pressure water cleaning and multi-layer exterior overcoat paint system;
- Interior spot repairs and painting;
- Installation of a Tideflex mixing system; and
- Repairs to the tank overflow, vent, and hatches.

EP recommends the Town inspect the storage tank annually to monitor the condition, and anticipates full interior and exterior rehabilitation will be required in the second half of the 2045 planning period.

Section 2.4.2 State Hospital Storage Tank

The State Hospital Tank was replaced in 2016. The new tank is a composite elevated pedestal tank with a base El. of 223 feet and an overflow pipe at El. 360 (NAVD 88). The Storage tank sits atop a concrete circular pedestal that is 50 feet in diameter and approximately 97 feet high. The base of storage is thus at approximately 320 feet elevation. Based on the key elevations outlined above, all storage is usable for fire storage, and approximately 32 feet is unusable for typical service. The tank was designed to provide 600,000 gallons of storage above 35 psi.

The bowl is a welded steel tank with a steel-lined concrete bottom. The tank is fitted with a Tideflex mixing system to promote improved water quality and water age. EP recommends the Town inspect the storage tank annually to monitor the condition, and anticipates full rehabilitation will be required in the second half of the 2045 planning period.

SECTION 2.5 HAWTHORNE VILLAGE WATER BOOSTER STATION

The Town's water system has one boosted pressure zone in the northeast corner of town. This pressure zone is serviced by the Hawthorne Village BPS. The pump station includes three closed impeller pumps that service the high pressure zone; with one duty pump, one standby pump, and one dedicated fire flow pump. The two duty pumps for normal water supply are 25 hp pumps that deliver 175 gpm at 90 feet TDH each. The fire pump is a 75 hp pump that delivers 1,500 gpm at 138 feet TDH. Normal operating conditions for the lead and lag pump can be seen in Table 2-4 below.

Table 2-4: Hawthorn Booster Pump Operations

	Lead Pump	Lag Pump
Turns on (psi)	60	50
Turns off (psi)	80	75

Under fire flow conditions the fire pump is able to produce 1,350 gpm of flow at 20 psi residual pressure for the entire high pressure zone. The pressure zone is a closed zone with no storage tank.

SECTION 2.6 DISTRIBUTION SYSTEM PIPING

The Town's water system is connected through approximately 83 miles of distribution piping. This piping is a combination of CI, DI, PVC, and AC, with DI and CI being the most common. Table 2-5 below shows a breakdown of the distribution piping by material.

Table 2-5: Water Main Breakdown by Material

Material	Total Length (ft)	Percent %
Cast Iron	223,246	50.9
Ductile Iron	213,043	48.6
Polyvinyl Chloride	607	0.1
Asbestos Cement	1,733	0.4
Total	438,621	100.0

This analysis of pipe materials shows that CI and DI are the predominant types of pipes, accounting for a combined 99.5% of the entire system's pipe material. The water mains range in size from 4" to 16" in diameter. Table 2-6 shows a breakdown of the distribution piping by size.

Table 2-6: Water Main Breakdown by Diameter

Diameter	Total Length (ft)	Percent %
4"	1,498	0.3
6"	136,895	31.2
8"	153,524	35.0
10"	45,758	10.4
12"	86,227	19.7
16"	14,719	3.4
Total	438,621	100.0

This breakdown shows that the majority of water mains in the system are 6", 8", or 12". Pipes of these sizes represent 85.9% of the total system.

SECTION 2.7 BACK-UP POWER

The Town completed a Risk and Resiliency Assessment (RAA) for the water system assets in June 2021. This assessment included the following:

- Identification of critical assets;
- Identification of threats;
- Assessment of utility resistance;
- Risk assessment; and
- Recommendation of countermeasures.

As part of this assessment an inventory of backup power was taken, presented in Table 2-7 below.

Table 2-7: Backup Power Inventory

Facility	Backup Power	Duration of Backup Power Available
Mt. Nebo Tank	Propane	72 hours
State Hospital Tank	Propane	72 hours
Well 3 & Well 4 WTP(1)	Natural Gas	Indefinite
Hawthorne Village BPS	Natural Gas	Indefinite
Well 1	None	N/A
Well 2	None	N/A
Well 3	Propane	48 hours
Well 4	None	N/A
Well 6	Propane	48 hours

1. This item was not part of RAA, the details of this item were taken from the construction documents of the WTP.

SECTION 2.8 SCADA SYSTEM

The Water Department is equipped with a supervisory control and data acquisition (SCADA) system that provides the ability to remotely monitor all operations at the wellfields, as well as monitoring the elevations at each of the three storage tanks. The SCADA system can:

- Monitor pump rates and water levels at each well field. The pump rates can be modified remotely, as needed to control water level drawdown and withdrawal rates.
- Monitor the water treatment systems. The pH, flow, chlorine residual, and pressure at each treatment facilities before the water enters the distribution system can be viewed.
- Monitor water level at the storage tanks.

The SCADA system improves the ability of the Water Department to manage the wellfields through direct monitoring of ground water supplies under a wide variety of pumping scenarios. Direct monitoring of the water treatment systems provide for more precise use of treatment technologies and thereby results in higher water quality and more efficient operations for the Town. In addition, monitoring of the storage tanks provides the Department with the ability to confirm that appropriate filling of the tanks is occurring in response to water system demands.

The recently commissioned Wells 3 and 4 WTP includes a state-of-the-art SCADA system for process monitoring and operational control. The overall control strategy for the water treatment plant includes:

- To measure and record plant raw water (Wells 3/3A and 4), backwash waste, and finished water flow rates.
- To monitor and control the pressure filtration process and associated process equipment, including filter valves and an air scour blower.
- To measure and record liquid levels in various chemical storage tanks.
- To provide control of sodium hypochlorite and sodium hydroxide chemical feed pumps.
- To monitor equipment operating status and to record motor run times and process variables.
- To monitor and record field instrument measurements including pressure, headloss, flow, pH/temperature, and chlorine residual.
- To monitor, record, and transmit designated alarms.
- To interlock chemical feed systems to well stations 3A and 4, in compliance with MassDEP Chapter 6 chemical feed safety.

The SCADA system also provides an alarm system that notifies the Department in the event that sudden elevation drop occurs in each of the tanks, which may be indicative that a water main break has occurred.

SECTION 3 DISTRIBUTION SYSTEM ASSESSMENT

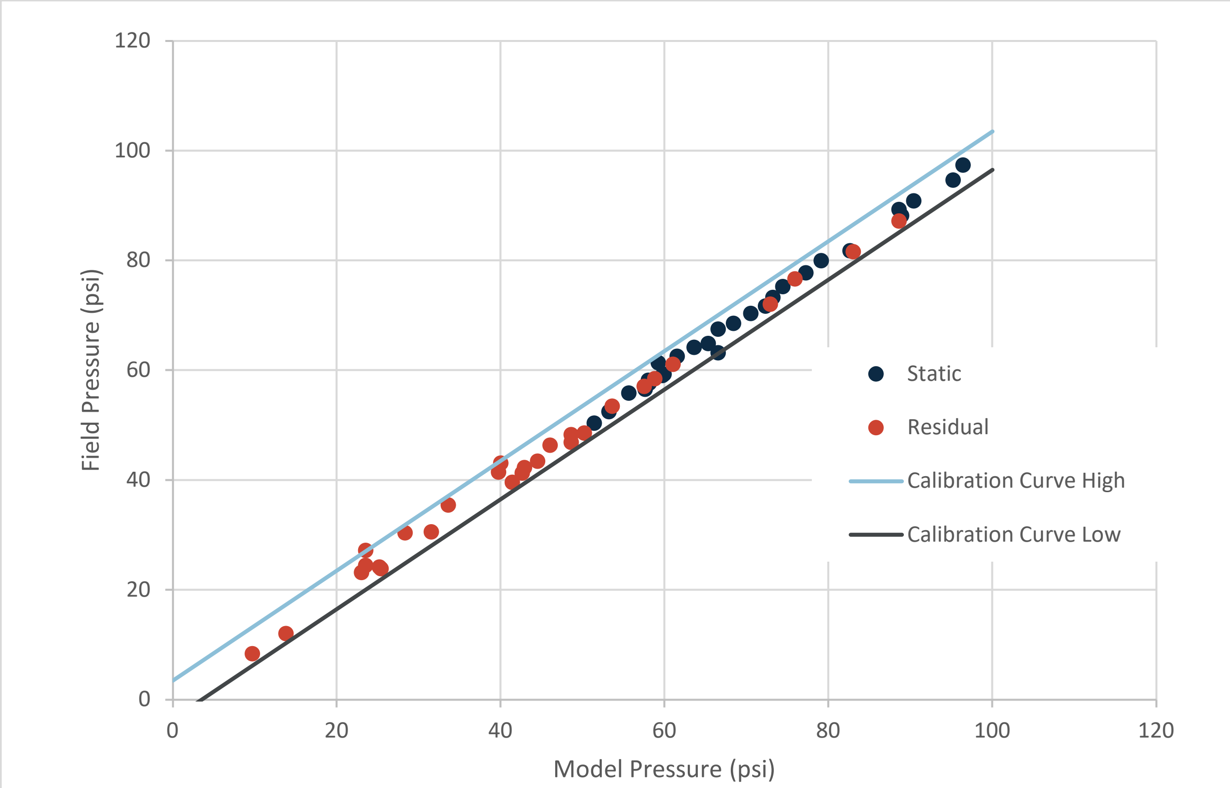
SECTION 3.1 MODEL CREATION AND CALIBRATION

A calibrated hydraulic model is a powerful tool for every water distribution system. It enables the Town to complete distribution system assessments, prioritize capital improvements, develop and optimize flushing programs, and estimate future impacts to the water system. In addition, a calibrated model can predict AFF at locations throughout the water system under varying system conditions. With additional calibration effort, a hydraulic model can even simulate water quality (e.g. chlorine residual) throughout the distribution system.

The Town provided EP with GIS shapefiles of the water system infrastructure. The Town also assisted EP in performing 28 hydrant flow tests and four C-factor tests in April 2023, and provided supplementary SCADA data to accompany the tests. EP created the hydraulic model using WaterCAD CONNECT Edition Update 4 (version 10.04.00.108) by Bentley Systems, Inc. EP then simulated each of the field tests and made adjustments to the interior pipe roughness to simulate the headloss observed in the field.

A full account of the hydraulic model and calibration is included in Appendix B. A summary of the static and residual pressure calibration is presented in Figure 3-1.

Figure 3-1: Pressure Calibration Results



SECTION 3.2 WATER SYSTEM HYDRAULIC ANALYSIS

EP utilized the hydraulic model to analyze the distribution system, simulating existing and future proposed supply and demand conditions. These simulations included ADD, MDD, and peak hour demand (PHD) scenarios, as well as fire flow availability. The analysis examined key performance metrics such maximum and minimum pressures, inadequate fire flows, and approximate water age.

Section 3.2.1 Demand Assumptions

EP assessed the model under current and future conditions. EP used 2030 ADD presented in the 2016 WSMP. EP calculated scaling to MDD based on a review of past Annual Statistical Report (ASR) data, as described in Appendix B. Scaling to peak hour is taken as 30% of MDD. The resulting demands are shown in Table 3-1 below.

Table 3-1: Current and Projected Demands

	ADD	MDD	PHD
Current Demand (MGD)	1.145	2.286	2.634
2030 Demand (MGD)	1.656	3.329	3.809

Section 3.2.2 Distribution System Pressure Analysis

According to MassDEP Guidelines for Public Water Systems Chapter 9: Distribution System Piping & Appurtenances, the ideal pressure range for the distribution system is 60-80 pounds psi and not less than 35 psi under normal operation conditions. Additionally, the Department must maintain a minimum residual water pressure of 20 psi during a fire event.

EP completed model simulations for ADD, MDD, and fire flow scenarios under current conditions and using the 2030 demand projections. For ADD and MDD conditions, EP flagged low pressures below 35 psi, high pressures above 80 psi, and additionally flagged elevated pressures above 100 psi. These elevated pressures represent a higher risk of developing leaks or breaks during transient pressure events such as pump or valve operations. For the fire flow analysis, EP used the model to determine the maximum AFF at each point in the distribution system before a residual pressure of 20 psi is reached at any point in the system.

The pressure analysis also revealed that there are three areas of high pressure: Main Street near Well 1 and Well 2, Causeway Street where it crosses the Stop River, and North Meadows Road near Well 6. Given the location of these areas and the small degree of the exceedance, EP does not advise creating new pressure zones. EP recommends prioritizing old cast iron water mains within high pressure areas for replacement early in the replacement program, and suggests the Town verify the presence of pressure reducing valves to protect against damage to plumbing fixtures.

The high pressures on Main Street near Well 1 and 2 are primarily driven by high internal friction (low C-factor) on the cast iron transmission main. The pumps must overcome the friction losses by producing additional system head. This creates a significant surge in pressures during pump operations. As mentioned above, high service pressures increase the risk of leaks and breaks. In addition, this water main is installed near Vine Brook and the Charles River, and may be influenced by groundwater, which can accelerate exterior pipe wall loss. As a failure in this pipe would result in temporary loss of both Wells 1 and 2, EP strongly recommends prioritizing this water main for replacement, as discussed further in Section 4.

Figures showing the maximum and minimum pressures observed in the hydraulic model are included in Appendix C.

Section 3.2.3 Available Fire Flow Analysis

EP also analyzed AFF under MDD conditions, assuming tanks levels are about halfway through their typical fluctuation cycle. The hydraulic model calculates the maximum available fire flow at all areas of the water distribution system. The model assigns incrementally increasing demand to the node in question until 20 psi residual pressure is reached at any point in the system. EP approximated residential needed fire flow (NFF) requirements based on an ISO house spacing guideline as outlined in Table 3-2 below.

Table 3-2: Required Fire Flow by House Spacing

Distance Between Buildings	Needed Fire Flow
More than 30 feet	500 gpm
21 – 30 feet	750 gpm
11 – 20 feet	1,000 gpm
0 – 10 feet	1,500 gpm

The analysis indicates the distribution cannot provide the NFF at 20 psi residual pressure in the following residential areas:

- North Street from Winter Street to Hunt Drive;
- Farm Street from North Street to Townline;
- Dover Farm Road;
- Hartford Street from Main Street to end of water main; and
- Westview Street from South Street to end of water main.

