FINAL

TOWN OF WRENTHAM
WATER SYSTEM MASTER PLAN

Prepared for:
Town of Wrentham, Massachusetts

November 2021

ENVIRONMENTAL PARTNERS
— An Apex Company —

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ADD	Average Day Demand
AL	Action Level
ASR	Annual Statistical Report
ATS	Automatic Transfer Switch
AWWA	American Water Works Association
BMP	Best Management Practice
BPS	Booster Pump Station
CI	Cast iron
ClO2	Chlorine Dioxide
CMR	Commonwealth of Massachusetts Regulations
CPVC	Chlorinated Polyvinyl Chloride
D/DBPR	Disinfection/Disinfection By-Product Rule
DBP	Disinfection By-Product
DBPR	Disinfection By-Product Rule
EP	Environmental Partners
ERP	Emergency Response Plan
FCV	Flow Control Valve
Fe	Iron
FEMA	Federal Emergency Management Agency
GAC	Granular Activated Carbon
gal	Gallons
GFCI	Ground Fault Circuit Interrupter
gpd	Gallons per Day
gpm	Gallons per Minute
GWC	Groundwater Withdrawal Category
GWR	Groundwater Rule

HAA5	Haloacetic Acids (group of 5)
HAAs	Haloacetic Acids
HGL	Hydraulic Grade Line
hp	Horsepower
ID	Identification
IDSE	Initial Distribution System Evaluation
ISO	Insurance Services Office
LCR	Lead and Copper Rule
LRAA	Locational Running Annual Average
MAPC	Metropolitan Area Planning Council
MassDEP	Massachusetts Department of Environmental Protection
MassDOT	Massachusetts Department of Transportation
MassGIS	Massachusetts Geographical Information System
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MCP	Massachusetts Contingency Plan
MDD	Maximum Day Demand
mg/L	Milligram per Liter
MG	Million Gallons
MGD	Million Gallons per Day
MGL	Massachusetts General Law
MGY	Million Gallons per Year
Mn	Manganese
MRDL	Maximum Residual Disinfection Level
NaOH	Sodium Hydroxide
NaOCl	Sodium Hypochlorite
ND	Not Detected
NGVD29	National Geodetic Vertical Datum of 1929

NHESP	National Heritage and Endangered Species Program
NFF	Needed Fire Flow
NOM	Natural Organic Matter
NT	Not Tested
O&M	Operation and Maintenance
OWR	Office of Water Resources
OSHA	Occupational Safety and Health Administration
PFAS	Per- and Polyfluoroalkyl Substances
PLC	Programmable Logic Controller
ppb	Parts per Billion
PPE	Personal Protective Equipment
ppt	Parts per Trillion
PRV	Pressure Reducing Valve
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
RAA	Running Annual Average
RGPCD	Residential Gallons per Capita per Day
RTCR	Revised Total Coliform Rule
SCADA	Supervisory Control and Data Acquisition
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level
SOP	Standard Operating Procedure
SWAP	Source Water Assessment and Protection
TCR	Total Coliform Rule
TEC	Tetrachloroethylene
THM	Trihalomethane
TOC	Total Organic Carbon
TTHM	Total Trihalomethanes

UAW	Unaccounted for Water
UMass	University of Massachusetts
USEPA	United States Environmental Protection Agency
USG	Utility Service Group
USGS	United States Geological Survey
UWS	Underwater Solutions, Inc.
VFD	Variable Frequency Drive
VLAC	Vinyl-Lined Asbestos Cement
VOC	Volatile Organic Compound
WMA	Water Management Act
WPS	Well Pumping Station
WRC	Water Resources Commission
WTP	Water Treatment Plant
μg/L	Micrograms per Liter
μm	Micrometers

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Environmental Partners (EP) Group, LLC contracted with the Town of Wrentham (Town) to prepare this Water System Master Plan (WSMP) with the primary goal of assisting the Town with providing high quality drinking water to all customers at adequate pressures and volumes. EP also evaluated the water distribution system hydraulically for providing adequate flows, pressures and fire protection now and through the 2040 planning year.

As part of this assessment, EP performed the following services:

- Collect required data and information on the water supply and distribution system;
- Document and describe the existing water system;
- Evaluate current raw water supply and customer demands;
- Prepare water demand projections and requirements through the year 2040;
- Identify water consumption by usage category;
- Determine historic and projected residential per-capita water use;
- Project future average day and maximum day demand;
- Assess the ability of the Town's water supply sources, pumping facilities, and treatment facilities to meet current and future demands;
- Review and assess the Town's existing water storage facilities for the ability to provide suitable storage volumes and pressures for existing and future proposed water demands;
- Review and assess the Town's existing water storage facilities for the ability to meet fire flow requirements;
- Analyze the distribution system using the computerized hydraulic model by simulating existing and future proposed supply and demand conditions;
- Assess the distribution system's ability to meet fire flow requirements using the computerized hydraulic model;
- Evaluate the hydraulic distribution system to identify hydraulic performance deficiencies;
- Develop a recommended improvements plan to address the identified deficiencies;

- Prepare a capital cost estimate for all recommended improvements;

- Categorize the recommended improvements in order of importance and prepare an implementation plan;

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

PROJECT GOALS

The Town is committed to providing a safe, reliable, and adequate water supply to the residents of Wrentham. This WSMP will help the Town meet these goals while also promoting water conservation. It defines measures that the Town can take to protect its water resources and improve water supply system efficiency, and sets forth a service plan for the future. The WSMP also recommends that the Town implement activities such as: protect its existing raw water sources, develop new groundwater supplies, and improve existing water supply facilities so the Town can safely, promptly and efficiently supply drinking water to its customers.

PROJECT APPROACH

Initially, the Town collected and provided background data for EP to use throughout the study. EP reviewed past reports and drawings for the supply, treatment, storage and distribution system facilities. After reviewing these documents, EP developed and calibrated a hydraulic model of the water system to better assess the Town’s current system operations and ability to supply the residents and businesses of Wrentham.

Future water demand estimates were established using historical and projected population trends, number of customers, anticipated development, water usage per customer, and other factors that influence demand. EP compared demand projections to current water supply yields and identified potential water supply surpluses and deficits.

The distribution system-piping network was reviewed to assess its capability of maintaining adequate supply during the target years using estimated maximum daily demand conditions. EP then determined required improvements necessary to provide adequate water supply throughout the Town’s service area.

Next, EP prepared a phased recommended capital improvement program (CIP) and estimated construction costs. The CIP identifies and prioritizes system improvements that are required to meet the future water demands within the Town's service area. The CIP also identifies potential system expansions to territories not currently served, and determines required supply, production, and piping projects which will provide adequate service to these areas.

REPORT CONTENTS

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

- Section 1 describes the Town's water supply system, including the raw water wells and piping, treatment facilities (TF), storage facilities, finished water piping, emergency supply interconnections and supervisory control and data acquisition (SCADA) system.

- Section 2 describes and defines current water quality standards.

- Section 3 addresses supply and demand issues, including present water use, potential future development, projected demands, water conservation, available water and recommendations for raw and treated water supplies.

- Section 4 assesses existing water storage and projected storage needs.

- Section 5 evaluates water system hydraulics and system control strategies.

- Section 6 recommends improvements and presents an implementation schedule and cost estimate for the recommended Capital Improvements Plan.

EXISTING SYSTEM DESCRIPTION

The Town currently operates five gravel-packed groundwater wells. Well 2 and Well 3 supply water to the Town's Treatment Facility (TF) #3; Well 4 and Well 6 are treated at TF#4; and Well 5 is treated at TF#5. Figure 1-1 locates these raw water supplies and treatment facilities. The water system consists of one pressure zone with sources withdrawing raw water from the Charles River and Taunton River Basins.

The Town performs treatment of its raw water using disinfection via ultraviolet (UV) radiation for disinfection, sodium hypochlorite (NaOCl) for chlorination, and potassium hydroxide (KOH) for pH adjustment. The raw water facilities supplying the TFs do not have active chemical addition equipment.

Overall, the operators keep their active groundwater well pump stations (PS) and TFs clean and well maintained. The Town provides site security with access gates, barbed-wire-topped chain-link fence, key card access, and alarm systems.

WATER SUPPLY FORECAST

To ensure an adequate supply of water during future periods of peak water usage, the firm capacity of the system should match or exceed the projected MDD. Figure ES-1 graphs the projected ADD and MDD below under several water supply scenarios including the loss of Treatment Facility #3.

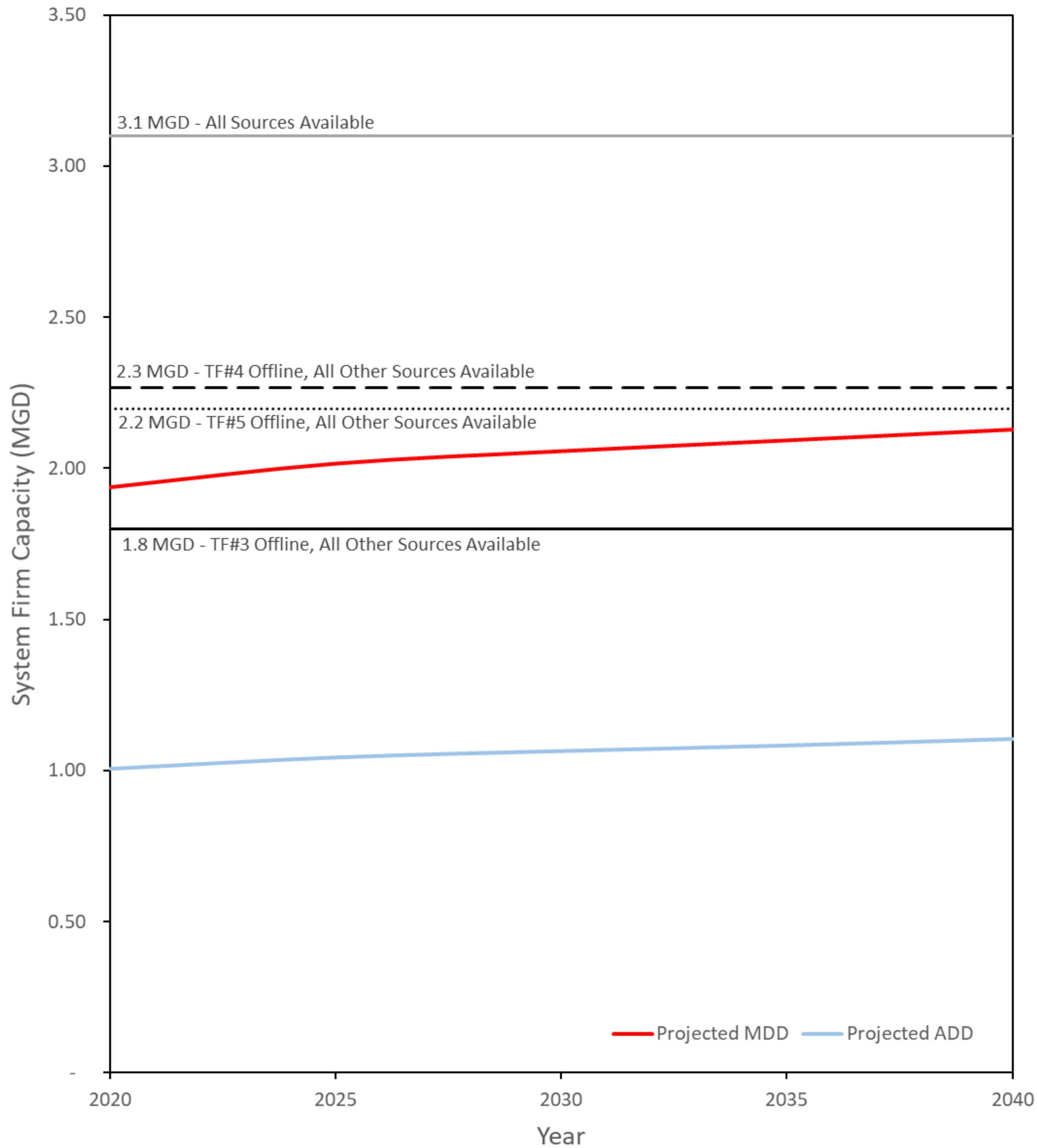

Figure ES-1 - Projected ADD and MDD versus System Capacity with Various Individual Facilities Offline

Under all future MDD conditions, the Town is vulnerable to losing supply from Treatment Facility #3. Starting at a deficit of 0.14 MGD, the supply deficit caused by the loss of Treatment Facility #3 will expand to 0.47 MGD in the year 2040.

With the projected increase in demand in 2040, the loss of either Treatment Facility #4 or Treatment Facility #5 will reduce the available supply to just above the projected MDD. Given the inherent variability in demand, the Town would experience supply deficits under these water supply circumstances as well, if water demands are 10 percent greater than anticipated in the future.

Overall, if operation of a treatment facility is compromised during peak demands, the Town may have difficulty providing a reliable supply of water throughout the 2040 planning period. Under this worst-case scenario, the Town may need to rely on neighboring communities to provide finished water via hydrant-to-hydrant or piped connections. If not done so already, the Town should draft or update standard operating procedures for this scenario with detailed instructions and relevant contact information. Wrentham should reference these standard operating procedures, instructions and contact information in the Water System Emergency Response Plan (ERP) and emergency interconnection agreements.

WATER SUPPLY RECOMMENDATIONS

Overall, the Town has the ability to meet present and future demands with all of their sources and treatment facilities operational. In the case of a loss of a treatment facility, however, the Town may fail or struggle to meet peak demands both now and in the future. To prepare for emergency scenarios and increased future demands, the Town should pursue new supply sources, improve resiliency at existing facilities, and maintain updated emergency response plans.

Outdoor Water Use Restrictions

With development expected to continue on Route 1 and the Wrentham Center, EP recommends that the Town increase enforcement of water use restrictions, including non-essential outdoor water use. Restrictions for non-essential outdoor water use should be in place from May 1st to September 30th and should limit use to one day per week, before 7:00 a.m. and after 7:00 p.m. on the customers designated trash pickup day. For additional conservation efforts, the Town has implement a water use restriction by-law to help limit non-essential outdoor water use and should initiate land use controls for future developments.

Water System Audit and Conservation Measures

The Town might also consider a water system audit, which would include the top ten water users in the system as a means to conserve water. Through site visits, the Town could survey each facility and discuss water use practices with each user to educate them on water usage and the potential for water savings. The water audit would also include a comprehensive distribution system leak detection survey and should document source meter testing and accuracy. The Town currently tests the accuracy of their source water meters annually.

As discussed during our meeting with the Wrentham Director of Planning and Economic Development, the Town should carefully review the water supply needs of future large residential developments and all commercial and industrial. Specifically, the Planning Board should include water supply evaluations when reviewing all future major developments in Wrentham to assess potential negative impacts on:

- available water supply,
- system pressures,
- available fire protection, and
- existing water customers.

EP has experience assisting other communities with developing and implementing water conservation bylaws and programs and highly recommends this practices to avoid potential negative effects on drinking water supplies.