A figure showing the fire flow deficient areas is provided in Appendix C.

ISO also specifies fire flow requirements at a number of locations, typically non-residential users or high-density residential developments. The most recent report available from ISO listed a number of locations which were tested on 11/17/2017 and compared against the requirements. EP extracted AFF from the hydraulic model at each of these locations, as shown in

Table 3-3 below.

Table 3-3: ISO Fire Flow Analysis

Test Location	Test Number	NFF	AFF (ISO)	AFF (Model)	Difference
Farm St @ Donnelly Dr	#1	500	650	1,032	532
Nebo & Main	#2	2,500	4,600	2,236	**-264**
South & Metacomet	#3	4,500	600	3,165	**-335**[1]
Elm & Steven Ln	#4	3,000	1,200	1,082	**-1918**
Ridge Rd @ Snyder Rd	#5	500	1,500	1,180	680
Onondaga Ln & Indian Hill Rd	#6	500	450	782	282
Pine Street @ Hawthorne Dr	#7	500	2,000	1,533	1033
West & No. Meadows	#8	1,750	2,500	4,500	2,751
Adams & W. Mill St	#9	1,500	2,200	4,500	3,002
Adams & Dale St	#10	2,250	2,500	3,727	1,477
Frairy & Dale	#11	4,500	1,900	3,723	**0**[1]
Main & Spring	#12	3,000	2,600	2,881	**-119**
Main & Hatters Hill Rd #1	#13	4,000	3,900	2,663	**-837**[1]
Main & Hatters Hill Rd #2	#14	2,250	3,900	2,663	413

1. Needed fire flows greater than 3,500 gpm are not considered in determining the classification of the municipality when using ISO's fire suppression rating system. For areas with an NFF above 3,500 gpm, the resulting surplus or deficiency has been adjusted to reflect the maximum requirement of 3,500 gpm.

The hydraulic model results indicate deficiencies in five areas, highlighted in the table above. It is important to note that per the ISO's Public Protection Classification system, a municipality's classification is based on its ability to provide fire flow up to 3,500 gpm. Buildings with NFF above those values receive a separate classification.

As such, EP adjusted the "Difference" values for areas that have needed fire flows over 3,500 to reflect this requirement (denoted with a footnote). One area, Frairy & Dale, meets the 3,500 gpm requirement but falls short of the 4,500 gpm requirement. EP recommends the Town discuss this observation with the property owner. Site improvements may reduce the NFF or AFF, or the owner may be willing to provide funding for the Town to make required system improvements to meet the NFF at this location.

EP recommends improvements projects in the Section 4 to address these deficiencies.

Section 3.2.4 Water Age

EP calculated the total volume of water in the distribution network and compared it to the typical demand to calculate the approximate average water age in the system. The total volume of distribution piping is approximately 1.45 MG. Added to the water storage tanks, the bulk water volume in the system is approximately 5.1 MG. Using the ADD of 1.145 MGD reported above, the current bulk water age would average to 4.45 days, which would result in 22.5% daily turnover of all water. Using the future ADD of 1.656 MGD, the resulting water age would be 3.08 days, or 32.5% turnover per day.

This average falls within the MassDEP guideline of 3-5 days for individual storage tanks. However, the water age may be much lower on average near sources or tanks depending on operations, and may be much higher in the far reaches of the system where demands are low, such as the Orchard Street Area.

If the Department has concerns of water age in specific regions or a history of low chlorine residual in some areas, EP recommends upgrading the hydraulic model to include a detailed extended period simulation to allow for a trace analysis or direct water quality modeling.

SECTION 4 RECOMMENDED SYSTEM IMPROVEMENTS

EP recommends water main replacements to address deficiencies outlined in the previous section, as well as a CI pipe replacement program to phase out aging CI pipe in the system. EP anticipates the need to rehabilitate the water storage tanks toward the end of the 2045 planning period. EP has also carried a small number of recommendations from the previous WSMP and ongoing projects, which are omitted from the CIP in the following section.

SECTION 4.1 WATER MAIN IMROVEMENTS TO ADDRESS DEFICIENCIES

Based on the results of the hydraulic analysis presented in Section 3, EP recommends a number of water main upgrades to meet fire flow requirements and improve system resilience, outlined below.

Section 4.1.1 Main Street Water Main Upgrade

The water distribution system experiences high pressure on Main Street and Causeways Street, particularly during when the Well 1 and 2 finished water pumps are running. Upgrades to the water distribution system on Main Street that connects Wellfield A with the water distribution system would significantly reduce the magnitude of the pressure spikes from about 114 psi to 100 psi, and also improve system resilience by reducing the likelihood of a water main failure that could otherwise render Wells 1 and 2 unusable. A summary of this upgrade is provided in Table 4-1 below.

Table 4-1: Main Street Upgrade

Project Area	Work Description	New Pipe Dia	Pipe Length
Main Street Upgrade	Replace 8" Cast Iron on Bridge St with 12" Ductile Iron	12	1,250
	Replace 8" Cast Iron on Main St with 12" Ductile Iron	12	4,725

The work includes replacing the 8” CI main with 12” DI on Main Street from Well 1 and Well 2 to the intersection of Main Street and Spring Street, and replacing the 8” CI on Bridge Street from Main Street to Essex Road.

Section 4.1.2 Elm Street Water Main Upgrade

The water system does not meet the NFF at the ISO test location #4, on Elm Street near Wheelock Elementary School. An upgrade to the Elm Street water main will provide the school with the required flow, summarized below in Table 4-2.

Table 4-2: Elm Street Upgrade

Project Area	Work Description	New Pipe Diameter	Pipe Length
Elm St improvement	Replace Elm St 6" CI with New 12" DI from Raven Way to Knollwood Rd	12	3,575
	Replace the 6" CI loop around Wheelock school with new 8" DI.	8	1,400

This work includes replacing the 6" CI main on Elm Street from Raven Way to Knollwood Road with 12" DI and replacing the 6" CI loop around Wheelock School with 8" DI. This upgrade increases the total available fire flow available at the ISO location from 1,080 gpm to 3,345 gpm, exceeding the requirement.

Section 4.1.3 Nebo Street Water Main Upgrade

The water system does not meet the NFF at the ISO test location #13 at the intersection of Main Street and Hatters Hill Road. An upgrade to the Nebo Street water main will provide this location with the required fire flow, summarized in Table 4-3 below.

Table 4-3: Nebo Street Upgrade

Project Area	Work Description	New Pipe Diameter	Pipe Length
Nebo St improvement	Replace Nebo St 6" CI with New 12" DI from Foundry St to Main St. Also add an interconnect between 12" DI and 8" CI.	12	4,025

This work includes replacing the 6" CI on Nebo Street from Foundry Street to Main Street with 12" DI. There should also be a new interconnection made between the 12" DI and 8" CI water mains on Main Street at the intersection of Main Street and Nebo Street.

Section 4.1.4 North Street Water Main Upgrade

The water system does not meet the NFF on North Street from the intersection of North Street and Farm Street to the end of North Street. An upgrade to the North Street water main will provide sufficient fire flow to North Street, as described in Table 4-4 below.

Table 4-4: North Street Upgrade

Project Area	Work Description	New Pipe Diameter	Pipe Length
North St	Replace 8" and 6" Cast Iron on North St after Farm St North St split with 8" Ductile Iron	8	3,075
	Replace 10" Cast Iron on North St with 12" Ductile Iron	12	4,225

This work includes replacing the 10” CI main on North Street from Winter Street to intersection of North Street and Farm Street with 12” DI and replacing the 6” CI on North Street from the intersection of North Street and Farm Street to the end of the water main with 8” DI. This upgrade increases the total available fire flow from 215 gpm to approximately 1,050 gpm.

Section 4.1.5 Farm Street Water Main Upgrade

The water system does not meet the NFF on Farm Street and Dover Farm Road. An upgrade to the Farm Street water main will provide sufficient fire flow to Farm Street and Dover Farm Road. A description of the work can be seen in Table 4-5 below.

Table 4-5: Farm Street Upgrade

Project Area	Work Description	New Pipe Diameter	Pipe Length
Farm St	Replace 8" and 6" Cast Iron on Farm St with 8" Ductile Iron	8	3,175

This work includes replacing the 6” CI on Farm Street from the intersection of North Street and Farm Street to the end of the water main. This upgrade increases the total available fire flow from 160 gpm to 1,200 gpm.

Section 4.1.6 Westview Road Water Main Upgrades

The water system does not meet the NFF on Westview Road. An upgrade to the Westview Road water main will provide sufficient fire flow to the homes on Westview Road, as summarized in Table 4-6 below.

Table 4-6: Westview Road Upgrades

Project Area	Work Description	New Pipe Diameter	Pipe Length
Westview Rd	Replace 6" Cast Iron with 8" Ductile Iron	8	2,550

This work includes replacing the 6” CI on Westview Road from South Street to the end of the water main with 8” DI. This upgrade increases the total available fire flow from 340 gpm to 900 gpm.

Section 4.1.7 Hartford Street Water Main Upgrades

The water system does not meet the NFF on Hartford Street. An upgrade to the Hartford Street water main will provide sufficient fire flow to the homes on Hartford Street, as summarized in Table 4-7 below.

Table 4-7: Hartford Street Upgrades

Project Area	Work Description	New Pipe Diameter	Pipe Length
Hartford St	Replace 8" Cast Iron with 8" Ductile Iron	8	2,225

This work includes replacing the 6” CI on Westview Road from South Street to the end of the water main with 8” DI. This upgrade increases the total available fire flow from 260 gpm to 1,325 gpm.

SECTION 4.2 CAST IRON REPLACEMENT PLAN

The Town has over 40 miles of cast iron pipe in the water system. The Town was not able to provide records of water main installation dates. Therefore, EP does not know the exact age of any of the cast iron water mains in the system. As most cast iron most likely would have been installed prior to 1960, it is likely any cast iron mains are at least 65 years old at the time of this report, while some may be over 100 years old. This puts most, if not all, of the cast iron mains near the end of their effective service life. Below is a breakdown of the CI pipe by diameter.

Table 4-8: CI Water Main Breakdown by Diameter

Diameter	Total Length (ft)	Percent %
6”	118,927	53.3
8”	73,309	32.8
10”	11,075	5.0
12”	7,757	3.5
16”	12,178	5.5
Total	223,246	100.0

The Town currently completes a system-wide leak detection survey annually. Past leak detection surveys have produced estimates of daily leak rates which, when projected over the year, appear to account for a large portion of the reported UAW. Replacing aging cast iron pipes may greatly reduce the UAW over time. EP recommends the Town begin replacing its CI pipe on a recurring basis, prioritizing both the projected condition of the pipe and the criticality of the pipe in question. EP assigned an anticipated condition or risk to the Town’s CI pipes based on known factors including:

- History of documented breaks/leaks
- Proximity to water bodies
- History of water quality complaints
- Average service pressure observed in the model
- Low C-factor from calibration (a proxy for interior condition)

This approach should help the Town lower its overall risk and likelihood of failure profile over time and minimize the number of annual breaks and leaks. EP has divided the CI pipe into replacement phases, detailed in Section 5. EP recommends the Town complete Phases 1 and 2 within the planning period, if possible. This amounts to approximately 9.4 miles of pipe. Phases 1 and 2 are shown in Appendix C.

SECTION 4.3 WATER STORAGE TANK REHABILITATION

The Mt. Nebo Storage Tank was partially rehabilitated in 2020, and the State Hospital Storage Tank was constructed in 2016. EP anticipates both tanks will need full rehabilitation and recoating before the end of the 2045 planning period. It is likely the Mt. Nebo Storage Tank will need to occur first, as the 2020 rehabilitation only included a partial outer coating and spot repairs and painting internally.

SECTION 4.4 HAWTHORNE BPS IMPROVEMENTS

EP anticipates the Hawthorne BPS will be in need of rehabilitation or equipment replacement within the 2045 planning period. EP recommends the Town consider modifying the station to either include VFDs or a hydropneumatics tank as a means of controlling pressure fluctuations in response to rapid changes in customer demands.

SECTION 4.5 WATER AUDIT

While the Town's historical residential gallons per capita per day (RGPCD) is below the MassDEP guideline of 65, the Unaccounted for Water (UAW) is averaging above the guideline of 10%, with a recent high of 24%. UAW is a measurement of how well a water supply system can account for all the water that it pumps into its distribution system. UAW values may be high because water is lost through leaks in the distribution system, which may occur in older systems. UAW values may also be high if meters are incorrectly calibrated so that over-registration of water use occurs or if unmetered uses are not documented in the ASR. The RGPCD and UAW for the Town can be seen in Table 4-9 below.

Table 4-9: RGPCD and UAW 2018-2022

Year	RGPCD (gal/capita/day)	UAW (%)
2018	69	16
2019	60	10
2020	66	20
2021	65	16
2022	57	24
Average	63	17.2

MassDEP may not approve new sources until the Town is able to gain compliance with the RGPCD and UAW standards. Additionally, high UAW causes unnecessarily high pump wear and energy consumption, both of which contribute to elevated operating costs, while simultaneously causing lost revenue. Considering this, EP recommends that the Town perform a water audit in order to lower the UAW.

A water audit provides water suppliers with a means of identifying and tracking lost water, revenue lost through meter inaccuracies, data handling errors, and theft. Controlling these losses not only can make better use of water resources but can also increase revenue.

EP understands the Town is currently conducting a water audit. After this information is reviewed a plan for mitigating the UAW most efficiently can be developed.

SECTION 4.6 PFAS TREATMENT

PFAS screening results at Wells 1 and 2 have revealed the presence of PFAS6 compounds above the 10 ppt level to trigger monthly monitoring, but below the current MassDEP MCL of 20 ppt. EP understands the Town has evaluated the feasibility of providing PFAS treatment for Wells 1 and 2. These wells were installed prior to 1960. EP recommends any treatment facility modifications include assessing the condition and remaining useful life of these two wells, and rehabilitating or replacing the wells as necessary.

The United States Environmental Protection Agency (USEPA) is in the process of developing national drinking water standards for two PFAS compounds, PFOA and PFOS. The USEPA published draft MCLs for these compounds at 4 ppt each. The final MCLs are expected to be published in early 2024. EP recommends the Town reevaluate PFAS compliance at each of the wellfields due to the pending MCLs, which are more conservative than the MassDEP PFAS6 MCL.

SECTION 4.7 UPGRADE METERING INFRASTRUCTURE

The previous water master plan included a CIP for the Town’s water system. The plan included a recommendation to update the Town's billing and reporting capabilities and monitor public water use to assess the impact on UAW. EP understands that the Town is in the process of migrating to an advanced metering infrastructure (AMI) water meter system, which when fully implemented will improve billing, reporting, and performance monitoring of the water system.

SECTION 5 CAPITAL IMPROVEMENT PLAN

SECTION 5.1 OPINION OF PROBABLE PROJECT COSTS

For all recommended improvements, EP developed an OPPC that includes the construction cost, engineering fee, and contingencies. These costs represent the current value of the project in 2023 dollars and should be compared to the ENR CCI from October 2023 of 13,497.97 when extrapolating to future value. For construction costs, EP included a 30% planning contingency, 25% for engineering design fees, 10% for resident project representative fees, and 2% for police details and traffic management, for a total of 67%.

Using recent projects and current construction costs, EP developed a cost per linear foot to replace the water mains of various sizes with ductile iron pipe, including an estimated three-inch-thick trench pavement, but excluding final road paving. The costs per linear foot are shown in Table 5-1 below. These linear foot costs exclude planning contingencies and engineering fees, which are applied separately in the project summaries below.

Table 5-1: Linear Foot Construction Costs for Water Main Replacement by Diameter

Main Size (in)	Price Per Linear Foot
20	$ 650.00
16	$ 450.00
12	$ 375.00
8	$ 325.00
6	$ 275.00

SECTION 5.2 WATER MAIN IMROVEMENTS TO ADDRESS DEFICIENCIES

Based on the above values, OPPCs for the water main projects identified during the distribution system assessment (excluding the full CI replacement program) are shown in Table 5-2 below.

Table 5-2: Water Main OPPCs for Deficient Areas

Project Area	New Pipe Diameter	Pipe Length	Cost ($/LF)	Construction Cost	Engineering and Contingency (67%)	Total Project Cost
Main St	12	1,250	$375	$469,000	$315,000	$784,000
	12	4,725	$375	$1,772,000	$1,188,000	$2,960,000
					Project Total	**$3,744,000**
Elm St	12	3,575	$375	$1,341,000	$899,000	$2,240,000
	8	1,400	$325	$455,000	$305,000	$760,000
					Project Total	**$3,000,000**
Nebo St	12	4,025	$375	$1,510,000	$1,012,000	$2,522,000
					Project Total	**$2,522,000**
North St	8	3,075	$325	$1,000,000	$670,000	$1,670,000
	12	4,225	$375	$1,585,000	$1,062,000	$2,647,000
					Project Total	**$4,317,000**
Farm St	8	3,175	$325	$1,032,000	$692,000	$1,724,000
					Project Total	**$1,724,000**
Hartford St	8	2,225	$325	$724,000	$486,000	$1,210,000
					Project Total	**$1,210,000**
Westview Rd	8	2,550	$325	$829,000	$556,000	$1,385,000
					Project Total	**$1,385,000**

SECTION 5.3 CAST IRON PIPE REPLACEMENT

EP recommends the Town begin replacing its aging CI pipe with an annual replacement program to mitigate the risk of leaks and failures and promote improved water quality. EP has grouped the CI pipe into six phases based on the perceived risk and urgency associated with the pipe, as described below. EP recommends the Town plan to complete Phases 1 and 2 within the 2045 planning period, which amounts to approximately 0.5 miles per year on average.

EP assumed 6-inch diameter pipe is replaced with 8-inch diameter pipe for planning purposes, as EP generally does not recommend installing new 6-inch pipe unless the adequacy can be verified during preliminary design.

Section 5.3.1 Phase 1 (2025 – 2034)

Phase 1 consists of pipes with a history of breaks and leaks, but which are still recorded as CI in the GIS records. EP assumes these contain wraps or spot repairs, and the risk of adjacent failures or pipe degradation over the length of the pipe remains high. EP supplemented Phase 1 with additional pipes adjacent to water bodies, which often correlates with elevated groundwater and elevated risk of degradation. These are assumed to be the most urgent CI replacement projects (except some water mains related to fire flow deficiencies). A breakdown of Phase 1 is included below.

Table 5-3: Phase 1 CI Replacement

Diameter	Total Length (mi)	OPPC	Contingency and Engineering (67%)	Subtotal
8”	4.25	$7,295,300	$4,887,900	$12,183,200
12”	0.43	$850,500	$569,900	$1,420,400
16”	0.15	$362,700	$243,100	$605,800
Total	**4.83**	**$8,508,500**	**$5,700,900**	**$14,209,400**

Section 5.3.2 Phase 2 (2035 – 2045)

Phase 2 consists of pipes with elevated operating pressures and low C factors from calibration, indicating significant deterioration of internal condition, loss of effective pipe area, or tuberculation. These pipes have a higher likelihood of contributing to poor water quality, reduced fire flow, and may be more prone to breaks during sudden changes in flow. A breakdown of Phase 2 is included below.

Table 5-4: Phase 2 CI Replacement

Diameter	Total Length (mi)	OPPC	Contingency and Engineering (67%)	Subtotal
8”	**4.54**	**$7,795,200**	**$5,222,800**	**$13,018,000**

SECTION 5.4 WATER STORAGE TANK REHABILITATION

Based on the previous rehabilitation costs scaled to include the full surface rehabilitation and adjusted for the inflation in the ENR CCI from the time the project occurred, plus engineering fees and contingencies, EP estimates the project cost to be approximately **$1,488,000**.

Using a similar methodology, but scaling down for the smaller metal surface on the State Hospital Tank, EP estimates the project cost of the State Hospital Tank rehabilitation to be approximately **$1,008,000**.

SECTION 5.5 HAWTHORNE BPS IMPROVEMENTS

EP anticipates the Hawthorne BPS will be in need of rehabilitation or equipment replacement within the 2045 planning period. EP recommends the Town consider modifying the station to either include VFDs or a hydropneumatics tank as a means of controlling pressure fluctuations in response to rapid changes in customer demands. EP recommends the Town budget approximately **$150,000** to cover these modifications, including the engineering analysis.

SECTION 5.6 ONGOING AND PLANNED PROJECTS

EP understands the following projects are already underway or being pursued and has not included them in the CIP.

Section 5.6.1 Water Audit

EP understands the Town is currently conducting a water audit. EP did not carry a capital cost for the audit, as our understanding is it is already funded.

Section 5.6.2 PFAS Treatment

The Town completed a feasibility study for implementing PFAS treatment at Wells 1, 2 and 6 in 2022. The Town has maintained compliance with the Massachusetts PFAS6 MCL since screening began in 2021. However, the USEPA is expected to publish final MCLs of 4 ppt for two PFAS compounds, PFOA and PFOS, in early 2024.The PFAS levels at Wells 1 and 2 have routinely exceeded these proposed standards. The Town should reevaluate PFAS compliance considerations for each of the wellfields in light of the proposed MCLs. Since the PFAS regulations are continuing to evolve and further evaluations of each of the wellfields would be necessary, PFAS treatment capital costs have not been incorporated into the CIP.

Section 5.6.3 Upgrade Metering Infrastructure

The previous water master plan included a CIP for the Town's water system. The plan included a recommendation to update the Town's billing and reporting capabilities and monitor public water use to assess the impact on UAW. EP understands that the Town is in the process of migrating to an advanced metering infrastructure (AMI) water meter system, which when fully implemented will improve billing, reporting, and performance monitoring of the water system.

SECTION 5.7 RECOMMENDED SEQUENCE

EP recommends the Department allocate funding for one annual well rehabilitation. In addition, EP strongly recommends the Department complete Phases 1 and 2 of the CI replacement program. As the risks associated with foregoing these replacements are unknown due to limited data, EP recommends pursuing these in parallel with the other projects over the course of the CIP.

As there are a total of 10 CIP projects in the 20-year planning period, EP spaced the projects out every two years as a guideline and interspersed the CI replacement program. This approach will provide the Department with time to pursue potential funding for some of the deficiency-related projects, while maintaining a regular schedule of CI replacement.

EP has carried the total cost for Phase 1 CI replacement of $14,209,400 divided into five projects between 2025 and 2034 with an average cost of $2,841,880 each. This represents an average for planning purposes including 8-inch, 12-inch, and 16-inch pipe. Actual costs may be slightly higher or lower based on the diameters of the water mains actually replaced that year.

Similarly, EP has carried the total cost for Phase 2 CI replacements of $13,018,000 divided into five projects between 2035 and 2045 with an average cost of $2,603,600. While all pipes in Phase 2 are 8-inch diameter, actual lengths may deviate slightly from 20% of the Phase totals. EP assumes tank rehabilitation and BPS improvements will not be required until the final years of the planning period. A funding projection for the CIP projects is shown in the table below.

Table 5-5: CIP Sequence

Year	Project Name	Project Cost	Annual Well Rehabilitation	Total
2025	Main Street Water Main Replacement	$3,744,000	$25,000	$3,769,000
2026	CI Replacement, Phase 1 Part 1	$2,841,880	$25,000	$2,866,880
2027	Elm St Water Main Replacement	$3,000,000	$25,000	$3,025,000
2028	CI Replacement, Phase 1 Part 2	$2,841,880	$25,000	$2,866,880
2029	Nebo St Water Main Replacement	$2,522,000	$25,000	$2,547,000
2030	CI Replacement, Phase 1 Part 3	$2,841,880	$25,000	$2,866,880
2031	North St Water Main Replacement	$4,317,000	$25,000	$4,342,000
2032	CI Replacement, Phase 1 Part 4	$2,841,880	$25,000	$2,866,880
2033	Farm St Water Main Replacement	$1,724,000	$25,000	$1,749,000
2034	CI Replacement, Phase 1 Part 5	$2,841,880	$25,000	$2,866,880
2035	Hartford St Water Main Replacement	$1,210,000	$25,000	$1,235,000
2036	CI Replacement, Phase 2 Part 1	$2,603,600	$25,000	$2,628,600
2037	Westview Rd Water Main Replacement	$1,385,000	$25,000	$1,410,000
2038	CI Replacement, Phase 2 Part 2	$2,603,600	$25,000	$2,628,600
2039	Mt. Nebo Tank Rehabilitation	$1,448,000	$25,000	$1,473,000
2040	CI Replacement, Phase 2 Part 3	$2,603,600	$25,000	$2,628,600
2041	State Hospital Tank Rehabilitation	$1,008,000	$25,000	$1,033,000
2042	CI Replacement, Phase 2 Part 4	$2,603,600	$25,000	$2,628,600
2043	Hawthorne BPS Improvements	$150,000	$25,000	$175,000
2044	CI Replacement, Phase 2 Part 5	$2,603,600	$25,000	$2,628,600
			Total	**$48,235,400**

APPENDIX A
WATER SYSTEM MAPS

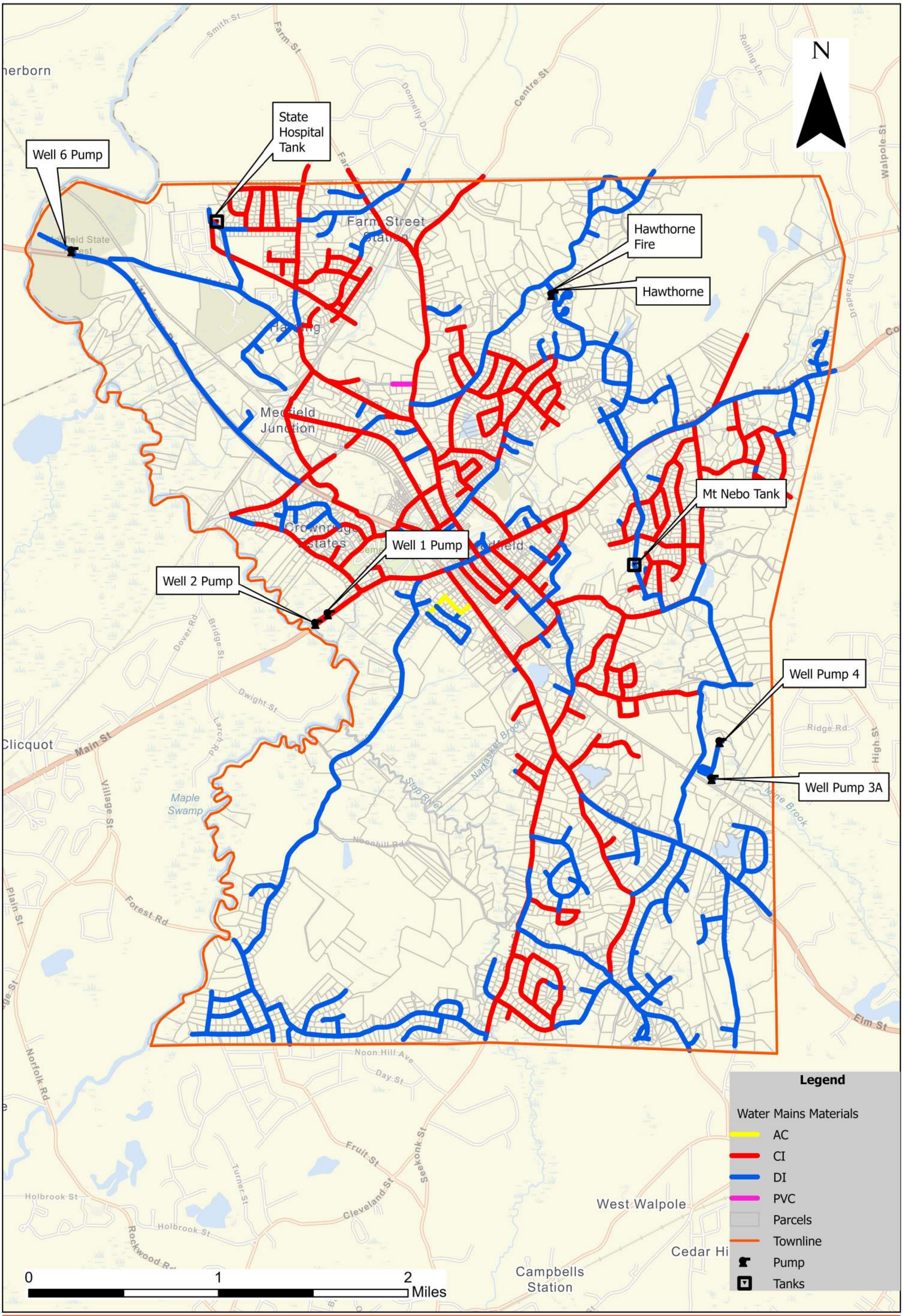


Figure A-1
Pipe Materials
Medfield, MA
January 2024

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I:\Medfield.134\Water System\22004054 -Water Syst CIP Update & Hydraulic Model\98. Hydraulic Model\GIS\WaterMap