Prior to the approval of any new development, EP also recommends that the Town require water saving devices that meet or exceed current plumbing codes to minimize water consumption. Options for these devices include water-less urinals and low-flow shower heads. For existing users, the Town could expand its current public outreach and increase customer awareness by providing water-saving devices and rain barrels to the consumers to enhance water conservation. MassDEP provides a list of additional water efficiency practices including irrigation controls, the adoption and enforcement of efficiency ordinances, and adjustments to billing policies in Appendix A of the latest Water Management Act (WMA) permit. With the most recent WMA permit renewal of the Town's Taunton Basin sources, the MassDEP conditions require quarterly billing of all water customers for Wrentham.

Since the water system has historically experienced elevated residential per capita usage, the Town should particularly stress water efficiency on proposed residential developments to maintain compliance with the 65 residential gallons of water per capita per day (RGPCD) standard. The Town can delay costly capital improvements by implementing or enhancing water conservation and instituting additional water use restrictions.

Potential Source Water Supply Improvements

In Section 6, EP has recommended source water supply improvements to limit the Town's vulnerability and risk including potential emergency interconnections with adjacent water supplies, the planning and implementation of new groundwater sources in West Wrentham and the replacement of Wells 3 and 4, which are failing.

Develop New West Wrentham Groundwater Supply

EP highly recommends that the Town investigate additional groundwater supplies in West Wrentham as the primary solution for reducing risk and water supply vulnerabilities. We believe that interconnections would only be a short-term solution because the Town would be relying on neighboring systems for water for emergency water supply. These bordering communities have their own water supply restrictions and their water customers will take priority over water supply to Wrentham residents.

Also, due to current and potentially more restrictive WMA limitations on the basins in eastern sections of Wrentham, we are targeting West Wrentham to provide supply redundancy and reliability to the Town's water customers in the western part of Town. The proposed new groundwater supply source is more sustainable for the health and wellbeing of current residents and would provide additional water supply volume for anticipated future growth and development. EP is also recommending the new source in West Wrentham to create a new high service area to limit water quality concerns caused by current system operations. This proposed remote water supply facility would reduce water age and decrease chlorine concentration during water treatment thereby enhancing water quality throughout the system.

Emergency Replacement of Wells 3 and 4

In early November 2021, the screen for Well 3 failed during redevelopment. Since Maher Services was on site for the redevelopment, the Town extended their contract to perform emergency repairs on the well screen; however, the improvements were only temporary. Maher recommended that the Town replace Well 3 soon to avoid potential total collapse of the well and screen.

In the Town's most recent WMA permit renewal of their Taunton Basin sources, MassDEP increased the allowed withdrawal limit for Well 4 and Well 6 to 0.86 MGD and 0.19 MGD, respectively. Although an increase in the Town's withdrawal capacity is welcome, both wells are currently operating at their maximum capacity so the Town cannot benefit from these increases in permitted capacities. In addition, the Town has expressed concerns about the condition and operating capacity of Well 4 and believe that the existing well casing and/or screen is damaged.

EP recommends that the Town conduct a groundwater source site-screening program near Wells 3 and 4 to site the replacement wells and enhance the new well capacity to the permitted flow rate of each well. The results of this site screening process will help the Town identify the most cost effective and efficient approach to replacing these existing permitted raw water sources.

After completing the groundwater source site-screen program, the Town can select the sites for the replacement of Wells 3 and 4. Following MassDEP's approval of the pump test and replacement well report, the Town would the design and construct the connection of replacement Wells 3 and 4 to the water system.

SUMMARY OF RECOMMENDED IMPROVEMENTS

In Section 6, EP presents water supply, treatment, storage, transmission, and distribution system improvements in a four-phase program each with a five year duration.

Using water supply industry standard practices, EP recommended improvements relating to water supply development and treatment first, followed by transmission/distribution system improvements, and finally storage. In Section 6, we also present recommendations pertinent to supply redundancy and improvements to system operation and maintenance. Figure 6-1, appended to the Water Supply Plan, locates all recommended improvements.

EP has established costs for each recommended improvement, which are also presented in Section 6. Table ES-1 summarizes recommended improvements for each planning period (phase), which includes the anticipate planning-level costs. These recommendations will improve system operation and reliability, increase supply redundancy, and treatment capabilities. Table ES-1 reflects the Town's updated CIP with all supply, treatment, storage and transmission/distribution recommendations. All projects are arranged in order of priority, and cost estimates are based on July 2021 price levels.

Table ES-1 – Water System Capital Improvement Program (CIP)

Phase I Improvements - Years 2021-2025		
1	Water Audit and Leak Detection Study	$55,000
2	Well 3 Exploration and Replacement Improvements	$1,100,000
3	Chemical Feed Improvements	$809,000
4	New Source Development Phase 1: Exploration	$300,000
5	Unidirectional Flushing Program	$65,000
6	Water and Stormwater GIS Needs Assessment	$10,000
7	Well 4 Exploration and Replacement Improvements	$1,100,000
8	Bellingham Interconnection	$570,000
9	Franklin Interconnection	$1,770,000
	Phase I Improvements Total :	**$5,779,000**

Phase II Improvements - Years 2026-2030		
1	Water Main Replacement - Fire Flow	$4,390,000
2	Building Improvements	$38,000
	Phase II Improvements Total :	**$4,428,000**

Phase III Improvements - Years 2031-2035		
1	Knuckup Hill Tank	$8,094,000
2	Boosted Pressure Zone Study	$75,000
3	Water Main Replacement - Unlined CI Phase I	$6,450,000
	Phase III Improvements Total :	**$14,169,000**

Phase IV Improvements - Years 2036-2040		
1	Water Main Replacement - Unlined CI Phase II	$1,240,000
2	Water System Master Plan	$125,000
	Phase IV Improvements Total :	**$1,365,000**

SECTION 1 - DESCRIPTION OF WATER SUPPLY SYSTEM INFRASTRUCTURE AND SOURCES

Environmental Partners (EP) toured each of the Towns' wells, treatment facilities, and storage tanks with an operator to gather an understanding of the current state of the Town's water system infrastructure. This section provides the information and observations gathered during these visits supplemented further by documents provided by the Town.

1.1. WATER SYSTEM OVERVIEW

The Town currently operates five gravel-packed groundwater wells. Well 2 and Well 3 supply water to the Town's Treatment Facility (TF) #3; Well 4 and Well 6 are treated at TF#4; and Well 5 is treated at TF#5. Figure 1-1 locates these raw water supplies and treatment facilities. The water system consists of one pressure zone with sources withdrawing raw water from the Charles River and Taunton River Basins.

The Town performs treatment of its raw water using disinfection via ultraviolet (UV) radiation for disinfection, sodium hypochlorite (NaOCl) for chlorination, and potassium hydroxide (KOH) for pH adjustment. The raw water facilities supplying the TFs do not have active chemical addition equipment.

Overall, the operators keep their active groundwater well pump stations (PS) and TFs clean and well maintained. The Town provides site security with access gates, barbed-wire-topped chain-link fence, key card access, and alarm systems.

1.2. WATER SUPPLIES

The Town operates three treatment facilities fed by five groundwater wells to produce potable water. The treatment facilities and water supply wells are configured as follows:

- Treatment Facility #3 treats water from Well 2 and Well 3.
- Treatment Facility #4 treats water from Well 4 and Well 6.
- Treatment Facility #5 (Lake Pearl Water Treatment Plant) treats water from Well 5.

The Town's groundwater sources withdraw from two watersheds: the Taunton River Watershed (Wells 4 and 6) and the Charles River Watershed (Wells 2, 3, and 5).

The Federal Safe Drinking Water Act (SDWA) Amendments of 1996 included measures to protect drinking water sources from contamination and required states to develop a Source Water Assessment and Protection (SWAP) program. As part of the Massachusetts program, the Town's SWAP Report was completed in March 2003 and the Report defined the Zone I and II protection areas for each of Town's groundwater supplies. Under the SWAP Program and 310 CMR 22, these zones are generally defined as follows:

- Zone I is the protecting area closest to the well and is typically a 400-foot radius, unless the well has an approved yield less than 0.1 MGD. According to the SWAP program, Zone I should be owned or controlled by the water supplier and limited to water supply activities.
- Zone II is the primary recharge area for the well and is defined by hydrogeologic studies that are approved by MassDEP.

Only water supply activities are allowed in the Zone I, however, the Town's Well 2 and 3 sources were developed prior to the Department's regulations and as such contain non water supply activities including homes and route 140. Additionally, in the Town's Zone IIs, EP identified several proximity hazards that threaten to contaminate source water. Proximal roadways threaten groundwater resources due to the possibility of hazardous material, fuel, or cargo spills.

- Route 495, a hazardous materials route, is located within the Zone II area of Wells 2, 3, and 5.
- Route 1 is located within the Zone II area of Wells 4 and 6.
- Route 1A is located within the Zone II area of Wells 2, 3, 4, 5, and 6.
- Route 121 is located within the Zone II area of Wells 2, 3, and 5.
- Route 140 is located within the Zone II area of Wells 2, 3, 4, 5, and 6.

1.3. WATER MANAGEMENT ACT (WMA) PERMIT

In the Commonwealth of Massachusetts, the Massachusetts Department of Environmental Protection (MassDEP) registers and permits all withdrawals of water for public water consumption greater than 100,000 gallons per day (gpd) under the requirements of the WMA (310 CMR 36.00) and M.G.L c. 21G.

Wrentham current has two WMA permits registered with MassDEP including the Charles River Basin issued on September 29, 1988 (Registration # 420350.01) and the Taunton River Basin, dated February 17, 1989 (Registration # 425350.01). Under the current permits, the Town may withdraw an annual average of 3.13 million gallons per day (MGD). Table 1.1 presents the maximum permitted withdrawal volume for each well.

Table 1.1 - Maximum Permitted Withdrawal Volumes for the Town's Wells in MGD

Wells	Permitted Max Withdrawal Volume (MGD)
Well #2	0.65
Well #3	0.68
Well #4	0.86
Well #5	0.94
Well #6	0.19

Under the latest WMA permits, MassDEP has documented a series of water use restrictions and requirements including:

- water conservation,
- unaccounted-for water performance,
- residential gallons per capita per day (RGPCD),
- seasonal limits on non-essential outdoor water use,
- cold water fishery resource protection,
- minimization, and
- mitigation.

The Town must operate within the standards of its WMA permit, including compliance with the residential water use standard of 65 gallons per day or less per capita and maintaining the unaccounted for water (UAW) standard of 10 percent or less.

1.4. TREATMENT FACILITY #3 (MASSDEP PLANT ID: 4350000-02T)

Located on Franklin Street, TF#3 treats water from Well 2 and Well 3 with pretreatment including UV disinfection. This UV system is wrapped in insulation to prevent condensation, which previously led to pooling of condensate and damage to the floor in the surrounding area.

Picture 1-1 Treatment Facility #3 Building Exterior

For chemical treatment, the Town utilizes Sodium Hypochlorite (NaOCl) and Potassium Hydroxide (KOH) at TF#3. NaOCl is injected for residual disinfection from a day tank located in a confined area within TF#3. The Town utilizes bulk storage of NaOCl, located outside of the NaOCl treatment area in various drums on top of spill containment trays. There is a bulk storage tank located in the containment area; however, the Town does not used this bulk tank because the tank is too large in volume, which lead to degradation of the chemical. The Town is also concerned because this bulk tank is not sealed, may leak and could eventually fail.

Currently, operators fill the day tank with a stick pump from the storage drums. The Town performs the same NaOCl disinfection operating procedures at all three treatment facilities. During our site visits, EP observed that the Town only had one active and operating NaOCl metering pump at TF#3 and all other treatment facilities with one spare metering pump for NaOCl disinfection. However, the Town has purchased spare chemical feed pumps for all treatment facilities since the initial site visits.

The Town adjusts the pH of the treated water using KOH, which is stored in another containment area adjacent to NaOCl. Bulk storage of KOH is limited to a 1,500-gallon tank, which is inadequate and requires frequent refilling to maintain the proper rate for chemical treatment.

To gain access to both chemical areas, operators must climb ladder rungs embedded on either side of the CMU containment wall. The Town indicated that this method of entry is cumbersome and dangerous, especially considering the location of the safety shower and eyewash station, which are outside of both areas.

The Town utilizes an air-cooled, propane generator that supplies backup power for TF #3 and Well 3. When inspecting the facility, EP observed that the TF#3 roof is leaking and requires repair.

1.4.1. Franklin Street Well 2 (MassDEP Source ID: 4350000-03G)

In 1944, the Town constructed gravel-packed Well 2 to a depth of about 58 feet. Well 2 is located in a brick building off Franklin Street and houses a single groundwater well, vertical turbine pump (VTP) equipped with a VFD and a standby generator.

Picture 1-2 Well 2 Building Exterior

The Town operates Well 2 at its permitted flow rate of 450 gpm, which pumps raw water down Franklin Street to TF#3 via a 12-inch water main. An underground propane storage tank provides fuel for the station heaters and the generator. Unlike other stations in the water system, the backup generator at Well 2 has a water cooling system instead of being air-cooled. The Town indicated the water cooling system is problematic due to the need to provide treated water to the station even when the well pump is not running. As such, the Town maintains a partially opened valve at TF#3 to ensure the supply of cooling water to the station.

As the oldest operating pump station, the Well 2 building is aging and requires continuous preventative maintenance to ensure the station remains sound and weather tight.

1.4.2. Franklin Street Well 3 (MassDEP Source ID: 4350000-04G)

As development and corresponding water demands increased, the Town constructed Franklin Street Well 3 in 1960 to a depth of about 60 feet. Well 3 is located off Franklin Street and adjacent to TF#3 in a brick building, which houses a single groundwater well and vertical turbine pump equipped with a VFD that regularly runs at the permitted flow of 475 gpm.

Picture 1-3 Well 3 Building Exterior

The Well 3 building receives power through TF#3, which is equipped with a stand-by generator. Similar to Well 2, the Well 3 building shows signs of aging with the roof and doors in disrepair and requiring replacement.

In early November 2021, the Town informed EP that the screen in Well 3 failed during redevelopment. Maher Services was performing the redevelopment so the Town extended their contract following the failure to perform emergency repairs on Well 3. Maher indicated that their repairs were only a temporary solution and that the Town should replace the well as soon as possible to avoid additional damage and potential total failure of the well. Due to this emergency condition and the importance and high capacity of Well 3, EP will recommend the replacement of Well 3 early in the first phase of the Capital Improvement Program.

1.5. LAKE PEARL WATER TREATMENT PLANT (MASSDEP PLANT ID: 4350000-03T)

Located on Elysium Street, Lake Pearl Water Treatment Plant, also known as TF#5, treats water from nearby Well 5. The Town constructed both Well 5 and TF#5 in 2003 which included an air-cooled, propane generator in TF#5, which provides backup power for both facilities.

Picture 1-4 Treatment Facility #5 Building Exterior

The Town begins treatment with UV disinfection at TF#5 followed by chemical addition of sodium hypochlorite (NaOCl) and potassium hydroxide (KOH). Similar to TF#3, the Town utilizes bulk storage of NaOCl in drums on top of spill containment trays; although there is a bulk storage tank in a depressed chemical containment area. Similar to TF#3, the Town recently purchased and installed a spare NaOCl chemical feed pump so TF#5 so the Town has redundant metering pumps for NaOCl.

The Town adjusts the pH of the treated water with KOH, which is stored in another depressed chemical-containment area adjacent to NaOCl. The KOH is stored in a 4,000-gallon bulk tank, which is more than adequate to keep up with the rate of chemical treatment.

To gain access to both chemical areas, operators climb down ladder rungs embedded on the wall of the chemical containment areas. A spill containment lip in front of these ladders to prevent any potential spills NaOCl from entering the chemical containment areas but also could be a tripping hazard.

1.5.1.Well 5 (MassDEP Source ID: 4350000-05G)

Well 5 is a gravel-pack with a depth of about 53 feet. Well 5 is pre-fabricated fiberglass structure located off Elysium Street approximately 100 feet to the rear of TF#5, which houses the single groundwater well equipped with a vertical turbine pump (VTP) and a variable frequency drive (VFD) motor. This pump station regularly produces the permitted flow of 650 gpm; however, the operators indicated that the pump can provide over 1,000 gpm but is limited by the WMA permit.

1.6. TREATMENT FACILITY #4 (MASSDEP PLANT ID: 4350000-01T)

Located off Thurston Street, TF#4 treats water from Well 4 (Thurston Street well) and Well 6 (Crocker Pond well). When constructing TF#4, the Town modified the original Well 4 building with two additions to expand the building footprint for chlorination and pH adjustment treatment processes. Well 6 pumps water to TF#4 where it combines with the raw water from Well 4 for treatment at TF#4.

Picture 1-5 Treatment Facility #4 Building Exterior

At TF#4, the Town provides water treatment with UV for raw water disinfection followed by chemical treatment with Sodium Hypochlorite (NaOCl) for finished water disinfection and Potassium Hydroxide (KOH) for pH adjustment. Similar to the other TFs, the Town stores NaOCl in drums on top of spill containment trays. The Town abandoned the existing 500-gallon bulk storage tank at TF#4 due to leakage and excessive capacity. Also similar to the other TFs, the Town recently installed a second NaOCl metering pump at TF#4.

KOH adjusts the pH of the treated water and is stored in a depressed chemical-containment area in the newest expansion of TF#4. The operators store the KOH in two, 1,500-gallon bulk tanks and indicated that this volume is slightly less than adequate for their current rate of chemical treatment.

Because of the size of the chemical feed equipment, the Town can only operate TF#4 with Well 4 or Well 4 and Well 6 operating but never Well 6 alone since the operating capacity of TF#4 requires a much higher flow rate than the permitted capacity of Well 6.

1.6.1. Well 4 (MassDEP Source ID: 4350000-02G)

Constructed in 1975, Well 4 is a 56-foot deep, gravel-packed well, located inside of TF#4 off Thurston Street. The well has a vertical turbine pump equipped with a VFD and regularly runs at 475 gpm. When compared to the other wells, Well 4 has the highest levels of iron and manganese.

1.6.2. Well 6 (MassDEP Source ID: 4350000-06G)

The Town constructed gravel-packed Well 6 in 2005 at a depth of 49 feet. Well 6 is located off Myrtle Street and adjacent to Crocker Pond. The well has a submersible pump that is not equipped with a VFD, but is manually throttled to provide 120 gpm. Well 6 pumps raw water down Myrtle Street, south on Route 1, and then cross country to TF#4 for treatment.

1.7. DISTRIBUTION STORAGE FACILITIES

Water storage facilities serve several functions within a water distribution system including system pressure equalization, fire suppression volume, emergency storage, and operational flexibility. The volume of water within a storage tank is immediately available for fire protection and provides flexibility to the Town to perform routine maintenance on its treatment facilities, groundwater wells, and distribution system. The Town's water distribution system contains three water storage tanks: two on Knuckup Hill and one on Bucks Hill, which provide a combined storage volume of about 2.5 million gallons (MG). Chain-link fence topped with barbed wire surrounds both tank sites.

1.7.1. Bucks Hill Tank

Constructed in 2000, the Bucks Hill Tank is a 750,000-gallon, partially buried standpipe. This pre-stressed concrete tank is accessible by a gated access road off Rhodes Drive.

Picture 1-6 Bucks Hill Storage Tank

The total height of the tank is 40.4 feet with an overflow elevation of the tank is 465.4 feet. In 2014, the Town installed a mixing system in the tank to eliminate stagnation, decrease water age, and improve water quality. Because of hydraulic restrictions between the Bucks Hill Tank and the Town's supply sources, the Bucks Hill Tank typically operates at a lower hydraulic grade line (HGL) than the other two tanks.

1.7.2. Knuckup Hill Tanks

The Knuckup Hill Tanks are located on a gated access road off Taunton Street. The smaller of the two tanks is a bolted-steel tank with a 250,000 gallons capacity and was constructed in 1907. The larger tank is a 1,500,000-gallon welded-steel tank built in 1960.

Picture 1-7 Knuckup Hill Storage Tanks (250,000 gallon left, 1,500,000 gallon right)

In 2014, the Town installed a mixing system in both tanks to eliminate stagnation, decrease water age, and improve water quality. The Town maintains a 12-inch ductile iron water main runs along the access road and connects the tanks to the main in Taunton Street. The tanks are also connected to the distribution system with two cast irons mains (16-inch and 10-inch) that run cross country to the water mains on South Street (Route 1A). According to previous reports, EP understands that the smaller tank has an overflow elevation of 464 feet and the larger tank an overflow elevation of 465 feet. Because the tanks are so close to each other, the water elevation is assumed to be the same in each tank so the SCADA system reports one level for both tanks. The Town also utilizes the tank site for cellular antennas, communication equipment and other associated infrastructure. The Town originally had antennas installed on the storage tanks; however, cellular service is now provided through a separate tower located on the tank site.

1.8. DISTRIBUTION SYSTEM PIPING

The Town's water distribution system consists of approximately 533,800 feet or 101 miles of water main ranging from 4-inch to 20-inch, as summarized in Table 1.2 below. Figure 1.1 attached shows the Town's water mains color-coded by diameter.

Table 1.2 - Breakdown of system piping by pipe diameter

Diameter (inches)	Length (feet)	Percent of System
4	4,500	1%
6	106,200	20%
8	231,700	43%
10	11,400	2%
12	144,800	27%
16	30,300	6%
20	5,000	1%
Total	**533,800**	**100%**

Table 1.3 provides information linear footage and percentages by pipe material with the majority (46 percent) of the distribution system piping being ductile iron (DI) pipe. Cast iron (CI) makes up the next largest portion at 27 percent while polyvinylchloride (PVC) and asbestos cement (AC) pipe also somewhat prevalent. Figure 1.2 (attached) shows the Town's water mains color-coded by material.

Table 1.3 - Breakdown of system piping by pipe material

Material	Length (feet)	Percent of System
Ductile Iron	244,200	46%
Unlined Cast Iron	95,700	18%
Asbestos Cement	70,400	13%
PVC	60,700	11%
Cement-Lined Cast Iron	47,200	9%
Unknown	13,400	3%
HDPE	2,200	<1%
Total	**533,800**	**100%**

1.9. SCADA SYSTEM

The Town maintains a supervisory control and data acquisition (SCADA) system to control and monitor all well supplies and storage tanks from two central computers. This system is in the final stages of being updated and has three main functions:

- Data communication;
- Data acquisition and presentation; and
- Equipment automation and remote control

EP describes each of these functions below.

Data Communication

During our initial site visits, EP confirmed that the Town has SCADA communication with the remote sites communicate via radio to the two SCADA computers and the one SCADA laptop. The Town is currently upgrading its SCADA software and hardware, which will replace the laptop with two tablets. Town personnel view and control water system parameters (e.g. water level, flow, water quality, pump run status, etc.) at each connected site from one of two computers.

The Town has equipped each well site and both storage tank locations with radio telemetry. Each radio system includes a radio modem and an antenna for transmitting information.

The SCADA software includes alarming functionality that alerts personnel of fault or abnormal conditions in the system including unauthorized intrusion and entry into its water system facilities. By using this alert system, the Town's personnel can diagnose the problem remotely, determine the urgency of the alarm, and direct suitably qualified staff to correct the issue. With this operational approach, the Town can more efficiently operate the water system. Without the SCADA system and its data communication capabilities, the Town would need 24-hour staffing of the Water Department to safely and properly operate the water system.

Data Acquisition and Presentation

The Town utilizes a remote server to store historical data in a database accessible by operations personnel. This historical data has a number of uses:

- Troubleshoot and improve system performance and operational efficiency;
- Complete state-mandated reporting;
- Monitor equipment operations to forecast maintenance, repair, and replacement;
- Identify leaks and variations from normal system operations; and
- Verify and update hydraulic water models.

The SCADA system presents real-time data in a user-friendly manner. Personnel are able to navigate to separate screens for each of the remote sites, which display current information on various water system parameters.

The Town is also able to use the SCADA software to view historical data trend lines; however they are only able to access past data by manually clicking through the trend lines.

Equipment Automation and Remote Control

The Town utilizes the SCADA system to review and collect real-time data throughout the water system and to automate equipment. Field instruments measure process parameters and report that information to a local PLC that reads and interprets the data in accordance with its programming. As process parameters change, the PLC will make automatic adjustments to process equipment, such as turning motors on/off, increasing/decreasing motor speed, opening/closing valves, or reporting an alarm condition to the SCADA system. Simultaneously, the PLC transmits process data, motor status, valve position, and other parameters to the central SCADA system via signal wiring or radio telemetry for remote viewing and control.

In general, the well supplies are turned on and off by water level in the storage tanks. In the event that the operations staff need to make changes to automatic operations, they are able to adjust operational set points from the SCADA computers.

Each facility with remote monitoring capabilities contains a number of instruments that are used for automatic process control and monitoring. These instruments include flow meters, water quality analyzers, level sensors, pressure transmitters, and more. The Town does not appear to have standardized their instrumentation around certain manufacturers or models. While not required to have a robust and functional process controls system, the Town can improve and streamline operations and maintenance, as well as reduce storage required for spare parts by standardizing their instrumentation system.

Cyber Security

With the increased reliability on process automation, remote communications, and automated billing, water suppliers are continuously threatened by cybersecurity attack, which have become a top threat for water system infrastructure in the United States. In 2018, the Department of Homeland Security warned that a foreign government continues to target water infrastructure as part of a multi-stage intrusion campaign. Attacks on water system operations have the potential to cause water quality issues, equipment failures, and service outages. Additionally, there have been notable efforts by cybercriminals to steal sensitive information from water system servers, such as employee records and customer billing information. Water system cyber security is a critical public health and safety issue.

The Town can take steps to limit water system vulnerabilities and prevent cyberattacks include:

- Allocating funds specifically dedicated to the security and resiliency of electronic networks;
- Utilizing the services of an IT specialist to monitor their networks and investigate possible network intrusions;
- Vetting all contract staff prior to allowing access to their electronic networks;
- Utilizing separate billing and accounting software and limiting access to select, trusted personnel;
- Enforcing a strict cybersecurity policy for mobile devices;
- Regularly implementing security updates and patches; and
- Training all Town employees on cybersecurity safety.

SECTION 2 - WATER QUALITY STANDARDS

2.1. WATER QUALITY STANDARDS

The Town is currently in compliance with the water quality requirements of 310 CMR 22.00. An overview of several drinking water quality regulations as they relate to the Town's water system is presented below. The Town has had water quality challenges at the well sources and in the distribution system, primarily related to iron and manganese.

2.2. SAFE DRINKING WATER ACT AND AMENDMENTS

The SDWA was passed in 1974 and subsequently amended in 1986 and 1996. The SDWA was enacted to protect public health through regulations developed by the United States Environmental Protection Agency (USEPA) to protect the nation's drinking water and its sources. The USEPA established two sets of standards: national primary drinking water standards, which are enforceable standards of maximum contaminant levels (MCLs); and national secondary drinking water standards, which are established Secondary MCLs (SMCLs). These SMCLs are not enforced by the USEPA, but are provided as guidelines for public water systems to voluntarily monitor their systems for aesthetic qualities such as taste, odor, and color. Iron and manganese are two secondary contaminants that when present in excess of their SMCLs have the potential for contributing to taste, color, and odor complaints.

The requirements of the SDWA are applicable to the Town's water system as it meets the definition of a public water supply that provides water to at least fifteen services or serves at least twenty-five people per day for at least sixty days of the year. Therefore, the regulations set forth under the SDWA are applicable to the water system. The requirements of the SDWA and its amendments that apply to the water system are discussed further in the following sections.

2.3. GROUNDWATER TREATMENT RULE AND REVISED TOTAL COLIFORM RULE

The Ground Water Rule (GWR) was promulgated by the USEPA in October 2006 to reduce the risk of exposure to fecal contamination that may be present in public water systems that use ground water sources. The 1996 amendments to the SDWA charged the USEPA with developing regulations requiring disinfection of select ground water systems based upon the results of a risk-targeted strategy that identifies systems at high risk for fecal contamination. The rule requires periodic sanitary surveys of ground water systems, source water monitoring for the presence of E. coli, corrective actions for systems with significant deficiencies, and compliance monitoring to ensure that installed treatment technology achieves at least 99.99 percent (4-log) inactivation or removal of viruses.

While the GWR addresses source water microbiological pollutants, the 1989 Total Coliform Rule (TCR) and the 2013 Revised Total Coliform Rule (RTCR) address the protection against waterborne bacteria in drinking water distribution systems. Compliance with the TCR is based on distribution system sampling results and the detection of Total Coliforms. Coliforms are a collective group of microorganisms that typically originate from the intestines of warm-blooded animals, but which may also occur naturally in the environment. Therefore, a subset of the Total Coliform group (E. coli or fecal Coliforms) is used to identify fecal contamination. The USEPA recognized that total coliform detection does not itself necessarily signify a health threat, so in 2013, the USEPA issued the RTCR to focus on E. coli. The MCL and MCL Goal (MCLG) for total Coliforms were eliminated and replaced with an MCL and MCLG for E. coli.

Water systems must collect a minimum number of distribution system samples per month based on the population served. The Town currently collects routine distribution samples, tank samples, raw water samples, and post-treatment samples per month. Compliance with the RTCR is based on the presence or absence of Total Coliforms. Each Total Coliform-positive (TC+) routine sample must then be tested for the presence of E. coli. For water systems collecting less than 40 distribution system samples per month, no more than one sample per month can be positive for E. coli. For water systems collecting more than 40 distribution system samples per month, compliance with the RTCR is achieved if no more than 5 percent of the samples are positive. Any positive sample must be resampled within 24 hours and two additional samples taken (upstream and downstream of the site). A system is out of compliance if the results of repeat sampling are positive for fecal coliforms or E. coli, in which case the water system must contact the MassDEP within 24-hours and perform public notification. Best available treatment techniques for compliance with the RTCR include source water protection, filtration, primary disinfection, and secondary disinfection. Detailed requirements of the RTCR for Massachusetts public water systems are provided in 310 CMR 22.05.

The Town is currently in compliance with the provisions of the RTCR with all water supplies in the system utilize NaOCl and ultraviolet (UV) for disinfection.