Disclaimer: This map is intended for planning purposes

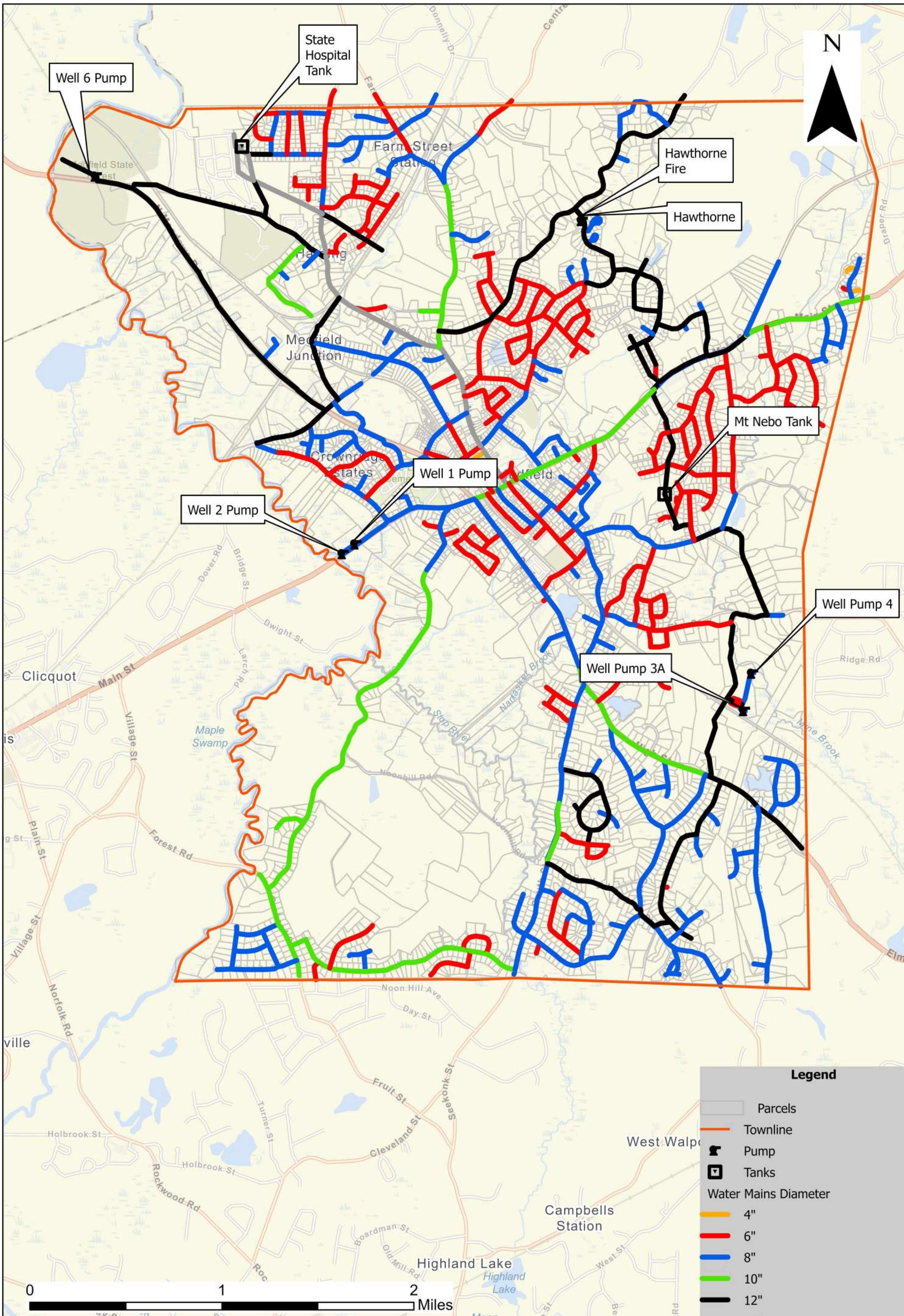

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Figure A-2
Pipe Diameters
Medfield, MA
January 2024

APPENDIX B
HYDRAULIC MODEL CREATION AND CALIBRATION MEMO

MEMORANDUM

Date: November 22, 2023

To Maurice Goulet, Director, DPW, Town of Medfield, MA

From Eric A. Kelly, Principal, Environmental Partners

CC William Harvey, Water & Sewerage Board, Town of Medfield, MA
Ben Mangan, Project Manager, Environmental Partners
Kevin Rathbun, Senior Project Engineer, Environmental Partners

Subject Water System Hydraulic Model Creation and Calibration Results

Introduction

Environmental Partners Group, LLC (Environmental Partners/EP) prepared this memorandum to describe the process and methods used to create and calibrate the Town of Medfield's (Town's) water distribution system hydraulic model.

A calibrated hydraulic model is a powerful tool for every water distribution system. It enables EP and the Town to complete distribution system assessments, prioritize capital improvements, develop, analyze, and optimize flushing programs, and estimate future impacts to the water system. In addition, a calibrated model can predict available fire flow at locations throughout the water system under varying system conditions. With additional calibration effort, a hydraulic model can even simulate water quality (e.g. chlorine residual) throughout the distribution system.

Model Creation

EP created and calibrated the hydraulic model using WaterCAD CONNECT Edition Update 4 (version 10.04.00.108) by Bentley Systems, Inc. This program solves for the distribution of flows and hydraulic grades using the Gradient Algorithm. This method is an iterative process and founded on two principles:

1. The total flow entering the junction of two or more pipes must equal the flow leaving the junction.

2. The change in pressure between any two points in the system must be equal by any and all paths connecting the points.

The computer software applies these two principles by assuming an initial flow pattern through the distribution system. Based on the assumed flow pattern, the software calculates head losses between the supply sources and the points of distribution. These head losses are compared and recalculated iteratively until the above stated principles are satisfied.

The computer model is a skeletonized version of the actual finished water system network. The model consists of a series of lines representing pipes, nodes simulating pipe intersections, fire hydrants, isolation valves, general purpose valves (GPVs), reservoirs, pumps simulating water supply, and storage tanks.

Water Mains

EP imported the water main network using a GIS geodatabase dated 2/17/2023. These files contained data included pipe material and diameter, as well as spatial representation of connectivity. EP made initial assumptions of Hazen-Williams "C" factors based on industry standard values of 120 DI pipe, and 130 for AC and PVC pipe. For CI pipe, EP assumed a range of starting values as high as 105 for larger diameter CI pipe, and as low as 70 for smaller diameter CI pipe. EP modified the C factors for CI pipe based on the field testing results, described below.

Demand Allocation

The Town supplied EP with a spreadsheet containing 2021 customer demand information. Using the addresses of each customer, EP geographically located the demands, assigned them to the nearest pipe, and then distributed them proportionally to the nearest node in the model. This approach yields a spatially accurate representation of the system demands. This spatial allocation can then be scaled up or down to match total system finished water production during a given calibration or analysis period.

Water Supply

EP reviewed recent pump testing reports and applied the recorded pump and total dynamic head (TDH) data points to the corresponding sources in the hydraulic model. EP added headloss curves upstream of the well pumps representing the specific capacity of the wells. The approximate specific capacities were taken from recent well testing or redevelopment reports. EP did not have pump curve data on the Pine Street/Hawthorne booster pumping station (BPS). However, as this station pumps to a closed pressure zone with no tank, the hydraulic model will vary the pump flowrate automatically to meet system demand, provided the pump curve is sufficiently large to overcome the system head.

If detailed analysis is needed on the BPS or the boosted pressure zone, EP recommends updating the model with more specific information regarding the pumping capacity and configuration.

Storage

EP designed the State Hospital Tank, and so was in possession of the record drawings. These drawings provided the tank geometry and base elevation in the same vertical datum as the elevation data extracted from the state Light Detection and Ranging (LiDAR) data. The Town was not able to provide record drawings for the Mt. Nebo Tank. EP was able to extract overall height and diameter information from the 2014 Water Master Plan completed by Polaris Consultants LLC. EP was not able to extract a reliable base elevation for the tank from the LiDAR data, and assumed a base elevation which resulted in matching overflows for the two tanks. This assumption was confirmed by static pressure readings in the field, as discussed below.

Modeling Calibration

The hydraulic model calibration aims to replicate the static and hydrant flow conditions of the system. With the Town's assistance, EP completed 28 hydrant flow tests and 4 C-factor tests the week of April 16, 2023. The hydrant flow tests consist of one flow hydrant and one gauge hydrant, ideally upstream of the flow hydrant. An initial pressure reading is taken at the gauge hydrant, followed by a subsequent pressure reading when the hydrant is open. A pitot pressure reading on the flow hydrant is used to estimate the flow observed. EP attempts to recreate both the initial pressure reading and the loss in pressure during the flowing event using the hydraulic model.

The C-factor tests consist of a similar arrangement, with the addition of closed valves to create higher velocities on a water main of interest. These tests also include an additional upstream gauge hydrant to record the change in pressure over the length of the entire water main. These tests are deployed in areas with many interconnections with surrounding mains, as a traditional hydrant flow test would be unlikely to yield useful data. A figure showing the flow testing locations is included in Attachment 1.

Hydrant Flow Tests

EP and the Town conducted 28 hydrant flow tests at night on April 16 and 17, 2023. EP also received Supervisory Control and Data Acquisition (SCADA) data during the time of the testing, which was used to recreate the system conditions in the hydraulic model at the time of each hydrant test. EP then ran a steady-state simulation in the model and compared the modeled static pressure (before hydrant flow) and residual pressure (during hydrant flow) at each location.

The target calibration accuracy is +/- 3 psi. This target reflects the limitations of flow and pressure measuring devices that introduce errors and limit the accuracy of test results, and falls within the general calibration guidelines of 2.2-4.3 psi presented in the AWWA Manual M32 – Computer Modeling of Water Distribution Systems. EP applies the target calibration accuracy to both static pressure readings and overall head loss (recorded pressure drop under flowing conditions).

The results of the calibration are presented in the table below.

Test	Field Data (psi)			Model Data (psi)			Comparison (psi)	
	Static	Residual	Delta	Static	Residual	Delta	Delta Static	Delta-Delta
1	94.7	81.6	13.1	95.2	83.0	12.2	-0.5	0.9
2	55.9	53.5	2.4	55.6	53.6	2.0	0.3	0.4
3	59.3	41.3	18.0	59.9	42.6	17.3	-0.6	0.7
4	59.1	8.4	50.7	59.7	9.7	50.0	-0.6	0.7
5	81.8	43.5	38.3	82.6	44.5	38.1	-0.8	0.2
6	88.2	87.2	1.0	88.9	88.6	0.3	-0.7	0.7
7	57.7	24.2	33.5	58.1	25.2	32.9	-0.4	0.6
8	58.2	23.2	35.0	58.0	23.0	35.0	0.2	0.0
9	52.5	46.4	6.1	53.2	46.0	7.2	-0.7	-1.1
10	56.6	12.1	44.5	57.6	13.8	43.8	-1.0	0.7
11	64.9	42.3	22.6	65.3	42.9	22.4	-0.4	0.2
12	63.2	23.9	39.3	66.5	25.4	41.1	-3.3	-1.8
13	50.4	39.6	10.8	51.4	41.4	10.0	-1.0	0.8
14	73.3	72.1	1.2	73.2	72.9	0.3	0.1	0.9
15	71.7	57.1	14.6	72.3	57.5	14.8	-0.6	-0.2
16	68.6	61.1	7.5	68.4	61.0	7.4	0.2	0.1
17	80.0	24.5	55.5	79.1	23.5	55.6	0.9	-0.1
18	70.4	46.9	23.5	70.5	48.6	21.9	-0.1	1.6
19	57.7	30.6	27.1	58.0	31.5	26.5	-0.3	0.6
20	64.2	48.3	15.9	63.6	48.6	15.0	0.6	0.9
21	67.5	30.4	37.1	66.5	28.3	38.2	1.0	-1.1
22	77.8	58.5	19.3	77.2	58.8	18.4	0.6	0.9
23	62.6	41.5	21.1	61.5	39.7	21.8	1.1	-0.7
24	75.3	35.5	39.8	74.4	33.6	40.8	0.9	-1.0
25	61.4	27.2	34.2	59.2	23.5	35.7	2.2	-1.5
26	89.3	48.6	40.7	88.6	50.2	38.4	0.7	2.3
27	97.4	43.1	54.3	96.4	40.0	56.4	1.0	-2.1
28	90.9	76.7	14.2	90.4	75.9	14.5	0.5	-0.3

As seen in the table above, all tests fell within the desired accuracy range, with the exception of Test 12. This discrepancy is discussed further in subsequent sections.

C-Factor Tests

EP and the Town also performed four C factor tests in areas where typical flow tests may not have generated useful results due to the high degree of looping (more flow paths result in lower velocities and less headloss per foot of water main, making the result more difficult to capture without additional instrumentation). These tests involved closing isolation valves to channel flow along the target water main, and applying an extra pressure gauge along the main to generate two residual pressure readings along the water main. The location of the C factor tests are shown in Attachment 2.

EP replicated these tests in the model using the same manner described in the previous section, with the valve closures represented as closed pipes in the model. EP adjusted the C factors of the target pipelines until the model accurately represented the static and residual pressures at both pressure gauges. The results of these tests are presented in the tables below.

Test	Gauge 1					
	Field Static	Model Static	Delta Static	Field Residual	Model Residual	Delta Head loss
C-1	71.3	71.8	-0.5	69.4	69.4	-0.5
C-2	66.1	64.7	1.4	55.8	54.3	-0.1
C-3	76.2	74.5	1.7	60.2	59.3	0.8
C-4	74.0	75.1	-1.1	71.0	71.9	-0.2

Test	Gauge 2					
	Field Static	Model Static	Delta Static	Field Residual	Model Residual	Delta Head loss
C-1	68.8	68.2	0.6	57.1	56.4	-0.1
C-2	68.5	68.3	0.2	54.1	54.9	1.0
C-3	76.8	76.2	0.6	37.6	37.8	0.8
C-4	79.9	79.8	0.1	76.2	76.0	-0.1

As seen in the table above, all tests fell within the desired accuracy range.

Calibration Changes to Base Model

Calibrating the above flow tests primarily required adjusting C factors in the model to replicate friction observed in the pipelines. The majority of the system was able to be calibrated with reasonable adjustments to C factors on cast iron pipes. In some cases, head losses were not explainable without changes in pipeline connectivity, valve status, or very low C factors (usually indicate a significant reduction in remaining pipe area). Below is a description of such cases.

Test 12

This test was immediately east of the Mt Nebo Tank. When converted to hydraulic grade line based on the elevation of the area, the resulting HGL is five feet lower than any other test, and considerably lower than the converted values of the tests immediately before and after Test 12 took place. EP therefore considers this an anomaly, and likely the result of either inaccurate ground elevations in the base data, or instrument error during the test itself.

EP was able to accurately replicate the headloss experienced at the flow test velocity, indicating the interior pipe condition accurately reflects the field data. While EP cannot rule out the possibility that a potential instrument issue during the static test carried over to the flowing test, the required C factors to achieve the calibration are within anticipated values.

Test 7

This test is located on Deerfield Drive, off North Street. Headlosses along the 10" main on North Street were considerably higher than anticipated. EP worked with the Town and did identify a valve with limited range of motion and unknown current position near Winter Street. This valve may be in the mostly closed position, which would restrict flow to come only from the north via Farm Street. The model result is very sensitive to the valve status. EP recommends revisiting this calibration once the valve is repaired to confirm the condition of the North Street water main.

Test 22

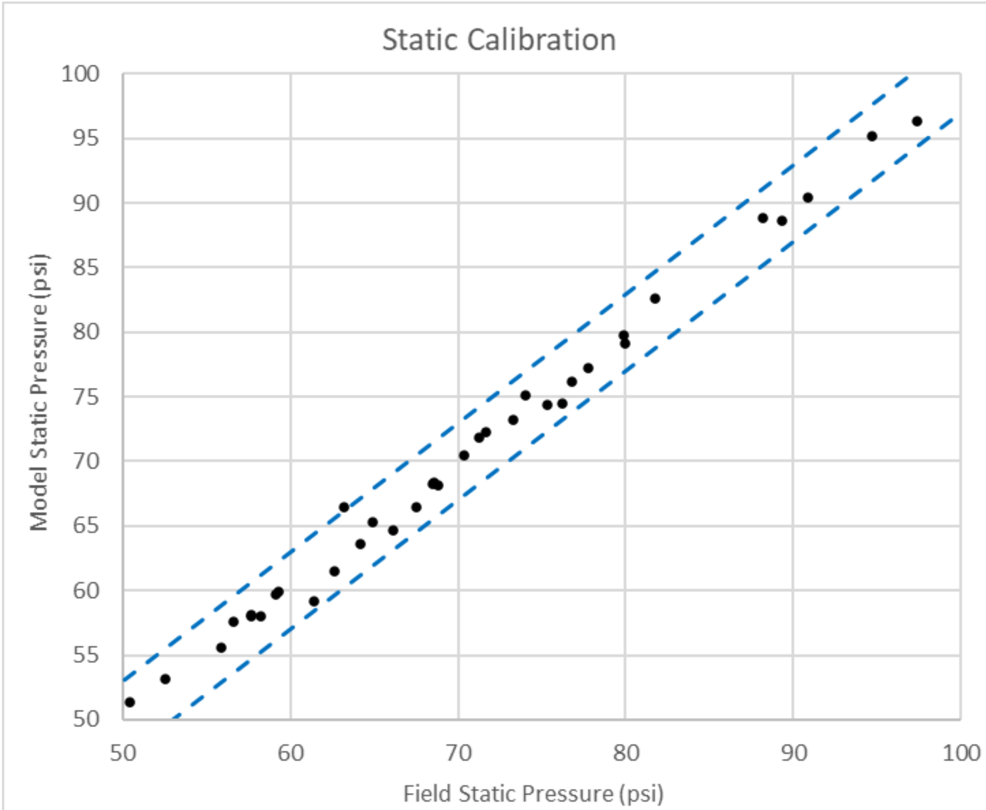
This test exhibited headloss in the model that was far greater than seen in the field. After discussing with the Town, EP was informed of a water main loop from Oxbow Road to to Ridge Road. This addition brought the test into the desired calibration range using acceptable C-factors. EP recommends the Town confirm the presence of this water main in their current GIS files.

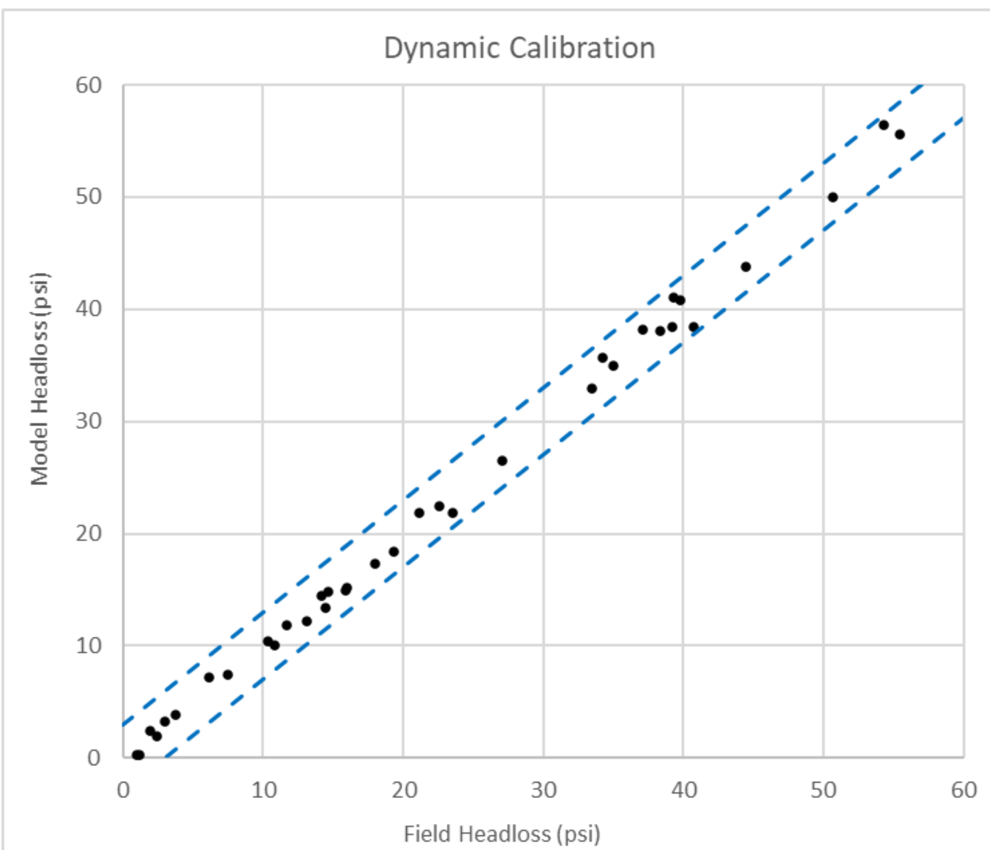
Test C-1

This test took place on Adams Street, with isolation valves closed to the south such that flow would be channeled from W Mill Street in a southeastern direction. Initial results revealed too much headloss at the W Mill Street side (upstream), even with C factors at the highest values. After reviewing with the Town, the Town informed EP that West Street connects all the way through from Adams Street to Harding Street, which would allow an additional flow path for water just north of the first pressure gauge. This addition allowed for accurate calibration using reasonable C factors. EP recommends the Town confirm the presence of this water main in their current GIS files.

Conclusion and Recommendations

Calibration was successful for the vast majority of the model, with one exception for the static pressure at Test 12 as discussed above. The figures below show the field results versus the model results for both static calibration and dynamic headloss calibration, with the target 3-psi accuracy range offsets shown as dashed lines.


Static Calibration
100
95
90
85
80
75
70
65
60
55
50
Model Static Pressure (psi)
50
60
70
80
90
100
Field Static Pressure (psi)

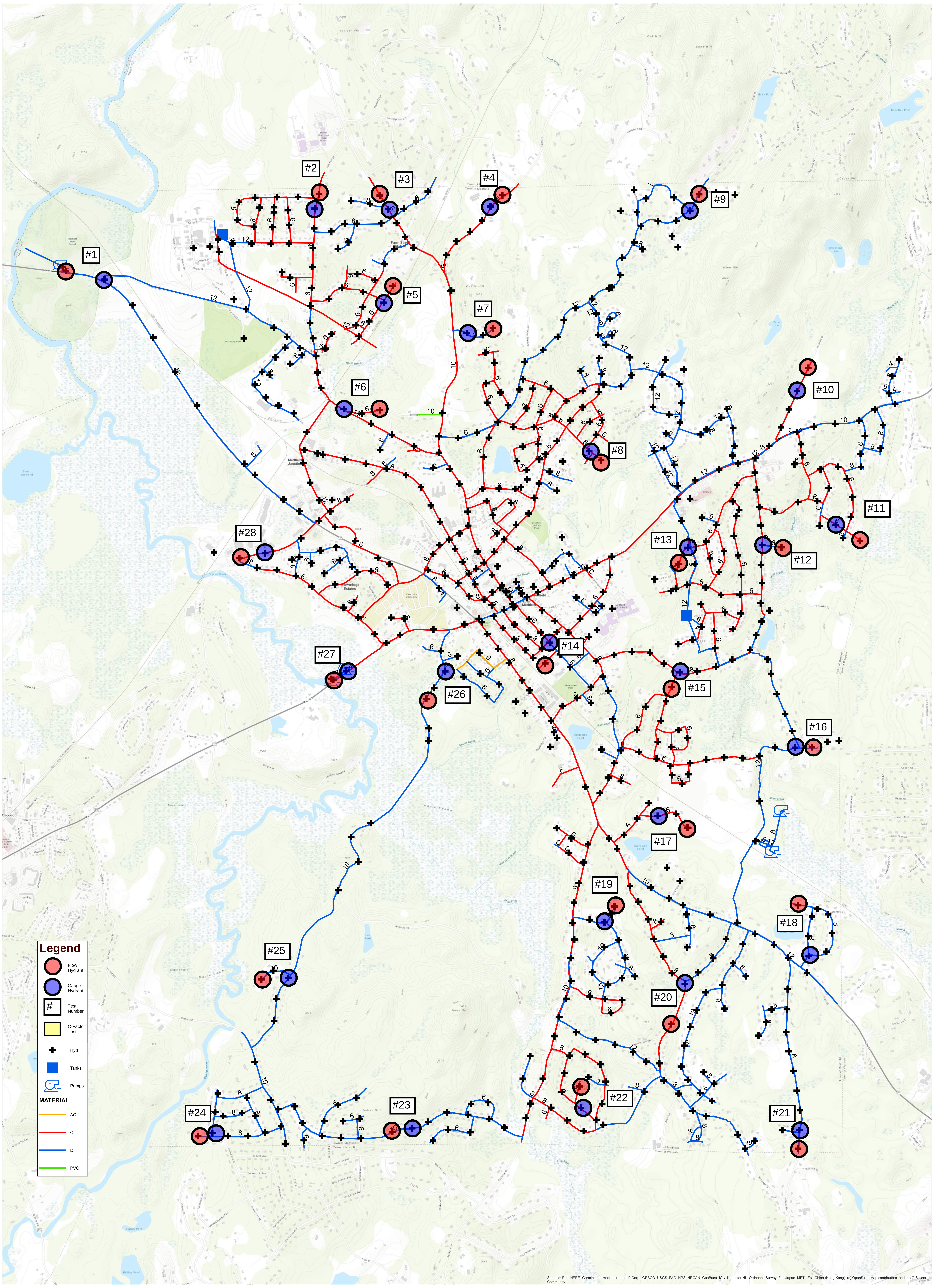

Dynamic Calibration
60
50
40
30
20
10
0
Model Headloss (psi)
0
10
20
30
40
50
60
Field Headloss (psi)

EP recommends the Town confirm their GIS records accurately reflect the pipe loops added at Tests 22 (Ridge Road) and Test C-1 (West Street and Adams Street). Additionally, EP recommends confirming the status of the 10-inch water main on North Street with an additional flow test after the valve replacement is completed.