2.4. DISINFECTANTS/DISINFECTION BY-PRODUCT RULE

Disinfection-by-products (DBPs) are regulated compounds formed in chemical reactions between precursor material, such as natural organic matter (NOM), and a disinfectant, such as chlorine. Total trihalomethanes (TTHMs) are regulated under the SDWA and are defined as the total concentration of four specific organic DBPs: chloroform, bromoform, bromodichloromethane, and dibromochloromethane. As defined under the SDWA of 1986, the MCL for TTHMs was 100 μg/L, which was based on a running annual average (RAA) of quarterly distribution system TTHM sampling results. This MCL for TTHMs applied only to community water systems that served a population of 10,000 or more and which used a disinfectant in any part of their drinking water treatment process.

In December 1998 (Federal Register December 16, 1998), the USEPA promulgated the Disinfectants/Disinfection-by-Product Rule (D/DBPR) for all water systems that utilize a disinfectant.

Under the Stage 1 D/DBPR, the TTHM MCL was lowered to 80 µg/L, and MCLs were established for a group of five haloacetic acids (HAA5: mono-chloroacetic acid, di-chloroacetic acid, tri-chloroacetic acid, mono-acetic acid, and di-acetic acid) at 60 µg/L, bromate at 10 µg/L, and chlorite at 1 mg/L. The USEPA determined compliance based on a RAA of samples taken quarterly or annually, where the number of samples taken depends on system size and whether the source is under influence of surface water. Chlorite monitoring is required for systems that use chlorine dioxide, and bromate monitoring is required for systems that use ozone. Systems may qualify for a reduced long-term monitoring schedule if byproduct concentrations remain low.

The USEPA also established maximum residual disinfectant levels (MRDLs) for chlorine, chloramines, and chlorine dioxide at 4 mg/L as free chlorine, 4 mg/L as total chlorine, and 0.8 mg/L as ClO2, respectively. For water systems in the Commonwealth of Massachusetts, detailed requirements of the Stage 1 D/DBP Rule are defined in 310 CMR 22.07E.

The Stage 2 Disinfectants/Disinfection-by-Product Rule was proposed by USEPA in August 2003 (Federal Register, August 18, 2003). The rule was finalized in January 2006 (Federal Register, January 4, 2006). For water systems in the Commonwealth of Massachusetts, Drinking Water Regulation 310 CMR 22.07F defined detailed requirements of the Stage 2 D/DBP Rule.

The Stage 2 D/DBPR applies to all water systems using a disinfectant other than UV and establishes more stringent TTHM and HAA5 standards. The USEPA updated TTHM and HAA5 standards in two phases:

- Under Phase I, all systems were required to meet running annual averages (RAAs) of 80 µg/L for TTHMs and 60 µg/L for HAA5s and locational running annual averages (LRAA) of 120 µg/L for TTHMs and 100 µg/L for HAA5s. Water systems had to comply with the Phase I levels within three years after the rule was promulgated in January 2006; however, an additional two-year extension was available for systems requiring capital improvements; and

- Under Phase II, all water systems were required to conduct an initial distribution system evaluation (IDSE) based on system size and source water type. IDSE was performed to determine new DBP monitoring sites that represent maximum DBP formation sites, unless historic monitoring results for TTHM and HAA5 levels less than 40 µg/L and 30 µg/L (40/30 certification), respectfully. In addition, the LRAA levels for TTHMs and HAA5s were lowered to 80 µg/L and 60 µg/L, respectively. All systems had to comply with the Phase II levels by October 2013, except that an additional two-year extension was available for systems requiring capital improvements.

2.5. LEAD AND COPPER RULE

On June 6, 1991, the USEPA promulgated the Lead and Copper Rule (LCR), based on the requirements of the 1986 Amendments to the SDWA. The objective of the LCR is to reduce consumer exposure to lead and copper resulting from corrosion of drinking water piping and plumbing systems. Unlike other drinking water regulations that establish MCLs, the LCR requires various treatment techniques including: optimal corrosion control treatment; source water treatment; public education; and lead service line replacement, which are triggered by lead and copper action levels (ALs) measured at the consumer's tap. USEPA has set ALs at a 90th percentile concentration of 0.015 mg/L for lead and 1.3 mg/L for copper, respectively.

Under the 1996 amendments to the SDWA, USEPA provided several revisions to the LCR (Federal Register, January 12, 2000; Federal Register, Minor Revisions, April 11, 2000) including changes or additions in requirements for: the demonstration of optimal corrosion control, lead service line replacement, public education, monitoring, analytical methods, reporting and record keeping, and special primacy considerations. Massachusetts drinking water regulation 310 CMR 22.06B provides detailed requirements of the LCR. The USEPA further revised the LCR in October 2007 to enhance some facets of the implementation of the LCR and improve compliance with public education requirements.

Water systems must sample tap water distribution system sites for lead and copper and for corrosion control water quality parameters based on service population. Sampling sites are selected based on an inventory of distribution system materials (lead services) and residential house age (homes built just prior to the USEPA lead ban, between 1982 and 1986). Systems are eligible for reduced monitoring when complying with the 90th percentile ALs. Systems exceeding the lead AL must install optimal corrosion control, replace lead service lines, and complete a lead public education program annually.

In November 2019, USEPA released proposed revisions to the LCR in the wake of the Flint, Michigan episode for public comment. As of June 16, 2021, the USEPA have scheduled the final revisions for the LCR to be December 16, 2021. After this date, water suppliers will have until October 16, 2024 to take any actions needed to meet regulatory compliance. Once USEPA finalizes the national regulations, Massachusetts is expected to begin a process of updating 310 CMR 22.06B. The updated regulations include GIS mapping of lead services, new procedures for residential testing, requirements for testing at elementary schools and childcare facilities, and a new 10 ppb limit to trigger installation or re-optimization of corrosion control treatment.

The Town has always been in compliance with the Lead and Copper Rule and plans to update its system mapping to GIS mapping to comply with the pending regulations.

2.6. EMERGING CONTAMINANTS – PFAS

Drinking water PFAS guidelines, regulations, and requirements are rapidly evolving and vary across the country. USEPA required testing of six PFAS compounds in 2013-2015 as part of the Third Unregulated Contaminant Monitoring Rule (UCMR 3). In 2016, USEPA issued a health advisory level of 70 parts per trillion (ppt) as the sum of two PFAS compounds: perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). In 2019, USEPA confirmed that they are following the standard Safe Drinking Water Act process to determine if an MCL for PFOA and PFOS will be issued. In the interim, some states are taking a more aggressive approach, including issuing MCLs, establishing regulations for more than two PFAS compounds, and setting drinking water limits below USEPA's 70 ppt level.

Massachusetts is among the states pursuing this more aggressive approach. In December 2019, MassDEP released proposed regulations with a Total PFAS MCL of 20 ppt as the sum of the following six PFAS compounds: PFOA, PFOS, perfluorononanoic acid (PFNA), perfluorohexane sulfonic acid (PFHxS), perfluoroheptanoic acid (PFHpA), and perfluorodecanoic acid (PFDA). The regulations require water systems to sample for PFAS quarterly at entry points to the distribution system. If monitoring results exceed 10 ppt Total PFAS, the proposed regulations require monthly monitoring at those sample sites. Compliance with the proposed Total PFAS MCL is based on a running quarterly average of monthly samples.

The Town has sampled all of its raw and finished water sources and all tested with concentrations lower than 10 ppt for Total PFAS including several non-detect sampling results.

SECTION 3 - EVALUATION OF SUPPLY AND DEMAND

3.1. ANALYSIS OF METERED WATER USE

The Town's Annual Statistical Reports (ASRs) list annual metered water use, which represents the total amount of water used by consumers and does not include UAW, water use during treatment, or confidently estimated municipal use. MassDEP requires water suppliers to report water use in the following categories:

- Residential,
- Residential Institutions,
- Commercial/Business,
- Agricultural,
- Industrial,
- Municipal/Institutional/Non-Profits, and
- Other.

Table 3.1 presents the Town's total water consumption by user type from 2015 to 2019 in million gallons per year (MGY). In Wrentham, the majority of average annual water use is residential consumption (83 percent) with the remaining usage mostly attributed to commercial end users (10 percent).

Table 3.1 - Annual Water Consumption by User Type in Millions of Gallons per Year (MGY), 2015-2019

Usage Type (MGY)	2015	2016	2107	2018	2019	Average	Percent Total Consumption
Residential	260.9	237.5	230.1	253.4	239.1	244.2	83%
Residential Institution	-	-	-	-	-	0.0	0%
Commercial	35.6	50.2	21.7	19.1	19.9	29.3	10%
Agricultural	-	-	0.2	0.2	0.2	0.1	< 1%
Industrial	-	-	-	-	1.2	0.2	< 1%
Municipal/Institution/Non-Profit	11.9	10.1	55.6	15.0	11.6	20.8	7%
Total Metered	**308.3**	**297.8**	**307.6**	**287.7**	**272.0**	**294.7**	**100%**

3.2. AVERAGE DAY DEMAND

Average-day demand (ADD) is the average volume of water pumped into the distribution system in a year, calculated by dividing total volume pumped in one year by the number of days in that year. This metric is a baseline for determining the adequacy of water supply sources. Table 3.2 summarizes the Town's water production, which includes UAW (further discussed below), for the five year period from 2015 through 2019. Based on the information available, the Town's average water production from 2015 to 2019 was approximately 0.93 MGD or 340.3 MGY.

Table 3.2 - Average Annual Water Production, 2015-2019

Year	Total Annual Production (MGY)	Average-Day Demand (MGD)
2015	353.2	0.97
2016	317.7	0.87
2017	354.6	0.97
2018	325.1	0.89
2019	350.7	0.96
5-Year Average	**340.3**	**0.93**

3.3. MAXIMUM DAY DEMAND

Maximum-day demand (MDD), the largest 24-hour demand during a calendar year, is essential in the evaluation of treatment and pumping facilities. MDD is typically expressed as a ratio of ADD. This ratio varies based on the characteristics of the individual community. Table 3.3 shows MDD relative to ADD between the years of 2015 and 2019. The average MDD is 1.80 MGD and the average ratio of MDD to ADD is 1.93.

Table 3.3 - Maximum versus Average Day Demand, 2015-2019

Year	Average-Day Demand (MGD)	Maximum-Day Demand (MGD)	MDD/ADD Ratio
2015	0.97	1.95	2.02
2016	0.87	2.08	2.39
2017	0.97	1.92	1.98
2018	0.89	1.09	1.23
2019	0.96	1.97	2.05
5-Year Average	**0.93**	**1.80**	**1.93**

3.4. RESIDENTIAL PER-CAPITA WATER USE

The WMA permit limit for residential gallons of water per capita per day (RGPCD) is 65 gallons. Between 2015 and 2019, the Town had an average water use of approximately 57.41 RGPCD. With demands being predominantly residential (83 percent), maintaining low residential per-capita water usage is important to the operation of the Wrentham water system.

Table 3.4 shows the residential water use data from 2015 to 2019.

Table 3.4 - Annual Residential Water Use, 2015-2019

Year	Residential Metered Water Sales (MG)	Percent of Total Water Sales	Residential Population Served	Residential Per-Capita Water Use (RGPCD)
2015	260.9	85%	11,657	61.3
2016	237.5	80%	11,704	55.6
2017	230.1	75%	11,453	54.9
2018	253.4	88%	11,686	59.4
2019	239.1	88%	11,734	55.82
5-Year Average		83%		57.41

3.5. MONTHLY WATER USAGE

EP has previously discussed average demand values for each year; however, water usage varies monthly. Table 3.5 below shows the average daily demand in MGD for each month from 2015 to 2019.

Table 3.5 – Average Monthly Water Use, 2015-2019

Month	Average Demand (MGD)
January	0.65
February	0.65
March	0.66
April	0.75
May	1.03
June	1.34
July	1.46
August	1.31
September	1.18
October	0.82
November	0.66
December	0.66
Average	**0.93**

As shown, Wrentham's water demands follow a seasonal pattern. From October to April, when the weather is colder, water consumption is less than the yearly average day demand of 0.93 MGD by at least 25 percent. However, during the summer, demands exceed the annual average day demand by as much as 57 percent in the case of July. When planning infrastructure upgrades, the Town should anticipate a supply source being offline, as required by industry standards. With this planning approach, it is critical to schedule system improvements during low demand periods to avoid a potential supply deficit.

3.6. UNACCOUNTED-FOR WATER

UAW is defined as the difference between finished water produced and total metered water used (not including confidently estimated unmetered usage). The volume of UAW includes water from undetected leaks, water theft, meter inaccuracies, and other sources of non-metered water usage. From 2015 to 2019, the ASRs report an average of 11.0 percent UAW, as shown in Table 7. Based on the Town's latest WMA permit, this percentage exceeds the allowable UAW threshold of 10 percent. The Town maintained UAW volumes under 10 percent from 2016 to 2018; however, it rose sharply to 21.3% in 2019. As demonstrated in Table 3.6 , the Town saw a decrease in both metered water use and confidently estimated municipal water use when compared to the previous four years. The 2019 UAW increase may also be the result of inaccurate source water metering, billing or customer metering inaccuracies.

Table 3.6 - Annual Unaccounted for Water (UAW), 2015-2019

Year	Total Finished Water Production (MGY)	Total Metered Water Use (MGY)	Confidently Estimated Municipal Use (MG)	Unaccounted for Water Loss (MG)	Percent UAW
2015	353.2	308.3	6.0	38.9	11.0%
2016	317.7	297.9	3.9	16.0	5.0%
2017	354.6	307.6	15.7	31.3	8.8%
2018	325.1	287.7	9.1	28.3	8.7%
2019	350.7	272.0	3.8	74.8	21.3%
5-Year Average	**627.9**	**294.7**	7.7	**37.9**	**11.0%**

3.7. WATER SUPPLY ASSESSMENT

In this section, EP summarizes the capacity of the existing water supply sources and the Town's ability to satisfy current water demands within the community.

The Town currently operates all of their treatment facilities in a sequence that has one facility turning on ahead of the other two facilities. The role of lead treatment facility rotates periodically to even out pump runtimes. The Town routinely maintains and redevelops their wells to produce reliable raw water volume and quality.

To ensure an adequate supply of water during periods of peak water usage, the firm capacity of the system (the supply capacity with the most critical component offline) should match or exceed the

MDD. Table 3.7 lists the treatment facilities alongside their permitted withdrawal capacity and the firm capacity under different scenarios.

Table 3.7 - Treatment Facility Capacities and Firm Capacity Scenarios

Treatment Facility	Supply Wells		Treatment Facility Operational Capacity (MGD)	Firm Capacity (MGD)		
	Name	Capacity (MGD)		TF #3 Off	TF #4 Off	TF #5 Off
TF #3	Well #2	0.65	1.33	0.00	1.33	1.33
	Well #3	0.68				
TF #4	Well #4	0.86	0.86	0.86	0.00	0.86
	Well #6	0.19				
TF #5	Well #5	0.94	0.94	0.94	0.94	0.00
	Totals	**3.13**	**3.13**	**1.80**	**2.27**	**2.19**

In the Town's most recent WMA permit renewal of their Taunton Basin sources, MassDEP increased the allowed withdrawal limit for Well 4 and Well 6. Well 4 is now able to withdraw an additional 0.17 MGD or 117 GPM. Well 6 is now able to withdraw an additional 0.02 MGD or 12 GPM. Although the Town's withdrawal capacity is increased, both wells are currently operating at their maximum operational capacity of 0.86 MGD combined. Improvements are required at TF#4 to be able to pump and treat 1.05 MGD.