ATTACHMENTS

Attachment 1 – Flow Test Map

Attachment 2 – C Factor Test Figures



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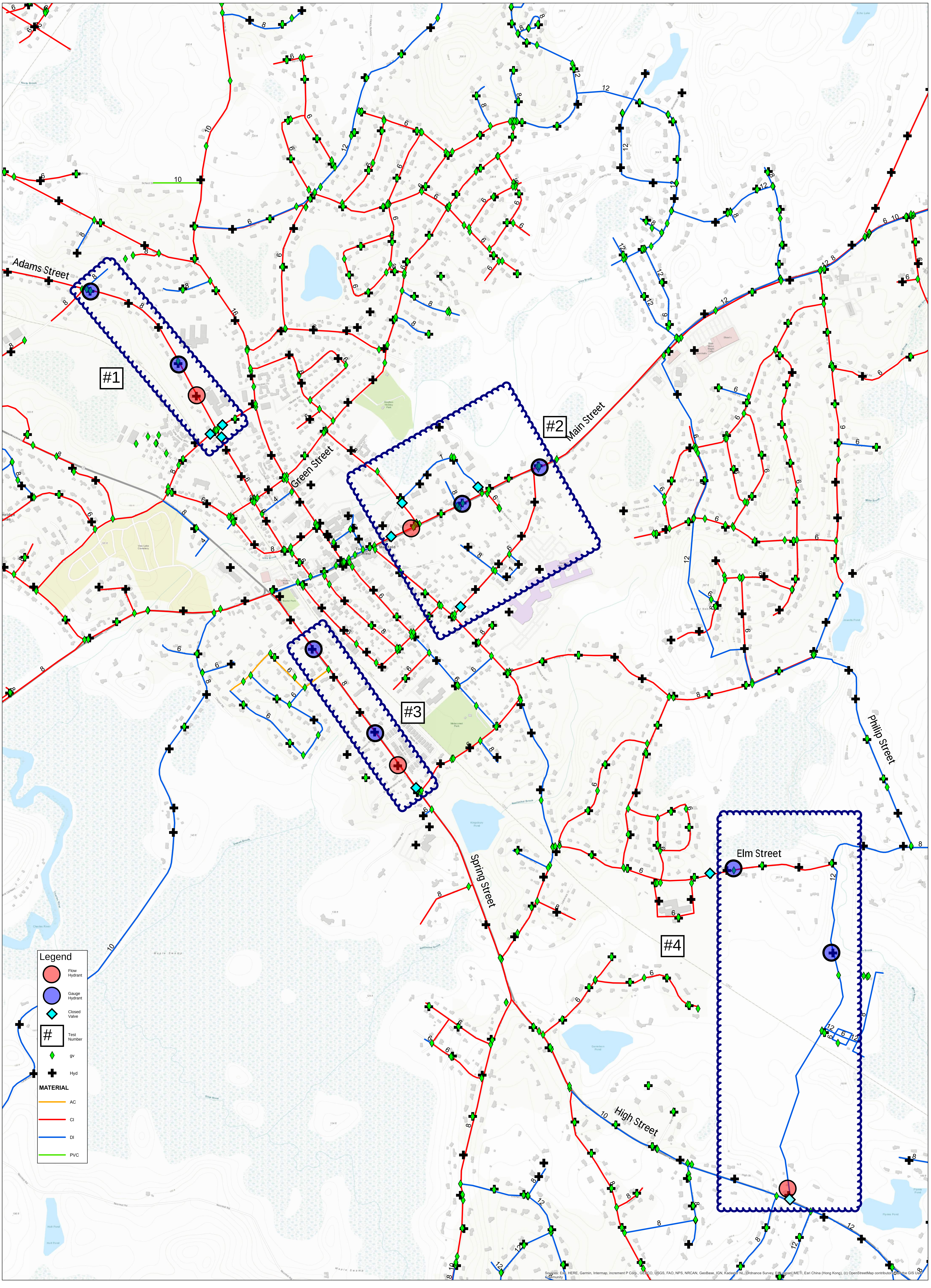
Attachment 1: Fire Flow Testing Map
Medfield, MA
2023

1,600 800 0 1,600 Feet

J:\Town GIS\Medfield\WSMP\FFMap.mxd



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Attachment 2: C Factor Testing Map
Medfield, MA
2023

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APPENDIX C
WATER SYSTEM HYDRAULIC ANALYSIS FIGURES

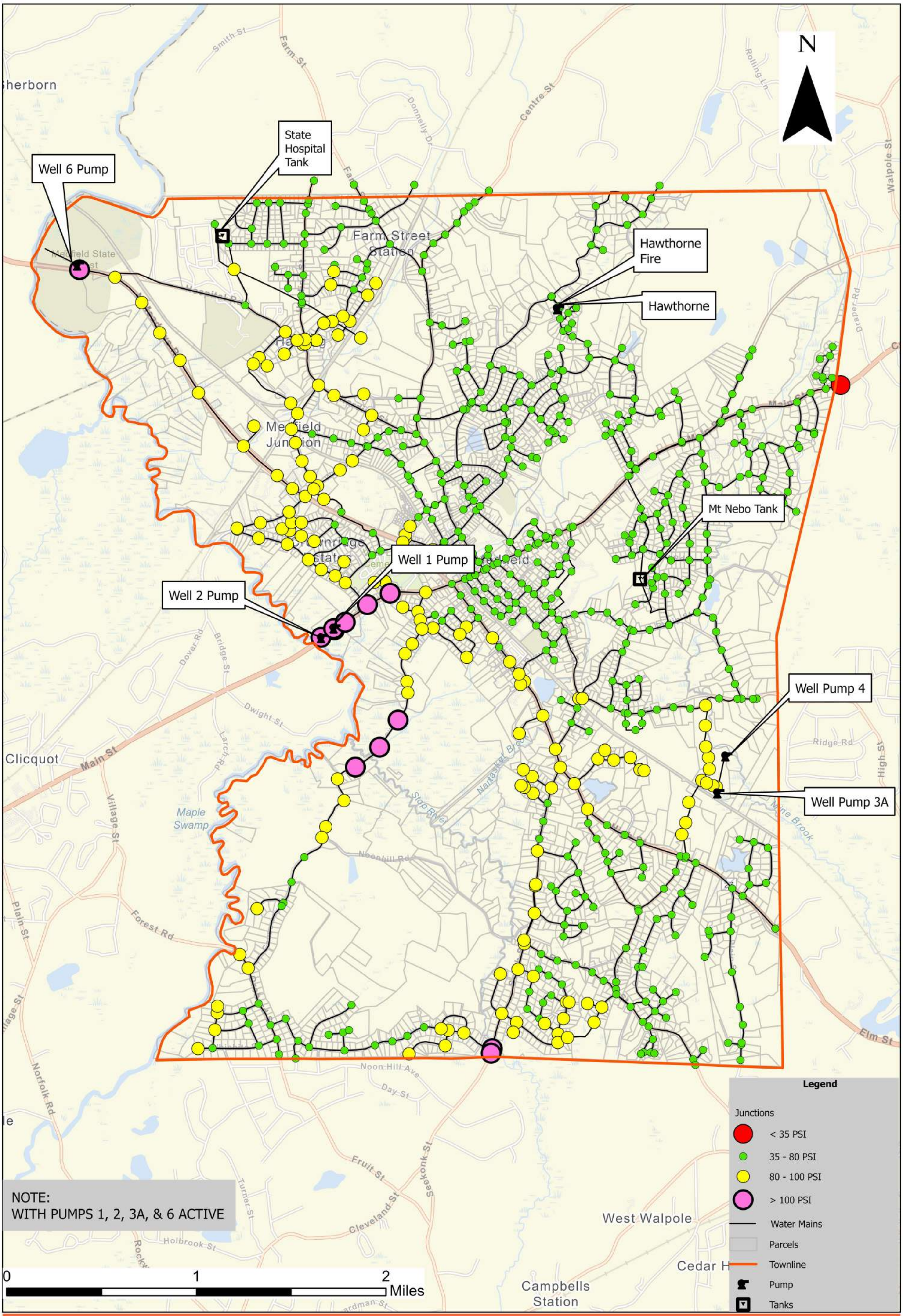

Figure C-1

System Pressure at Current Average Day Demand

Medfield, MA

January 2024

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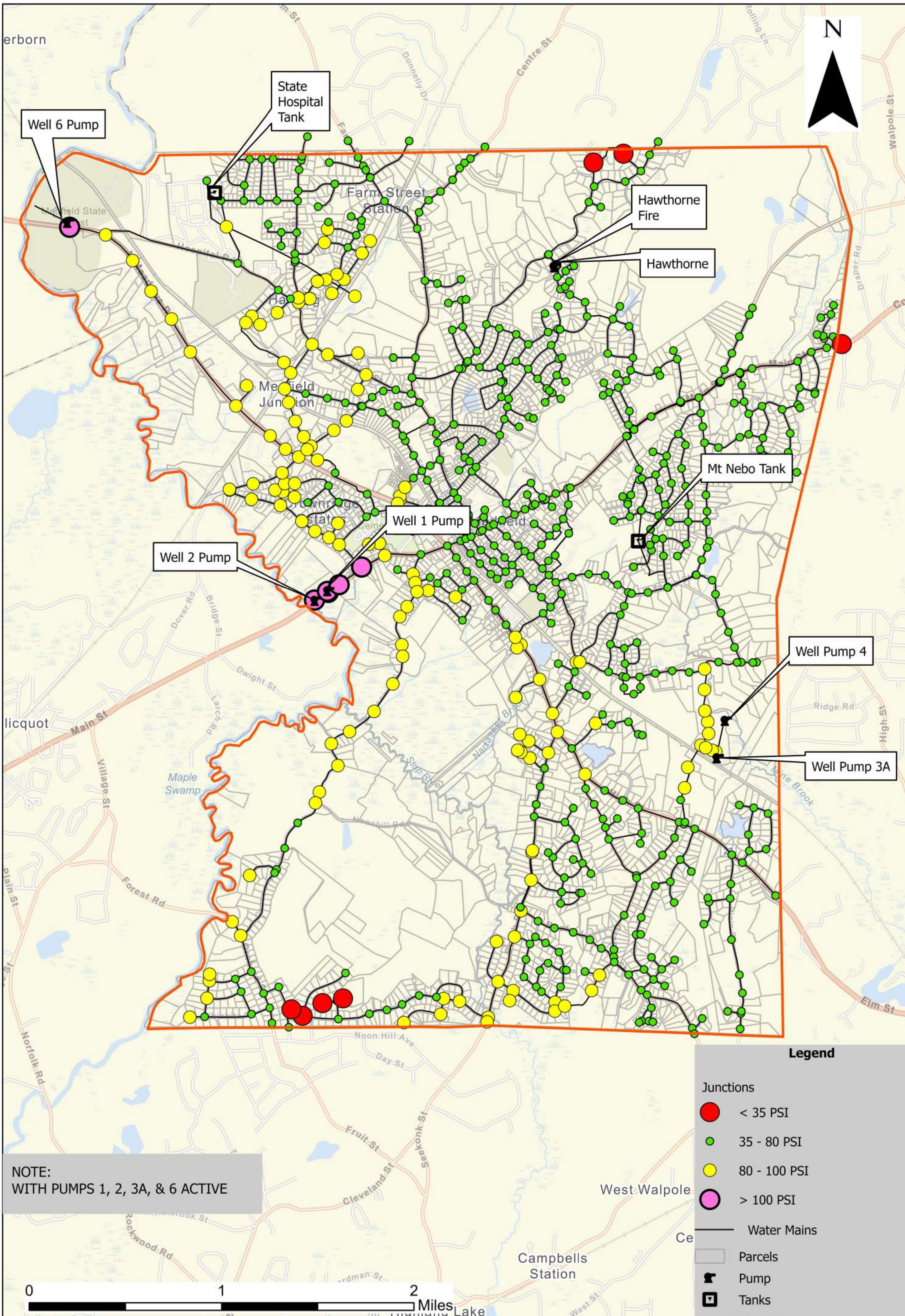

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Figure C-2
System Pressure at Peak Hour Demand
Medfield, MA
January 2024

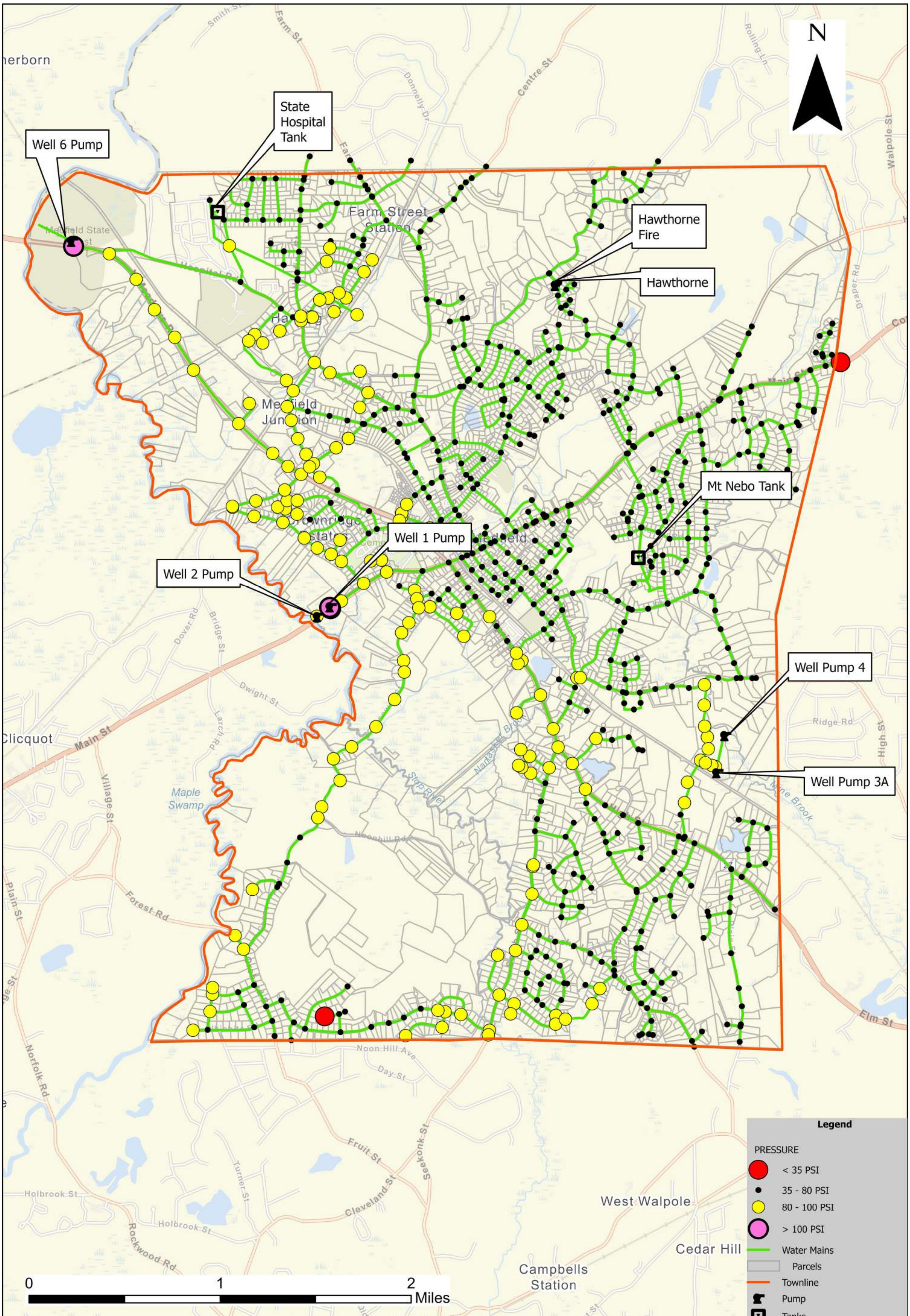

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Figure C-3
Junction Pressure After CIP Improvements
Medfield, MA
January 2024