The Town's highest producing facility is Treatment Facility #3 at 1.33 MGD. With that treatment facility offline, the maximum treated water supply capacity from all remaining sources would drop to 1.8 MGD, the average MDD of the past 5 years. As currently operated, the Town would not meet water demands with Treatment Facility #3 offline during higher demands or prolonged outages.

3.8. WATER SYSTEM DEMAND FORECAST

While the existing treated water supply sources meet current customer demands, the Town needs to assess projected demands to confirm water supply needs through the 2040 targeted planning year. While evaluating future water demands, EP reviewed historic water-use patterns along with Wrentham's anticipated population and employment projections. The Massachusetts Water Resources Commission (WRC) published the "Policy for Developing Water Needs Forecasts for Public Water Suppliers and Communities and Methodology for Implementation" (Rev. March 9, 2017), which outlined their methodology for demand forecasting through the year 2040. EP implemented this methodology to forecast the Town's customer water demands through the 2040 planning year.

3.9. POPULATION FORECAST

To predict future demands, EP gathered historic population data and population projections. The historic population data came from the Town's ASR reports, which use population numbers from the Wrentham Town Clerk. The Town obtained the population projections from the Massachusetts

Department of Transportation (MassDOT), which released statewide population forecasts in September 2018. The Town provided information from the Clerk's office, which indicates that the actual population in Wrentham in 2020 was higher than forecast by MassDOT in 2018. Table 3.8 presents a summary of the Town of Wrentham population data considered in this review:

Table 3.8 - Historic and Forecasted Population in Wrentham, MA

Estimating Organization	Historic			Forecasted		
	2010	2015	2020	2020	2030	2040
US Census Bureau	10,554					
Wrentham Town Clerk		11,657	12,014			
MassDOT				11,678	12,180	12,654

Currently, the Town plans on serving all Wrentham residents in the future. As such, EP has conservatively estimated the forecasted town population as the future population served by the Town.

3.10. EMPLOYMENT FORECAST

Following residential use, the Town's second largest water use classification is commercial. Similar to their population forecasts, MassDOT provides employment forecasts estimating the number people that will be working in Wrentham. Table 3.9 summarizes this forecast below:

Table 3.9 - MassDOT Employment Projections for Wrentham, MA

Census 2010	MassDOT 2020	MassDOT 2030	MassDOT 2040
5,542	6,510	6,296	6,402

3.11. KNOWN FUTURE DEVELOPMENTS

After reviewing current and future projects with the Wrentham Director of Planning and Economic Development, EP estimated water demands for these future developments and their expected occupancy using 65 RGPCD. The estimates are listed below in Table 3.10.

Table 3.10 - Estimated Daily Demand of Future Developments

Development	Units	Additional ADD (GPD)	Expected Completion
Weber Farm Senior Living Community	55	7,450	2025
Park Place Wrentham	92	16,206	2025
Wrentham Highlands Senior Living Community	46	6,580	2030
Total	**193**	**30,236**	

3.12. DEMAND FORECAST

For demand forecasting, the WRC forecasting methodology requires future residential demands be calculated assuming 65 RGPCD. Using similar reasoning, the WRC methodology requires a UAW assumption of 10 percent each year. Table 3.11 provides a summary of the demand forecast for the years 2020 to 2040 below.

Table 3.11 - Projected Demands in Gallons per Day, 2020-2040

Year	Projected Residential ADD	Projected Non-Residential ADD	Projected UAW, 10%	Known Development ADD	Projected Treatment Plant Losses	Projected Total ADD
2020	759,000	141,000	99,000	-	4,000	1,004,000
2025	776,000	139,000	101,000	24,000	4,000	1,044,000
2030	792,000	137,000	102,000	30,000	4,000	1,065,000
2035	807,000	138,000	104,000	30,000	4,000	1,084,000
2040	823,000	139,000	106,000	30,000	4,000	1,102,000

When forecasting estimated water needs as discussed above, the Town will experience a net increase in water demand of approximately 40,000 GPD between 2020 and 2025 and then 20,000 GPD every five years following that. However, this average, and the values shown in Table 11, only includes demands from known developments. As a result, projections beyond 2030 do not include additional development, with only anticipated increases in population accounting for additional water consumption. Over the twenty-year forecast, EP estimates that the total ADD will increase by nearly 0.17 MGD to 1.10 MGD. Similarly, the projected MDD will increase to 2.13 MGD.

3.13. WATER SUPPLY FORECAST

To ensure an adequate supply of water during future periods of peak water usage, the firm capacity of the system should match or exceed the projected MDD. Figure 1 graphs the projected ADD and MDD below under several water supply scenarios including the loss of Treatment Facility #3.

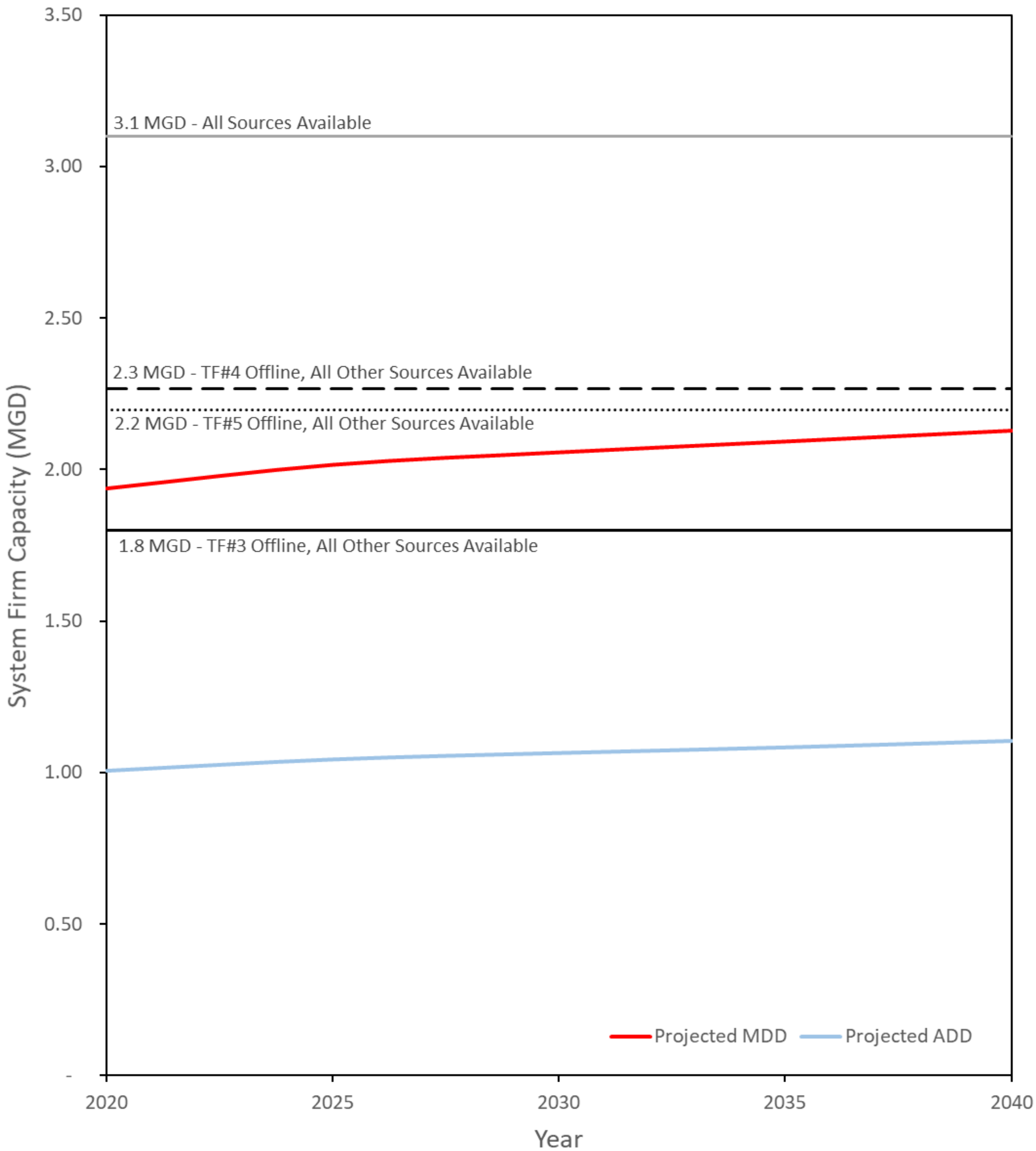

Figure 3-1 - Projected ADD and MDD versus System Capacity with Various Individual Facilities Offline

Under all future MDD conditions, the Town is vulnerable to losing supply from Treatment Facility #3. Starting at a deficit of 0.14 MGD, the supply deficit caused by the loss of Treatment Facility #3 will expand to 0.47 MGD in the year 2040.

With the projected increase in demand in 2040, the loss of either Treatment Facility #4 or Treatment Facility #5 will reduce the available supply to just above the projected MDD. Given the inherent variability in demand, the Town would experience supply deficits under these water supply circumstances as well, if water demands are 10 percent greater than anticipated in the future.

Overall, if operation of a treatment facility is compromised during peak demands, the Town may have difficulty providing a reliable supply of water throughout the 2040 planning period. Under this worst-case scenario, the Town may need to rely on neighboring communities to provide finished water via hydrant-to-hydrant or piped connections. If not done so already, the Town should draft or update standard operating procedures for this scenario with detailed instructions and relevant contact information. Wrentham should reference these standard operating procedures, instructions and contact information in the Water System Emergency Response Plan (ERP) and emergency interconnection agreements.

3.14. RECOMMENDATIONS

Overall, the Town has the ability to meet present and future demands with all of their sources and treatment facilities operational. In the case of a loss of a treatment facility, however, the Town may fail or struggle to meet peak demands both now and in the future. To prepare for emergency scenarios and increased future demands, the Town should pursue new supply sources, improve resiliency at existing facilities, and maintain updated emergency response plans.

Outdoor Water Use Restrictions

With development expected to continue on Route 1 and the Wrentham Center, EP recommends that the Town increase enforcement of water use restrictions, including non-essential outdoor water use. Restrictions for non-essential outdoor water use should be in place from May 1st to September 30th and should limit use to one day per week, before 7:00 a.m. and after 7:00 p.m. on the customers designated trash pickup day. For additional conservation efforts, the Town has implement a water use restriction by-law to help limit non-essential outdoor water use and should initiate land use controls for future developments.

Water System Audit and Conservation Measures

The Town might also consider a water system audit, which would include the top ten water users in the system as a means to conserve water. Through site visits, the Town could survey each facility and discuss water use practices with each user to educate them on water usage and the potential for water savings. The water audit would also include a comprehensive distribution system leak detection survey and should document source meter testing and accuracy. The Town currently tests the accuracy of their source water meters annually.

As discussed during our meeting with the Wrentham Director of Planning and Economic Development, the Town should carefully review the water supply needs of future large residential developments and all commercial and industrial. Specifically, the Planning Board should include water supply evaluations when reviewing all future major developments in Wrentham to assess potential negative impacts on:

- available water supply,
- system pressures,
- available fire protection, and
- existing water customers.

EP has experience assisting other communities with developing and implementing water conservation bylaws and programs and highly recommends this practices to avoid potential negative effects on drinking water supplies.

Prior to the approval of any new development, EP also recommends that the Town require water saving devices that meet or exceed current plumbing codes to minimize water consumption. Options for these devices include water-less urinals and low-flow shower heads. For existing users, the Town could expand its current public outreach and increase customer awareness by providing water-saving devices and rain barrels to the consumers to enhance water conservation. MassDEP provides a list of additional water efficiency practices including irrigation controls, the adoption and enforcement of efficiency ordinances, and adjustments to billing policies in Appendix A of the latest Water Management Act (WMA) permit. With the most recent WMA permit renewal of the Town's Taunton Basin sources, the MassDEP conditions require quarterly billing of all water customers for Wrentham.

Since the water system has historically experienced elevated residential per capita usage, the Town should particularly stress water efficiency on proposed residential developments to maintain compliance with the 65 RGPCD standard. The Town can delay costly capital improvements by implementing or enhancing water conservation and instituting additional water use restrictions.

Potential Water System Improvements

In Section 6, EP has recommended improvements to limit the Town's vulnerability and risk including well improvements, potential emergency interconnections with adjacent water supplies and the planning and implementation of new groundwater sources in West Wrentham. EP highly recommends that the Town investigate additional groundwater supplies in West Wrentham as the primary solution for reducing risk and water supply vulnerabilities. We believe that interconnections would only be a short-term solution because the Town would be relying on neighboring systems for water for emergency water supply. These bordering communities have their own water supply restrictions and their water customers will take priority over water supply to Wrentham residents.

Also, due to current and potentially more restrictive WMA limitations on the basins in eastern sections of Wrentham, we are targeting West Wrentham to provide supply redundancy and reliability to the Town's water customers in the western part of Town. The proposed new groundwater supply source is more sustainable for the health and wellbeing of current residents and would provide additional water supply volume for anticipated future growth and development. EP is also recommending the new source in West Wrentham to create a new high service area to limit water quality concerns caused by current system operations. This proposed remote water supply facility would reduce water age and decrease chlorine concentration during water treatment thereby enhancing water quality throughout the system. Section 6 further describes these recommendation and defines our approach to improve water quality for all water customers.

SECTION 4 - ASSESSMENT OF WATER DISTRIBUTION STORAGE

4.1. GENERAL

Distribution storage provides water for peak demands of short duration, minimizes pressure fluctuations during periods of demand changes in the distribution system, and furnishes a reserve storage volumes for fire protection. Storage may also serve to provide an emergency short-term supply in case of the temporary breakdown of pumping facilities.

Provided within the top portion of the tank, the peak hour demand storage volume typically maintains a minimum pressure of 35 pounds per square (psi) in the distribution system. Beneath this, the fire protection storage volume typically supports a minimum pressure of 20 psi throughout the distribution system during maximum day demands with a coincident fire flow.

As discussed in Section 1.7, the Town has three storage tanks in its distribution system. Table 4.1 provides a summary of pertinent engineering data associated with the Town's water distribution storage tanks.

Table 4.1 – Summary of Distribution Storage Facilities

Tank Name	Material	Year Built	Base Elevation (feet)	Storage Volume (MG)	Diameter (feet)	Height (feet)	Overflow Elevation (feet)
Bucks Hill Tank	Concrete	2000	425.0	0.75	56.5	40.4	465.4
Large Knuckup Hill Tank	Steel	1960	410.0	1.5	72.0	55.0	465.0
Small Knuckup Hill Tank	Steel	1907	413.0	0.25	29.0	51.0	464.0

As presented in the table above, the overflow elevation varies between 464 and 465.4 feet. For this storage evaluation, EP selected 464 feet as the maximum grade line throughout the system to avoid overflow at any tank. The following analysis evaluates peak hour demand and fire-flow storage requirements under current and future demand conditions for the Town's water system.