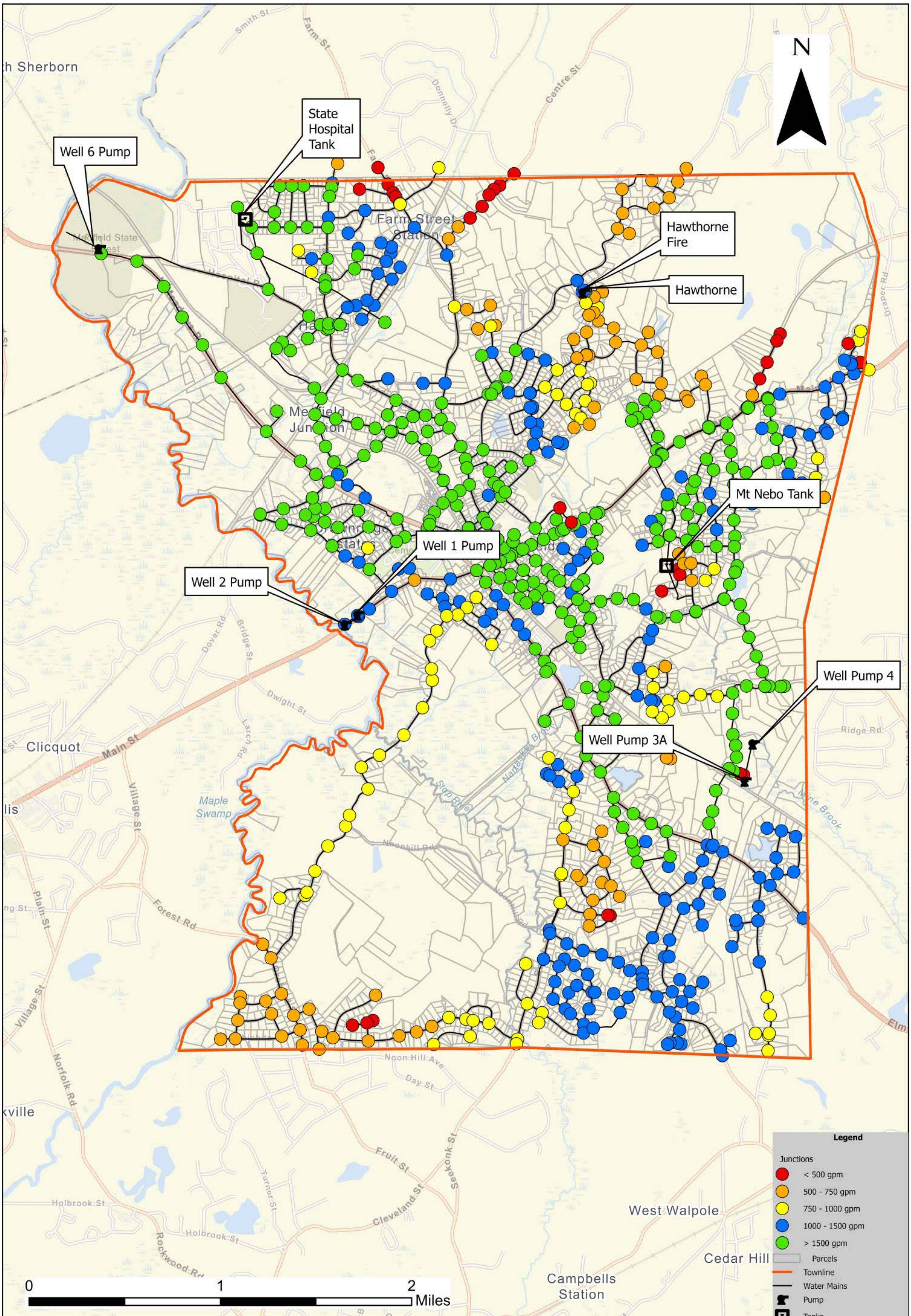

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Figure C-4
Current Available Fire Flow
Medfield, MA
January 2024

I:\Medfield.134\Water System\22004054 -Water Syst CIP Update & Hydraulic Model\98. Hydraulic Model\GIS\WaterMap

Disclaimer: This map is intended for planning purposes

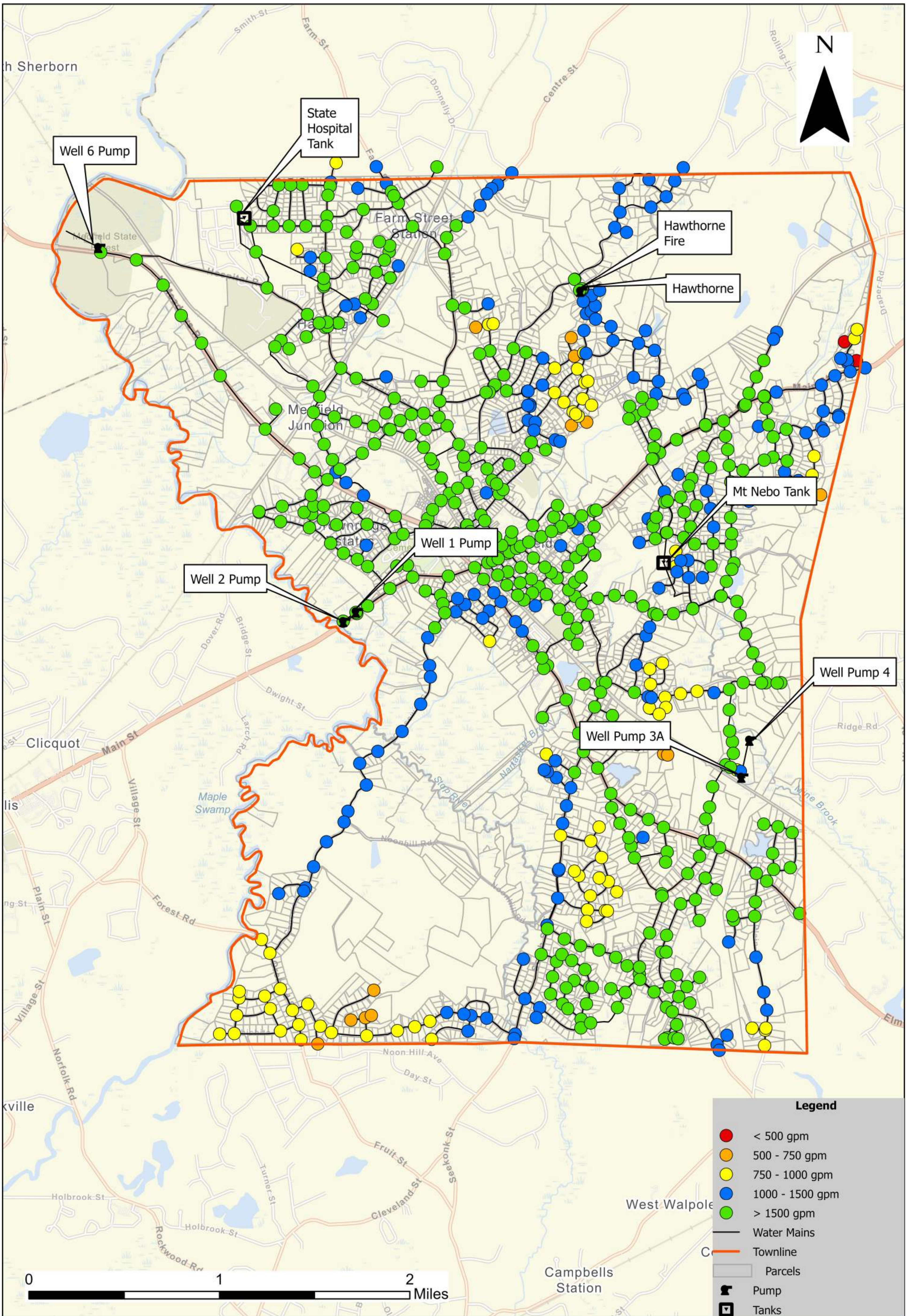

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Figure C-5
Available Fire Flow After CIP Improvements
Medfield, MA
January 2024

I:\Medfield.134\Water System\22004054 -Water Syst CIP Update & Hydraulic Model\98. Hydraulic Model\GIS\WaterMap

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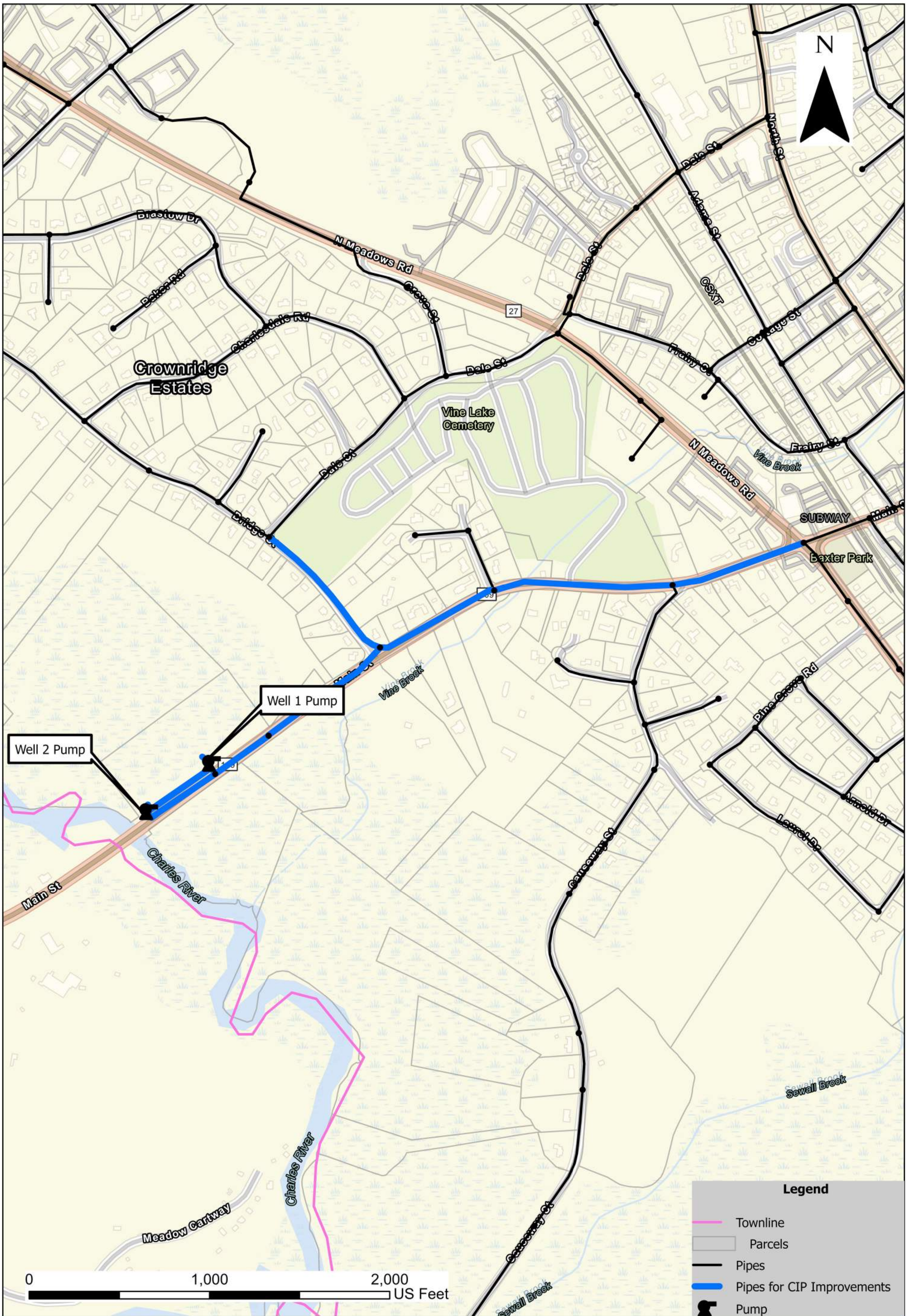

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Figure C-6
Main Street Upgrade Area
Medfield, MA
January 2024

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Disclaimer: This map is intended for planning purposes

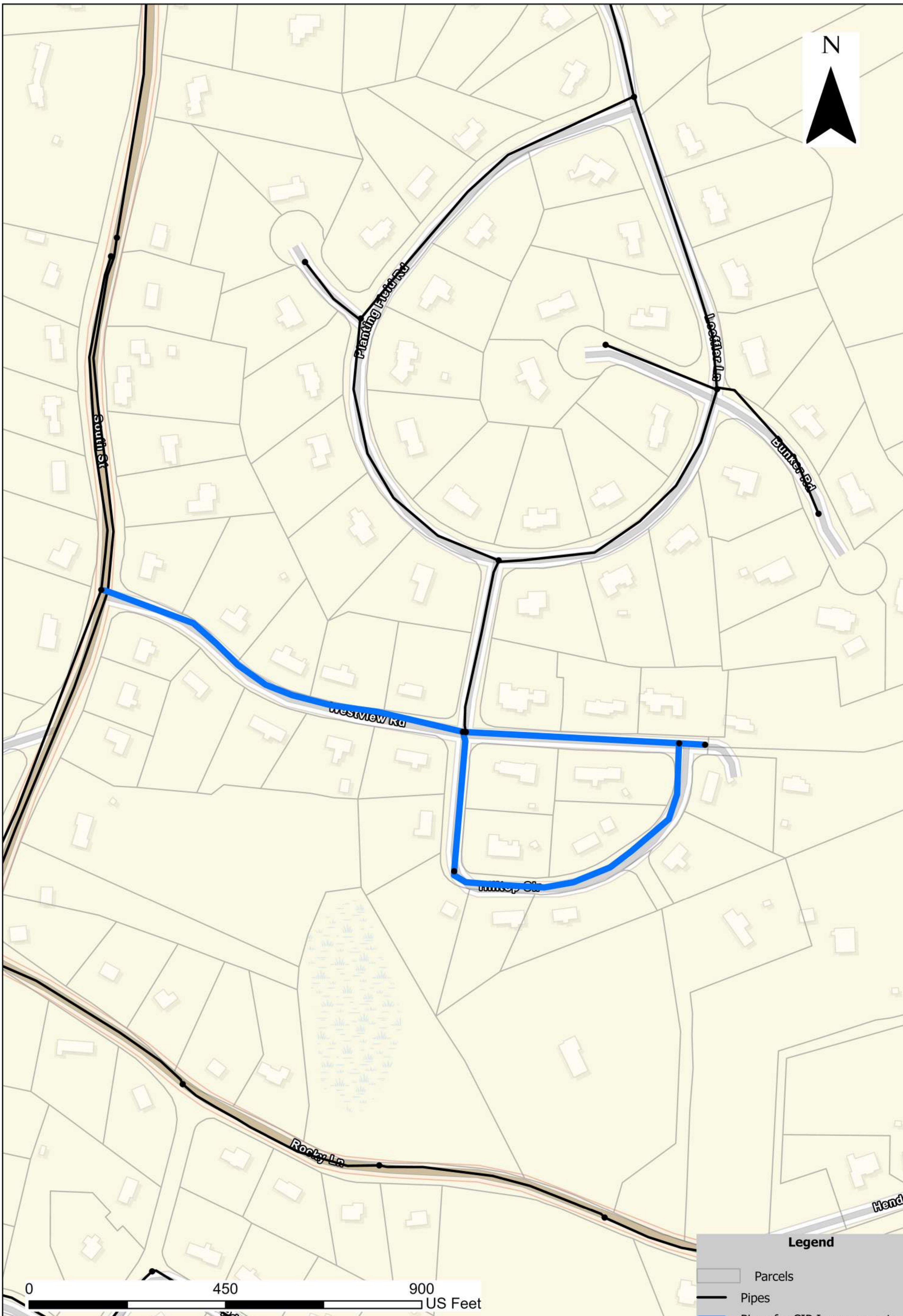

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Figure C-7
Westview Road Upgrade Area
Medfield, MA
January 2024

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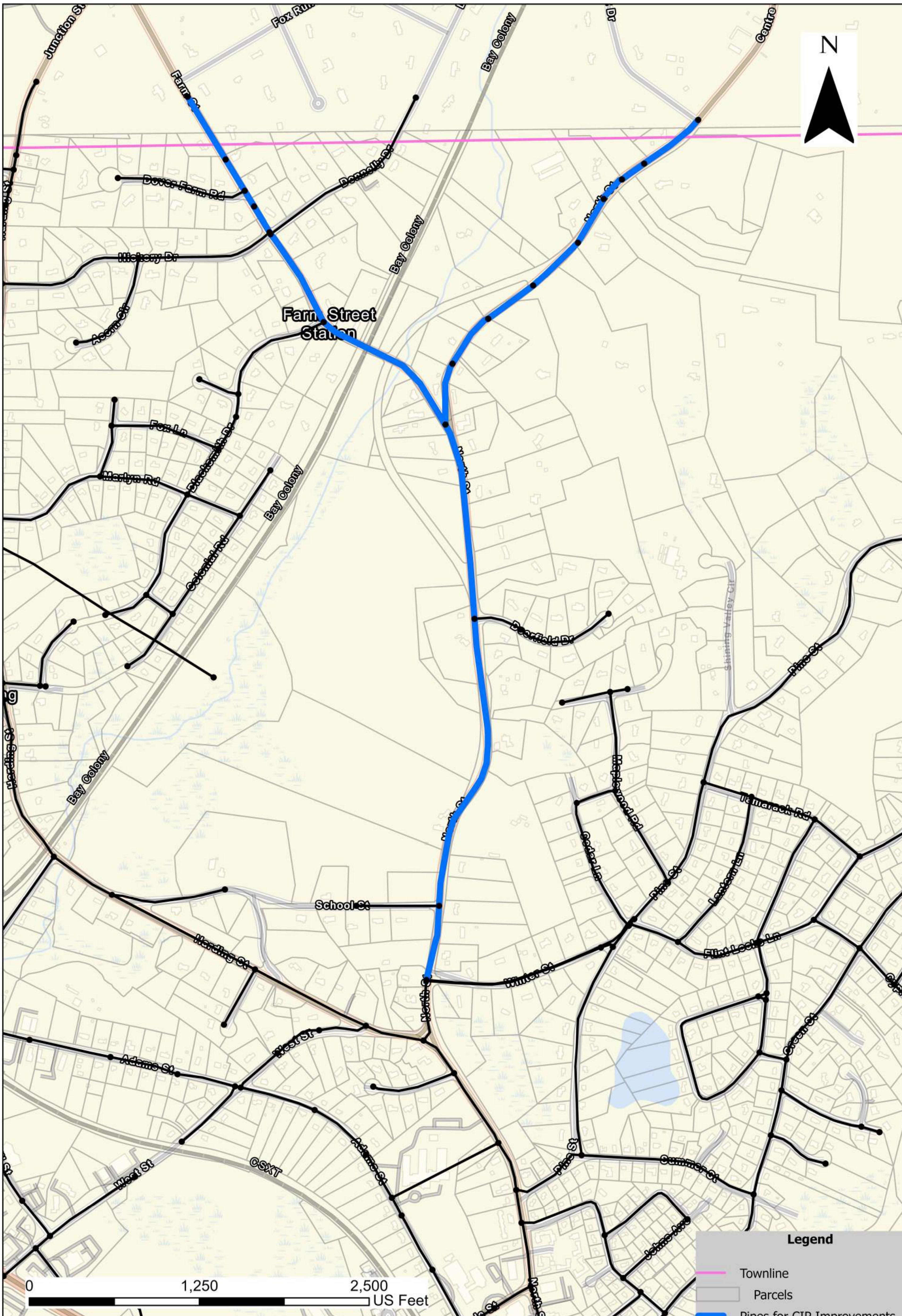

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Figure C-8
North-Farm Street Upgrade Area
Medfield, MA
January 2024

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Figure C-9
Hartford Street Upgrade Area
Medfield, MA
January 2024

I:\Medfield.134\Water System\22004054 -Water Syst CIP Update & Hydraulic Model\98. Hydraulic Model\GIS\WaterMap

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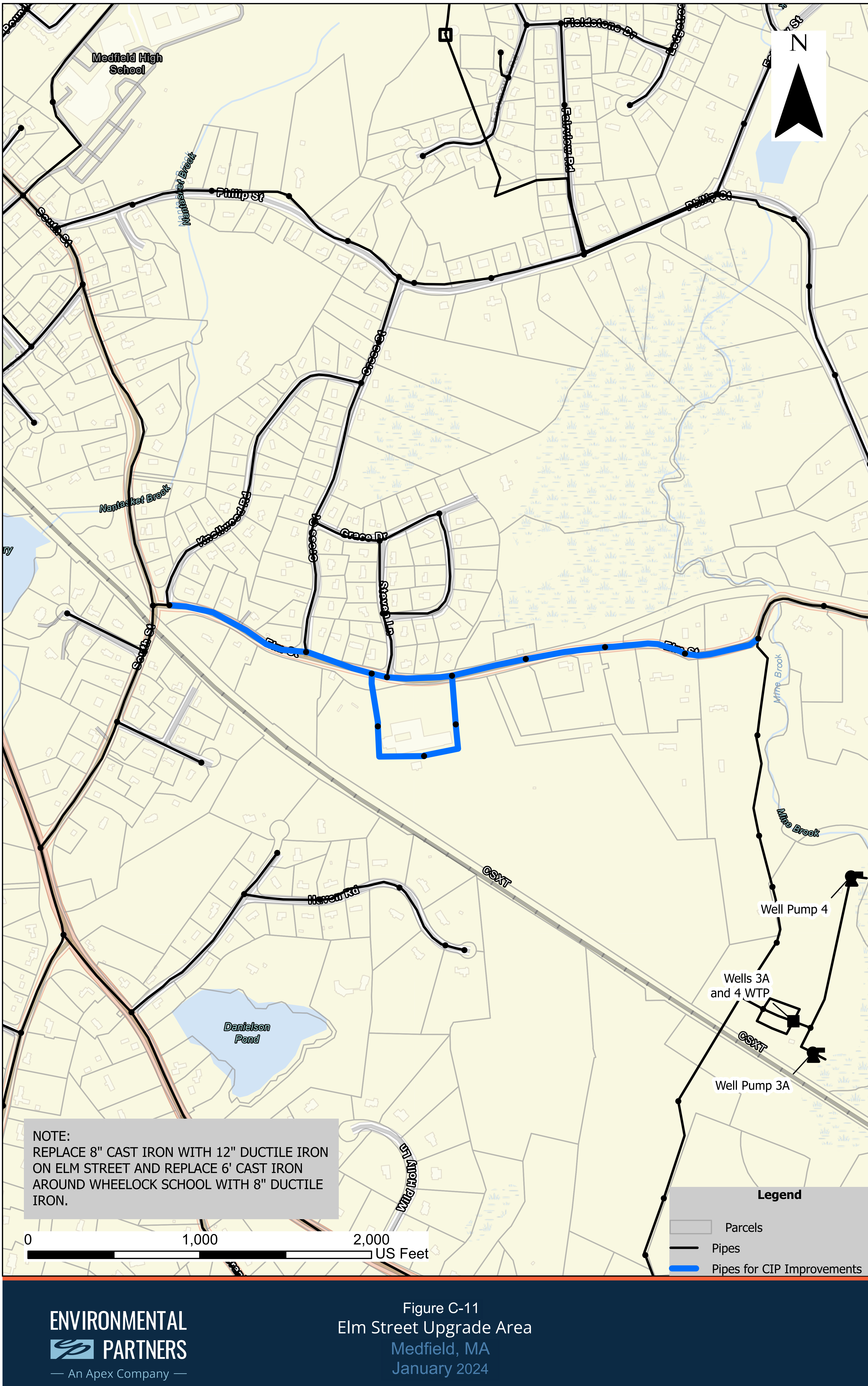
Figure C-10
Westview Road Upgrade Area
Medfield, MA
January 2024



NOTE:
REPLACE 8" CAST IRON WITH 12" DUCTILE IRON ON ELM STREET AND REPLACE 6' CAST IRON AROUND WHEELOCK SCHOOL WITH 8" DUCTILE IRON.

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Figure C-11
Elm Street Upgrade Area
Medfield, MA
January 2024

I:\Medfield.134\Water System\22004054 -Water Syst CIP Update & Hydraulic Model\98. Hydraulic Model\GIS\WaterMap

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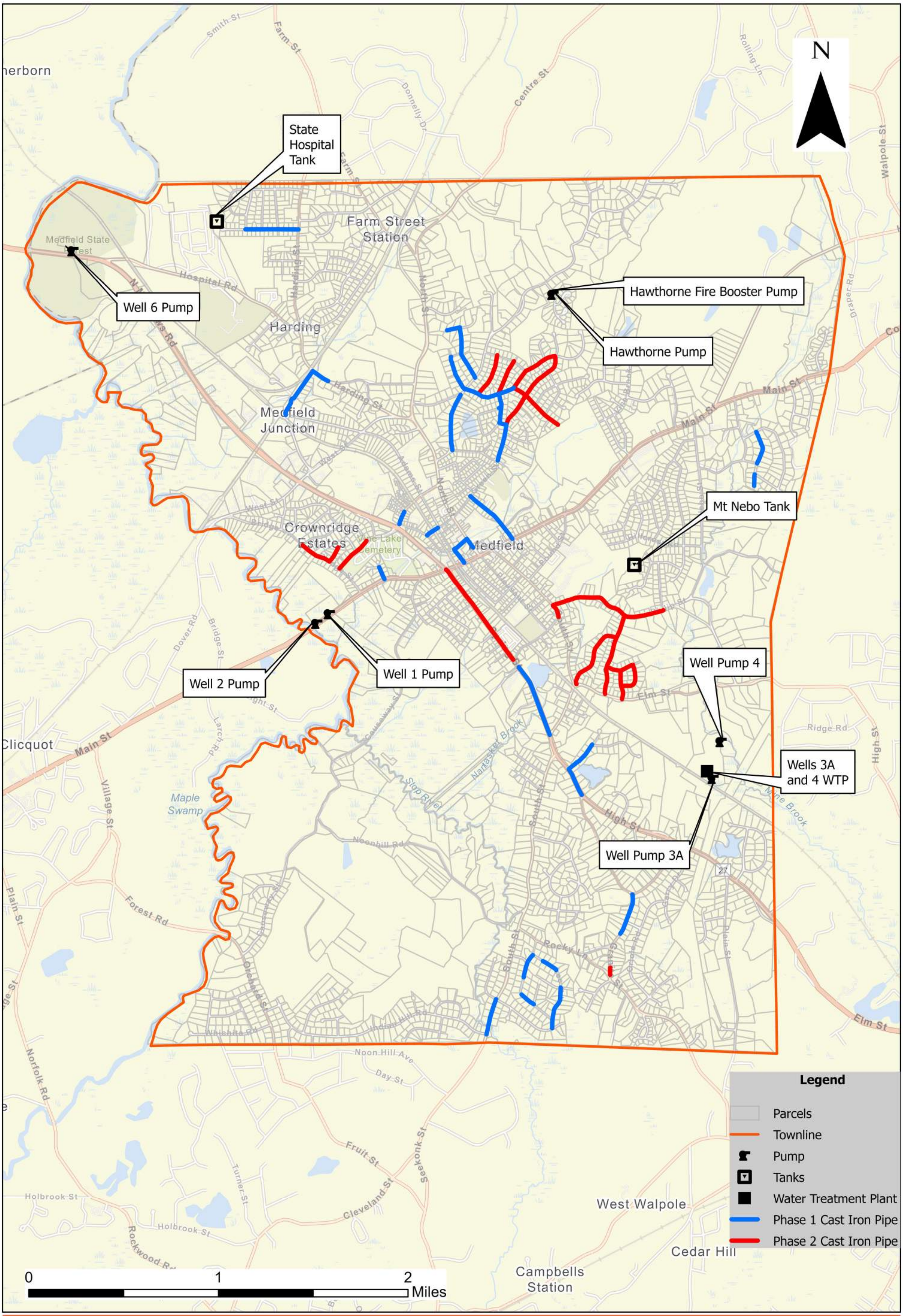

Figure C-12
Phase 1 and 2 Cast Iron Replacements
Medfield, MA
January 2024

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— An Apex Company —

1900 Crown Colony Drive, Suite 402
Quincy, MA 02169
P: 617.657.0200 F: 617.657.0201

envpartners.com