4.2. USABLE STORAGE

Prior to evaluating peak hour demand and fire flow storage, EP reviewed the usable storage for each of the tanks. In accordance with MassDEP Guidelines for Public Water Systems (Section 8.4.1.3), water systems are required to provide a minimum service pressure of 35 psi (81.2 feet). Based on this metric, the Town's usable storage is the volume of water within a tank that will provide a pressure of 35 psi to the highest customer under static conditions.

EP calculated usable storage based on the maximum grade line (464 feet) and the elevation of the highest customer in the system. Per Town regulations, Wrentham does not allow water service connections to the distribution system for buildings constructed above 410 feet of elevation. For this analysis, EP assumes total compliance with this regulation.

In order to supply 35 psi of water pressure at 410 feet, the tank water level would need to be 490.9 feet. Since this elevation is greater than the maximum tank water level elevation of 464 feet, the system currently provides no usable storage.

4.3. PEAK HOUR DEMAND STORAGE

The amount of distribution storage required to meet peak hour demands is a function of both the maximum daily demand (MDD) and the available pumping capacity. If pumping capacity is equal to or greater than the MDD, the storage required to meet peak hourly demands is estimated to be 30 percent of the MDD, as referenced in the American Water Works Association Manual of Water Supply Practices.

The Town's Annual Statistics Reports (ASRs) data from 2015 to 2019 show an average MDD if 1.80 MGD. As stated above, the peak hour demand is 30 percent of MDD or 0.54 MGD. The Town lacks usable storage within the tanks and therefore provides no available peak hour storage. Although the system still provides sufficient water through their pumped supply, the water system cannot provide peak hour water supply from the tanks as currently operated.

In Section 3.12, EP developed water demand projections and estimated a 2040 MDD of 2.13 MGD. At 30 percent of this MDD, we anticipate the peak hour demand will climb to 0.64 MGD. As demands increase in the future, the deficit of available peak hour storage continues to grow.

4.4. FIRE PROTECTION

The volume of distribution storage necessary for fire protection is based in part on the fire flow requirements established by Insurance Services Office, Inc. (ISO). The ISO establishes fire protection criteria, which are used by insurance companies to set insurance rates. According to ISO standards, a water system is responsible for providing fire flow up to 3,500 gallons per minute (gpm) while any property owners with higher fire flow requirements are responsible for the remainder of the flow. However, a water system may elect to provide additional fire flow to areas with elevated requirements. For this analysis, EP selected the maximum ISO fire flow requirement of 3,500 gpm for a duration of 3 hours (630,000 gallons of water) as the required fire flow.

4.5. USABLE FIRE FLOW STORAGE

During a fire event, water suppliers are required to maintain a 20 psi (46 foot) service pressure throughout the distribution system while providing adequate fire flow. Usable fire flow storage is calculated as the amount of water that will provide a pressure of 20 psi to the highest customer. With the highest customer at an elevation of 410 feet, any stored water above an elevation of 456 feet is considered usable fire flow volume. Table 4.2 shows the usable fire flow storage available in each tank.

Table 4.2 - Summary of Usable Fire Flow Storage by Tank

Tank	Maximum Tank Water Level (feet NAVD88)	Storage Tank Capacity (Gallons)	Usable Fire Flow Storage (Gallons)
Bucks Hill Tank	465.4	750,000	146,300
Large Knuckup Hill Tank	465.0	1,500,000	237,600
Small Knuckup Hill Tank	464.0	250,000	38,500

As presented in the table above, the Town has 422,400 gallons of usable fire flow storage.

Under the requirements listed above, EP reviewed fire flow storage under a worst-case scenario with current MDD demands during the 3-hour period. Table 4.3 below shows the results of this analysis.

Table 4.3 - Fire Storage Analysis – Existing Demands

Usable Fire Flow Storage (Gallons)	Fire Flow Storage Required (Gallons)	3 Hour Demand (Gallons)	Fire Flow Storage Surplus or *(Deficit)* (Gallons)
422,400	630,000	242,300	*(450,000)*

Even without considering depletion from demands, the water system does not provide adequate available fire flow storage. When you include demands, the resulting fire storage deficit is 450,000 gallons. Although the Town would be able to sustain fire flow events with lower flow or for shorter periods, they are unable to meet the requirements set forth by the ISO.

Using projected MDD, EP calculated the projected fire flow storage using the same conditions in the year 2040. With increased peak demands in 2040, the fire-flow storage deficit increases to 473,600 gallons. Table 4.4 shows the results of this analysis.

Table 4.4 - Fire Storage Analysis – Projected Demands

Usable Fire Flow Storage (Gallons)	Fire Flow Storage Required (Gallons)	3 Hour Demand (Gallons)	Fire Flow Storage Surplus or *(Deficit)* (Gallons)
422,400	630,000	266,000	*(473,600)*

4.6. CONCLUSIONS AND RECOMMENDATIONS

The Town is lacking both usable and fire flow storage. Although regulations limit high elevation development, the Town has no usable storage and the volume available above 456 feet is not adequate to supply a large fire-flow event.

To address this, the Town should install a new storage tank to increase fire flow storage. The location that makes the most sense for a new tank is Knuckup Hill. The hill already has the necessary infrastructure and site access for a storage tank and the Town owns the majority of the land as well. The Town might also consider demolishing the existing 250,000-gallon tank on Knuckup Hill at the same time. The Town has kept this tank in good condition since its installation in 1907 and it has surpassed its design life of 60-80 years. A thorough inspection could determine if keeping the tank is advisable or if demolishing it alongside the new tank would be worth the cost savings.

Another project for the Town to consider is installing altitude valves on the Knuckup Hill tanks. The hydraulic restriction along West Street causes the Bucks Hill Tank level to be several feet lower than the Knuckup Hill Tanks. Therefore, to fill the Bucks Hill Tank, the Town would need to overflow the Knuckup Hill Tanks. To better utilize their existing storage volume, the Town could use altitude valves to shut the Knuckup Hill Tanks and continue to fill the Bucks Hill Tank. However, the Town would only realize a slight increase in the hydraulic grade line in West Wrentham by installing an altitude valve at the Knuckup Hill Tanks. As discussed in Sections 3 and further defined in Section 6 (Recommended Improvements), EP recommends creating a high service area in West Wrentham to increase pressures in the western portion of Town while also moderating and reducing pressures on the east side of Wrentham.

The Town should also meet with the Wrentham Department of Planning and Community Development and discuss including a water supply evaluation requirement for all new developments in their regulations. EP recommends that this water supply review requirement be included in the Special Permit and Site Plan Approval process. With this approach, the Planning Board can confirm that the Town's water system can provide adequate water supply volume, proper pressures and acceptable fire protection for the new development without adversely impacting water supply to the existing customers. By implementing such a planning requirement, the Town can use the calibrated hydraulic model to confirm that all current and new customers will receive acceptable water pressures and fire protection prior to construction.

SECTION 5 - WATER DISTRIBUTION HYDRAULICS AND CONTROL STRATEGIES ASSESSMENT

5.1. EXISTING WATER SYSTEM CONTROLS

Following discussions with Town personnel, EP has prepared this section to document and assess current water system operations and controls. The Town uses a hierarchical control set that activates additional sources as the water level in the controlling storage tank falls. Periodically, the position of the wells rotates to rest the lead well and equalize pump run times. Because TF#4 is unable to provide proper treatment of only flow from Well 6, Well 4 and Well 6 are assigned the same position. Table 5.1 presents the current control set points for the wells.

Table 5.1 - Summary of Typical Summer Controls

Position	Controlling Element	On Set Point	Off Set Point
1	Knuckup Hill Tank or Bucks Hill Tank	47.0′	51.0′
2	Knuckup Hill Tank or Bucks Hill Tank	45.0′	47.5′
3	Knuckup Hill Tank or Bucks Hill Tank	44.0′	46.0′
4	Knuckup Hill Tank or Bucks Hill Tank	42.5′	44.5′
5	Knuckup Hill Tank or Bucks Hill Tank	41.0′	43.0′

The Town can use either the Bucks Hill Tank or the Knuckup Hill Tank as the controlling element in the system. However, given the hydraulic restrictions that limit the ability of the Town to fill the Bucks Hill Tank, the Town almost exclusively utilizes the Knuckup Hill Tank. Currently, the Town uses all sources to help meet demands in Town.

5.2. FIRE FLOW AVAILABILITY EVALUATION

As mentioned in Section 4.4, the ISO publishes guidelines on fire flow requirements. In addition, they also routinely visit Towns to perform field-testing of fire flow availability at a group of predetermined locations. Following testing, they compare the field data to the required fire flow is at each location and the Town receives a Public Protection Classification rating.

In Wrentham, the most recent ISO fire flow testing occurred in 2005. During this round of testing, the ISO found four of the fourteen locations that did not meet the required available fire flow at a residual pressure of 20 psi. However, a water system is only responsible for providing fire flow up to 3,500 gallons per minute (gpm). As such, although Test 14 did not meet the total required fire flow availability, the distribution system provided the required 3,500 gpm.

Using the calibrated model, EP calculated the expected fire flow availability at the fourteen test sites given current conditions. To represent worst-case conditions, EP assumed that storage tanks levels were half-way down their drain cycle and all pumped sources were offline. EP then compared the model results with the reported fire flow availability from the 2005 ISO report. Table 5.2 below shows the fire flow needed, the fire flow measured, and the fire flow modeled at each of the fourteen test sites.

Table 5.2 –ISO Fire Flow Test Locations – ISO Field Measured versus Modeled Fire Flow Availability

Test No.	Test Location	Available Flow @ 20 PSI (GPM)		
		Flow Required	Flow Measured	Flow Modeled
1	Park Street @ Warren Drive	500	3,000	4,400
2	Shears Street @ Short Street	1,500	7,300	2,720
3	Cushing Drive @ Dedham Street	1,750	3,900	5,370
4	Everett Street @ East Street	500	3,000	3,560
5	Myrtle Street @ Thurston Street	500	7,400	10,550
6	Route 1 @ Commercial Drive	2,000	2,100	5,520
7	Taunton Street @ Beech Street	750	450	4,600
8	East Street @ Common Street	3,500	3,800	12,990
9	South Street @ Wrentham Village Outlets	8,000	3,100	**5,630**
9A	South Street @ Wrentham Village Outlets	1,000	3,100	5,630
10	West Street @ Hancock Street	2,000	2,600	6,260
11	West Street @ Ash Street	500	850	1,050
12	Creek Street @ Lakeside Avenue	4,500	4500	7,370
12A	Creek Street @ Lakeside Avenue	3,000	4500	7,370
13	Industrial Road @ Franklin Street	1,750	450	4,730
14	Franklin Street @ High School	5,000	**3,500**	8,150

A review of the model results suggests that Wrentham's water system can provide either the required fire flow or at least 3,500 gpm to each of the fourteen test sites. In general, the available fire flow from the model is higher than what ISO measured. Since the last ISO testing in 2005, the Town made several distribution improvements that are reflected in the current hydraulic model, which more accurately represents existing water system hydraulic conditions. In addition, standard hydrant flow tests use the pressure drop that occurs from the measured flow to extrapolate how much flow is available at 20 psi of residual pressure.

Of the fourteen tests, EP simulated fire flows at two locations (Test 7 and Test 13) using the Town's hydraulic model, which had available fire flow that were significantly higher than measured in the field:. For both tests, significant distribution upgrades are responsible for this increase in available fire flow. For Test 7, the Town replaced the existing 8-inch cast iron water main on Taunton Street with 12-inch ductile iron in 2009. For Test 13, the Town improved flow to this area by installing new

12-inch ductile iron mains along Elysium Street, Eagle Brook Boulevard, and Black Birch Drive and by replacing some existing 6-inch cast iron mains as well.

Outside of the ISO test sites, the Town's system exceeds fire flow availability requirements with the exception of a few small, localized areas. Because house spacing in Wrentham is generally 30 feet or more, the required fire flow in residential areas is 500 GPM according to ISO needed fire flow requirements for 1- and 2-family dwellings. Based on hydraulic modeling results, EP determined that 98.3 percent of the system receives at least 500 GPM of available fire flow with 82.3 percent having the maximum residential requirement of 1,500 GPM available. In general, eastern Wrentham has a surplus of fire flow availability whereas fire flow availability decreases the further west in the system as ground surface elevations increase.

The remaining 1.7 percent of the system that does not have at least 500 GPM generally falls into two categories: long dead-end, cast-iron mains and high elevation areas. There are also two hydrants fed by 4-inch cast iron mains, 349 East Street and 69 Arnold Street, which have less than 500 GPM of available fire flow. Figure 5.1 shows the locations of these locations with deficient fire flow, which are depicted by the orange (250 to 500 GPM) and red (0 to 250 GPM) circles.

In the eastern portion of Wrentham, Gilmore Road off Creek Street has deficient fire flow due to the dead-end CI main on Gilmore Road. The Town can improve fire flow in this area by replacing the cast iron main with new ductile iron and/or eliminating the dead end by looping Gilmore Road to the nearby water main on Metacomet Street.

In west Wrentham, there are three areas where high elevation limits fire flow availability: the streets near the Bucks Hill Tank, the neighborhood near the old Ray Road Tank, and Oak Hill Avenue near Summit Circle. All three of these areas experience less than 500 GPM of available fire flow at 20 psi. For the hydrant at the end of Rhodes Drive and the hydrant on Crowley Drive, the Town's water system provides less than 250 GPM of available fire flow.

In general, West Wrentham receives limited fire flow availability due to higher elevations and distance from the system's water supply sources, which reduces the hydraulic grade. Therefore, at the highest elevations in this area, the West Wrentham water customers will likely experience water pressures below 20 psi during a fire emergency at higher elevation in their neighborhood

The Town could improve water service and fire flow availability by adding a source in West Wrentham.

5.3. WATER DISTRIBUTION HYDRAULICS AND CONTROL STRATEGIES ASSESSMENT

EP assessed the hydraulic performance of the distribution system during both ADD and MDD conditions utilizing current demand scenarios. For the hydraulic analysis, we evaluated the ability of the Town's water supply system to provide adequate system pressure and storage tank water turnover, as outlined in the MassDEP Guidelines for Public Water Systems. The analysis does not include anticipated demands from the proposed developments throughout the Town of Wrentham, which will be evaluated with recommended improvements in place under future water demand scenarios.

Pumped Supply

Under the Town's control set, the operation of all existing wells depends on their assigned position in SCADA. As the tank levels drop, the wells turn on in the order assigned by operators and then, as the tank levels rise, the wells begin turn off in the reverse order. As such, the source(s) in the first position will run the most each day with each successive position running for fewer hours. Under average day demands (ADD), tank levels may not drop enough to activate the wells in the lower positions. However, the Town normally activates all sources during the summer and maximum demand conditions.

System Storage

Storage levels fluctuate throughout the day as system demands drain the system's storage tanks and supply sources refill them. Furthermore, system hydraulics and proximity to supply sources affects water level changes in each storage tank. The level in the storage tanks influences pressures and fire flow availability throughout the distribution system. Dropping the tanks too low can lead to dangerously low pressures and fire flow availability. However, maintaining higher water surface elevations can lead to stagnation in the storage tanks, which increases water age, decreases residual disinfection, and promotes disinfection byproducts. The Town has been proactive in addressing water age by installing mixers in each of their storage tanks. These devices mix the water within the tank to prevent stagnation and aging water at the top of the tank.

Under ADD conditions, the Bucks Hill Tank and the Knuckup Hill Tanks follow generally the same trend. Over the course of 24 hours, the tanks experience one draw and one fill cycle. The peaks of each of these fill lines is softened by the gradual increase and decrease of active supply sources. Because the Knuckup Hill Tanks are located closer to the supply sources, they fill quicker than the Bucks Hill Tank. Additionally, there are multiple paths from the supply sources to the Knuckup Hill Tanks whereas flow to the Bucks Hill Tank is restricted to travelling an additional four miles down West Street.

Under MDD conditions, the supply sources struggle to fill the tanks throughout the day when customer water demands are highest. The water sources are only able to fill the storage tanks during the nighttime hours. Additionally, during certain supply scenarios, the discrepancy between the two storage areas is exacerbated when the water surface elevations in the Knuckup Hill tanks are two feet higher than the Bucks Hill Tank.

The daily tank turnover is defined as the volume of water that a storage tanks fills and drains each day. With minimal storage turnover, water in the distribution system will age, thereby decreasing quality. The Town's storage tanks currently turnover about 9 percent of their water each day. Because the tanks are fully mixed, that daily turnover percent represents how much water from a single day is removed from the tank each day (i.e. if 100 percent of the water was put in on day one, on day two the water would be 91 percent day one water and 9 percent day two water).

Using this model, EP determined that the average water age will be about 10.1 day in the storage tanks. Minor adjustments in tank controls could enhance operation, help reduce water age and enhance water quality. For example, with an additional foot of drawing and fill, the Town would increase turnover to 11 percent and decrease the average age to eight days. By adjusting and optimizing tank control levels, the Town can reduce water aging in the storage tanks, which reduces disinfection byproducts (DBPs) formation and enhances water quality for its customers.

System Pressures

According to MassDEP Guidelines for Public Water Systems Section 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 operating conditions. Additionally, the Town must maintain a minimum residual water pressure of 20 psi at all times, even during a fire event.

Figure 5.2 shows the maximum pressures throughout the distribution system under existing average day demand conditions. EP used the calibrated hydraulic model under normal operating conditions and determined that the majority of the system (74.6 percent) experiences maximum pressures over 80 psi. At these pressures, the Town has and will continue to require that these houses be equipped with necessary pressure reducing valves to prevent potential damage to internal plumbing fixtures and appliances. When pressures exceed 120 psi, there is a greater threat and danger of distribution system pipes breaking and/or leaking.

Currently, the Town's distribution system only has one area where pressures exceed 120 psi. This location is on Madison Street at the Plainville Line on the east side of Route 1 where the ground elevation drops to 180 feet. At such high pressure, the Town increases the risk of pipe failure and the Town indicated that this 6-inch, cast iron water main has failed with breaks and leaks on several occasions. Therefore, the Town should replace this water main and ensure that water services on this stretch of main are properly equipped with pressure reducing valves.

Figure 5.3 shows the modeled minimum pressures in the system under existing average day demand conditions. Under normal conditions, only 2.7 percent of the system experiences pressures under 35 psi. While this is a small portion of the system, these low-pressure areas affect the Town's usable storage and available fire flow as previously discussed. These low-pressure areas are exclusively located in West Wrentham.

Conclusions

Overall, West Wrentham is the largest point of weakness for the Town's water system where customers experience both low service pressures and limited fire flow availability. One solution to these issues would be to create a high service area encompassing West Wrentham. As discussed earlier, EP evaluated the ability of the Town's water system and storage tanks to meet peak hour demand and fire protection volumes while also maintaining a residual pressure of 35 psi and 20 psi to all customers during these respective demand conditions. We confirmed that the system, as currently configured, is insufficient to meet peak hour demand and fire flow requirements. These inadequacies are largely due to the higher elevation areas served in West Wrentham rather than undersized tanks. It should be noted that more recent developments in West Wrentham at higher elevations were constructed after the storage tanks, which established the available maximum hydraulic grade line (HGL).

By creating a high service area in West Wrentham, the Town would increase the water pressure and elevate the hydraulic grade to improve service pressures under normal operations and improve residual pressures during fire events. This high service area could either focus solely on improving service to existing customers or be designed to potentially to expand the Town's customer base by extending the system to neighborhoods where houses are located above 410 feet.

To maintain acceptable pressures in West Wrentham, the Town currently operates the tanks with minimal fluctuations in the water surface elevation and this is not an efficient or effective water supply practice. By implementing the West Wrentham high service area, the Town could also optimize operation of the existing storage tanks by allowing the great fluctuation in storage tank water surface elevations. With great drops in the storage tank elevations, water will circulate more efficiently in the tanks and distribution system thereby enhancing fire protection, reducing water age and improving water quality.

The Town could create a smaller, targeted high service zone in the neighborhood surrounding the old Ray Road Tank including Ray Road, Heather Lane, and Crowley Drive, which all experience low pressures and low fire flow availability. However, implementing a boosted zone with an elevated storage tank for this small area of the Town would be cost-prohibitive.

If the high service area were designed to allow for expansion of the water system into high elevation neighborhoods, the Town could potentially benefit from additional customers and revenue. The new customers would benefit from both clean drinking water as well as fire protection. To avoid potentially increasing existing customers' water pressure to levels where leaks are more common and household PRVs are required, the design of the high service area will need to prioritize meeting the needs of the existing system.

Recommendations

EP recommends establishing an area in West Wrentham with an elevated HGL, which will be isolated from the low gradient on the east side of Town to provide the required pressures and fire protection throughout Wrentham. As defined earlier, the ideal solution would be establishing a new groundwater source in West Wrentham and constructing an elevated storage tank to meet peak hour demand and fire protection volumes while also maintaining acceptable residual pressures.

To understand the practical extent of a new pressure zone, EP recommends the Town perform a boosted pressure zone study. This study will identify the extents of the new pressure zone along with the required infrastructure and associated cost. The study should also include a cost/benefit and payback period analysis comparing a smaller zone serving existing customers to a larger zone that encompasses new neighborhoods not currently served. With a better understanding of the feasibility, the Town can then make an informed decision as to whether either option is right for their system.

SECTION 6 - RECOMMENDED IMPROVEMENTS

6.1. OVERVIEW

In Section 6, EP presents the recommended Capital Improvements Program (CIP). This program details each project that should be implemented over the next 20 years along with an associated planning-level opinion of probable cost. The Town should strictly follow the CIP to properly maintain and improve its public water system.

6.2. OPINION OF PROBABLE COSTS

The estimated capital costs presented represent the opinion of probable costs (OPC) for the construction and/or implementation of each project, include a 20 percent allowance for engineering services, and are typical for public works projects. These engineering services include preliminary study, design, permitting, bidding assistance, construction administration, resident project representation, and record drawing services. The OPC also include a 25 percent contingency to account for planning level estimates and unforeseeable factors that may affect cost such as inflation and market conditions.

EP estimated water main improvement projects based on a cost per linear foot. All of these costs are current as of July 2021 and are based on recent bid results for water main projects in communities in eastern Massachusetts. The future use of this cost data must be adjusted accordingly. The new water main unit costs include the material costs for piping and appurtenances (valves, hydrants, etc.), installation, paving and appurtenant items required for a complete project. Unit costs for the construction of water main projects include all costs associated with traffic control and police detail requirements necessary to complete such work. Engineering and contingency allowances are also included. Table 6-1 presents the unit costs for construction items and are based on recent bid tabulations for similar projects.

Table 6.1 - Unit Costs for Water Main Projects

Pipe Size	Units	$ / Unit	Engineering, Design, and Resident Observation	Contingency	Total ($ / Unit)
6-inch	L.F.	$200	20 percent	25 percent	$295
8-inch	L.F.	$210	20 percent	25 percent	$305
10-inch	L.F.	$215	20 percent	25 percent	$315
12-inch	L.F.	$220	20 percent	25 percent	$320

Sections 6.3 through 6.6 present the four phases of the CIP alongside the OPPC for completing the recommended improvements. Section 6.7 provides a summary of costs for the entire CIP.

6.3. PHASE I (2021 – 2025)

6.3.1. Comprehensive Water Audit and Leak Detection Survey

The Town has recently experienced large volumes of unaccounted for water within the distribution system. As such, MassDEP regulations require that the Town perform a water audit to review potential sources of unmetered consumption and adequacy of existing customer meters. In the Town's Water Management Act (WMA) permit dated March 17, 2021, MassDEP provided conditions on its approval for groundwater withdrawals at Wells 4 and 6. Special Condition No. 6 states that Wrentham must initiate a comprehensive water audit within one year of its WMA permit issuance. The water audit must follow the requirements of the documents in the "*AWWA Water Audits and Loss Control Program, Manual of Water Supply Practices, M36*".

Additionally, during this study, the Town should contract with a leak detection firm to locate leaks through the distribution system. The results of this study will outline where possible leaks are occurring and allow the Town to target these areas with water main improvement projects.

6.3.2. Well 3 Emergency Improvements

In early November 2021, the screen for Well 3 failed during redevelopment. Since Maher Services was on site for the redevelopment, the Town extended their contract to perform emergency repairs on the well screen; however, the improvements were only temporary. Maher recommended that the Town replace Well 3 soon to avoid potential total collapse of the well and screen.

Therefore, EP recommends that the Town conduct a groundwater source site-screening program near Well 3 to site the replacement well and enhance the new well capacity to the permitted flow rate of 475 gpm. The results of this site screening process will help the Town identify the most cost effective and efficient approach to replacing this existing permitted raw water source.

After completing the groundwater source site-screen program, the Town can select the site for the replacement of Well 3. Following MassDEP's approval of the pump test and replacement well report, the Town would the design and construct the connection of replacement Well 3 to the water system.

6.3.3. Chemical Feed System Improvements

The existing treatment facilities require improvements to the chemical storage and feed systems to improve operations and resiliency. The Town cannot utilize any of its NaOCl bulk storage tanks because of leaking pipes, faulty transfer pumps, or because they are oversized (allowing chemical to degrade due to age). Instead of using these tanks, the operators utilize NaOCl stored in 55-gallon drums on top of chemical spill trays. To transfer NaOCl to the day tanks, the operators manually feed the chemical with stick pumps. Under these operating conditions, operators are at increased risk of exposure to the chemical.

EP recommends that the Town install updated NaOCl storage and transfer systems at all treatment facilities to improve operations and limit the potential for operator injury. By installing new, adequately sized bulk tanks, the Town will provide a suitable amount of NaOCl that balances chemical degradation from age and allows for more cost effective bulk chemical deliveries. By replacing the day tanks, the operators will need to fill the tank less frequently and new transfer pumps will reduce the operator exposure to chemicals. By implementing these upgrades, the Town will promote operator safety, improve treatment facility reliability, save time, and reduce chemical costs.

At TF#3, EP observed that the KOH bulk chemical storage tank is significantly undersized. In the past, operators have resorted to filling the tanks above the maximum fill line to keep up with the chemical demand. Meanwhile, the NaOCl bulk tank is not utilized because it is oversized. As discussed previously, both chemicals are located within separate containment areas formed by CMU walls; however, separate containment storage is not required because the two liquids are non-reactive. Given these conditions, the Town should combine and/or extend their chemical containment areas to allow for a larger KOH bulk tank, which will help reduce the frequency of chemical deliveries, limit equipment runtime, and maintain adequate supply of chemicals for continuous operation of the treatment system. While installing this new tank, the Town must remove the roof of the treatment facility. Since the roof is showing signs of deterioration due to age, EP recommends replacing the roof while installing the new storage tanks.

6.3.4. West Wrentham Groundwater Study and New Source Development

The Town and EP discussed the concerns about MassDEP limiting future withdrawals from the stressed Charles River Basin. The Town's primary and highest capacity wells are located in this basin and are scheduled for renewal next year (2022). Due to potential WMA source water withdrawal restrictions along with an ever-growing list of potential emerging contaminants and associated new water quality requirements, the Town has concerns about potential future limitations of its existing water supply facilities. With the continual increase in the demand for water, the Town is already approaching their current registered withdrawal rates and may need to limit future growth if the current Charles River Basin withdrawals are reduced in 2022.

Additionally, as mentioned throughout the report, a single water main break west of Route 495 could isolate a large portion of the distribution system from the Town's supply sources. To provide supply redundancy and improve resiliency throughout the distribution system, EP strongly recommends installing a new source in West Wrentham. By constructing emergency interconnections, as discussed above, and investigating a potential new groundwater source in West Wrentham, the Town can increase the reliability of its water system thereby maintain water supply to vulnerable customers south and west of Route 495.

This recommendation would also provide supply flexibility and increase the hydraulic grade line and service pressures in West Wrentham. As mentioned previously, the level in the Buck's Hill Tank and the hydraulic grade in West Wrentham is lower than the Knuckup Hill Tanks due to headloss along West Street. Adding a supply in West Wrentham could help improve the hydraulic grade locally and allow Bucks Hill Tank to fill more. If the Town were to create a higher-pressure zone to supply higher elevations and more customers with water supply and fire protection, the new source in west Wrentham could provide water to this zone.

The best location for a new source would be on a parcel currently owned by the Town. Ideally this parcel would encompass the entire Zone I area of well, reducing the cost and complexity of the project.

EP recommends that the Town conduct a new groundwater source site-screening program. In previous studies, Wrentham investigated potential locations for future groundwater sources in western and southern areas of the Town. Due to the limitations of its existing supplies in the eastern portion of Wrentham and limited supply redundancy in West Wrentham, the Town should renew and intensify efforts for siting new groundwater sources in West Wrentham at the following potential locations (see Figure 6.1):

- Burnt Swamp Conservation Area (Town Owned Land)
- Miscoe Lake Area
- The Preserve at Oak Hill Conservation Area (Town owned land off Oak Hill Avenue)
- Franklin State Forest off West Street and Ash Road (Both Town and State owned land)
- Birchwood Farm Conservation Area (Town Owned Land)

A typical site screening protocol includes the following tasks:

- Performing an initial desktop screening, including an initial screening of geologic conditions, land use, and aquifer productivity,
- Assessing the proximity of potential sites to environmental receptors, such as Wetland Resource Areas and other sensitive sites, and
- Determining potential sources of contamination.

With the MassDEP permitting requirements, EP cautions that a new source approval process is an extensive and detailed process with an estimated duration of up to five years. The Town would need to perform the following work to properly identify, permit, design and construct a new well source in West Wrentham:

- Phase 1: Groundwater Exploration for Potential New Sources
- Phase 2: Submit Massachusetts Department of Environmental Protection (MassDEP) Bureau of Resource Protection (BRP) Water Supply (WS) Permit 17 – Request for Site Exam/Pumping Test Proposal
- Phase 3: Conduct 5-day or 15-day Pumping Test
- Phase 4A: Submit BRP WS 19: Approval of Pumping Test Report for Source of 70 Gallons per Minute or Greater
- Phase 4B: Submit Water Management Act (WMA) Permit Application

- Phase 4C: Submit MEPA Environmental Notification Form (ENF)
- Phase 4D: Develop a cost estimate to construct the new source
- Phase 5A: Submit BRP WS 20: Approval to Construct Source
- Phase 5B: Submit NOI for new facilities
- Phase 6: Public Bidding for Construction of Facilities
- Phase 7: Construction of Facilities
- Phase 8: Notify MassDEP when Construction is Complete
- Phase 9: Facility Start-Up and Commissioning
- Phase 10: MassDEP Site Inspection and Approval
- Phase 11: Final Source Approval

By performing this new site screening process, Wrentham can identify the most cost effective and efficient approach to expanding the Town's available water supplies, help secure a reliable supply of water for years to come, improve water service to customers in West Wrentham, and expand the water distribution system to currently unserved areas.

6.3.5.Unidirectional Flushing Program

The development and use of an optimized distribution system unidirectional flushing program is an essential component for every public water supply system. According to operators, the Town last developed a flushing program over 15 years ago. To keep up with water system improvements, the Town has had to physically mark up and adjust the plans based on experience and recent modification to the distribution system. As such, the current plan is inefficient in its layout and may not be producing adequate velocities to scour water mains. To ensure the flushing program is both efficient and effective, EP recommends that the Town optimize their flushing program using the calibrated hydraulic model.

EP has worked with many water suppliers to develop unidirectional flushing (UDF) programs using hydraulic modeling. This process increases flushing efficiency by minimizing valve closures while optimizing flushing velocities. With an optimized UDF program, the Town can systematically flush select fire hydrants to remove (by scouring) accumulated sediment and pipe tuberculation from within the distribution piping network. If a flushing program is not properly designed, the hydrant flushing simply stirs up and moves deposits from one area of the system to another. This ineffective approach to distribution system flushing can result in water quality issues and serious customer complaints. This is especially concerning given the large amount of dead-end water mains in Wrentham where water travels slowly allowing for greater buildup in the pipes. In order to physically remove or "flush" the deposits from the water main, the velocity of the water must be relatively high, typically between 2.5 and 5 feet per second. When properly executed on a regular basis, the proposed UDF program will result in improved water quality and provide incremental increases in the hydraulic capacity of the Town's water mains.

The general project scope for developing a flushing program is as follows:

1. Meet with Town staff to discuss normal flushing schedule, system constraints, areas of poor water quality, hydrants that are inoperable or cause flooding, if flushed, and work force availability.
2. Develop a unidirectional flushing program using the Town's recalibrated hydraulic model to create flushing zones.
3. Prepare mapping of the flushing zones showing the sequence of flushing hydrants, with a plan for each zone documenting the direction of flow, water main diameters, flushing hydrants and required valve closures.
4. Provide written directions for each zone plan, including operation instructions for each well station during flushing.
5. Develop spreadsheets for each zone, which will include hydrants to flush, approximate flushing time and expected flow rate.
6. Meet with Town staff to review flushing program.
7. Provide electronic file copies (in pdf format) of the complete unidirectional flushing program after receipt of the Town's comments.
8. Provide field training for the unidirectional flushing program implementation with Town staff.

6.3.6. Water and Stormwater GIS Needs Assessment

As the industry begins to utilize more digital platforms, the Town expressed a need to update their current water distribution system mapping to a Geographic Information Systems (GIS) platform. With the current GIS mapping software, the Town will have a valuable tool that not only shows graphically how the system is connected, but can also be used to connect useful information like pipe age, material, break history, and condition to each individual feature. The Town can also use the GIS mapping with its newly calibrated hydraulic model to best represent actual piping data and hydraulic conditions throughout the system.

Currently, the Town has a GIS map of their hydrant locations and a shape file showing their water mains. While the hydrants are accurate, the water main shape file does not show the water mains in their true locations and may not show accurate connectivity. To enhance this available data, EP recommends that the Town locate the water gate valves throughout the system using global positioning system (GPS) technology. These valve locations will help determine the layout of mains below grade while also allowing operators to determine how they can isolate sections of water main for repairs.

Because the creation of a UDF program relies on accurate mapping of water system infrastructure, EP recommends that the Town develop its water system GIS alongside the proposed unidirectional flushing program described above. In addition, as operators complete the UDF program, they may be able to log leaky hydrants, inoperable valves, and other maintenance items using the GIS platform. Thus, the Town could benefit by completing both projects at once.

The Town also wishes to develop geographic information System (GIS) mapping for the Town's existing stormwater system. EP believes that the Town has spatial locations for all of the manholes, catch basins and outfalls in the stormwater system but we will need to confirm the form and accuracy of this data.

Since more information is needed to confirm the available data and information, we recommend performing an initial GIS needs assessment so EP can confirm the Town's goals and needs for the proposed water and stormwater GIS platform. Therefore, EP recommends that Wrentham perform a GIS needs assessment, which will include:

- establishing the GIS mapping goal,
- reviewing your existing data,
- assessing potential computer hardware and software
- confirming which Town officials will access, maintain and update the GIS, and
- recommending an efficient and effective approach to developing the Town's GIS platform

6.3.7. Well 4 Improvements

In the Town's most recent WMA permit renewal of their Taunton Basin sources, MassDEP increased the allowed withdrawal limit for Well 4 and Well 6 to 0.86 MGD and 0.19 MGD, respectively. Although an increase in the Town's withdrawal capacity is welcome, both wells are currently operating at their maximum capacity so the Town cannot benefit from these increases in permitted capacities. In addition, the Town has expressed concerns about the condition and operating capacity of Well 4 and believe that the existing well casing and/or screen is damaged.

Therefore, EP recommends that the Town conduct a groundwater source site-screening program near Well 4 with the goal of replacing the damaged existing well with a new, higher capacity well. The results of this site screening process will help the Town identify the most cost effective and efficient approach to expanding the Town's available water supply and benefit from the recently increased WMA permitted capacity.

After completing the groundwater source site-screen program, the Town can select the site for the new replacement for Well 4. Following MassDEP's approval of the pump test and new well replacement report, the Town would the design and construct the connection of replacement Well 4 to the water system thereby increasing its capacity to the new higher withdrawal rate of 0.86 MGD.

6.3.8. Emergency Interconnections

As discussed in Section 3, the Town could fail to meet demand with their supply sources if they were to lose TF#3 during a period of maximum demands. To address this potential loss of source water supply, EP recommends increasing the Town's available supply sources. However, the new groundwater source development process takes several years, thereby leaving the Town vulnerable to limitations in water supply. To quickly address this concern, we recommend that the Town develop interconnections with neighboring water systems to help supply water in emergency scenarios. Wrentham could develop emergency interconnections with two neighboring water systems: Bellingham and Franklin. Ideally, these interconnections would be located in the western portion of Wrentham to provide supply redundancy to customers if West Wrentham becomes isolated from the Town's supply sources.

Depending on the hydraulic grade difference between the two systems, this connection could flow by gravity or require pumping. If Franklin and Bellingham wish to receive water supply from Wrentham through the proposed interconnections, Wrentham may consider working with the Towns by developing interconnections that supply both systems during emergencies with a combined pump and gravity flow station. Although temporary interconnections setups are possible, EP recommends permanent installations in case the Town needs to rely on either of these interconnects for an extended period. The design of either interconnection should include considerations for the potential for west Wrentham to be a high service area.

Bellingham Interconnection

Located to the west of Wrentham, the Town of Bellingham could supply water to the Town during a water supply emergency. The two distribution systems are located close to one another, making an interconnection more feasible and affordable. While communicating with Bellingham officials and reviewing their distribution system mapping, EP learned that an emergency interconnection could be established at Locust Street in Bellingham near Luke Street in Wrentham and Wrentham Road in Bellingham, which becomes West Street in Wrentham.

At the town line, Bellingham's 8-inch water main on Locust Street is within 20-feet of the 8-inch ductile iron pipe on Luke Street in Wrentham where the Town owns two parcels of land. For the potential West Street emergency interconnection, Wrentham would need to extend the existing 12-inch main an additional 1,000 feet. Unlike the potential Luke/Locust Street connection, neither town owns any parcels in this area.

To determine the feasibility of a Wrentham-Bellingham interconnection, EP performed flow tests with the Bellingham DPW on both Locust Street and Wrentham Road. We found that the hydraulic grade in Bellingham in these areas is around 437 feet. In Wrentham, the hydraulic grade in the same area is around 455 feet. Therefore, the Town would need to install a pump station to access water from Bellingham. According to our hydrant flow tests, Bellingham could provide up to 1,500 gpm at either site without pulling pressures below 20 psi. Bellingham would need to simulate emergency supply to Wrentham in their hydraulic model to confirm any potential adverse impacts to its system and supply to its customers before Wrentham can confirm this interconnection as a viable alternative supply source.

Franklin Interconnection

Located to the north and west of Wrentham, Franklin is another neighboring community that could supply water to the Town in case of an emergency. However, unlike the potential Bellingham interconnections, the two water systems are not in close proximity to one another in west Wrentham. To connect the two systems, EP has proposed replacing the existing 4-inch cast iron main on Arnold Road and extending it to the Franklin town line. In total, this would be about 3,750 feet of 12-inch water main. This recommended water main would provide Wrentham with an additional supply source for emergencies while also expanding the Town's current customer base and addressing existing fire flow deficiencies on Arnold Road due to the condition and small diameter of the existing pipe. EP has discuss the fire flow deficiency on Arnold Road in more detail in Section 6.4.1 below.

EP was able to work with the Town of Franklin to determine available flow at the proposed interconnection. Using their own hydraulic model, they determined that Franklin could potentially provide 0.5 MGD for consistent use and up to 1.5 MGD for emergency use. Franklin indicated that the hydraulic grade is about 455 feet in their distribution system at the proposed interconnection site. In Wrentham, the hydraulic grade in the same area is also around 455 feet. Given how close the two hydraulic grades are, both towns would need to install a pump to access water from the other. If Arnold Street were to be included in the high service area, pumping would only be required to get water from Franklin to Wrentham.

6.3.9. Opinion of Probable Cost

For the projects listed above in Phase I, EP has prepared the following opinion of probable costs:

Table 6.2 - Phase I Opinion of Probable Costs

Phase I Improvements - Years 2021-2025		
1	Water Audit and Leak Detection Study	$55,000
2	Well 3 Exploration and Replacement Improvements	$1,100,000
3	Chemical Feed Improvements	$809,000
4	New Source Development Phase 1: Exploration	$300,000
5	Unidirectional Flushing Program	$65,000
6	Water and Stormwater GIS Needs Assessment	$10,000
7	Well 4 Exploration and Replacement Improvements	$1,100,000
8	Bellingham Interconnection	$570,000
9	Franklin Interconnection	$1,770,000
	Phase I Improvements Total :	**$5,779,000**

6.4. PHASE II (2026 – 2030)

6.4.1. Water Main Replacement: Fire Flow Protection Improvements

As referenced in Section 5, the Town's distribution system cannot provide sufficient fire flow due to the size, condition, or configuration of the existing water mains. As discussed previously, there are two hydrants fed by 4-inch cast iron mains, 349 East Street and 69 Arnold Street, which have less than 500 GPM of available fire flow. In addition, Gilmore Road has limited fire protection with less than 500 GPM of available fire flow because the road is supplied by a long dead-end, cast iron main. The Town must improve fire flow in these areas to meet ISO standards by replacing the old and undersized cast iron main with new ductile iron mains.

In addition to these areas, the distribution system has several other dead end mains where available fire flow is less than 750 gpm due to undersized pipes that are in poor condition. Several of these mains were identified in the Capital Efficiency Plan created by Tata and Howard in 2011. EP recommends upgrading these mains to ensure that there is sufficient fire protection for residents. Table 6.3 shows the location and length of each proposed water main improvement.

Table 6.3 – Proposed Water Main Improvements for Available Fire Flow

Street Name	Current Main	Length (feet)	Proposed Main
69 Arnold Street	4” CI	1,000	12” DI
Gilmore Road	6” CI	1,800	8” DI
Lakeside Avenue	4” & 6” CI	1,750	8” DI
Forest Grove Avenue	6” CI	2,250	8” DI
Berry Street and Wampum Street	6” AC	4,500	8” DI
Franklin Street (Rt. 140) (West of Elysium Street)	6” CI	3,000	8” DI

6.4.2. Building Improvements

As discussed previously, EP observed deteriorating conditions at the Town’s well stations and treatment facilities due to age. Operators noted that the roofs of the well stations and TF#3 experience leaking and are in poor condition. Additionally, the doors at Well 3 are in need of replacement.

EP recommends performing these building repairs at the same time as the chemical feed improvements as the most cost effective while also allow the Town to install the largest KOH bulk tank possible for efficient operation of the facilities.

EP also confirmed a trip hazard in the Lake Pearl Water Treatment Plant (TF#5) where spill containment lip prevents any potential spills from entering the chemical containment areas. Since the Town only uses KOH and NaOCl at TF#5 and they are non-reactive, we recommend the Town remove this lip to prevent a tripping hazard.

We recommend that the Town perform a comprehensive assessment of all well and treatment buildings to confirm needed repairs and improvements thereby extending the service life of these facilities. By proactively performing the repairs now, the Town can limit future, more costly and extensive improvements in the future.

6.4.3. Opinion of Probable Cost

For the projects listed above in Phase II, EP has come to the following opinion on probable costs:

Table 6.4 - Phase II Opinion of Probable Costs

Phase II Improvements - Years 2026-2030		
1	Water Main Replacement - Fire Flow	$4,390,000
2	Building Improvements	$38,000
	Phase II Improvements Total :	**$4,428,000**

6.5. PHASE III (2031 – 2035)

6.5.1. Knuckup Hill Tank Replacement

As mentioned in Section 4, the Town has a fire storage deficit. To address this, the Town will need to increase system storage by installing a new tank. The most feasible location for this tank would be on Knuckup Hill alongside the existing storage tanks. Due to the age of the small Knuckup Hill Tank, it may make sense to demolish it at the same time as construction of the new tank.

Regardless, sizing of the new storage tank should consider that in the future it will be taken out of service. With this assumption, the tank will need to be able to store 250,000 gallons between an elevation of 456 and 465 feet. This will exactly meet the required storage volume requirements for 3 hours of 3,500-gpm fire flows.

Planning for future demands however, the proposed tank should allow the Town to accommodate both peak demands and a fire flow event simultaneously. In that case, the new tank would need to store 525,000 gallons above 456 feet to provide 250,000 gallons of fire flow storage and 275,000 gallons of storage for demands. This equates to a storage tank with a diameter of 100 feet. To maximize storage while minimizing dead zones, the best choice for the type of tank would be a composite elevated storage tank (CET). As opposed to a standard standpipe, a CET will have much less water stored in a range that is not regularly drained and filled. This will decrease the average time water spends in the storage tank, reducing the risk of disinfection byproduct formation.

6.5.2. Future West Wrentham High Pressure Zone Evaluation

As mentioned throughout the report, the western portion of Wrentham is at a higher elevation than the eastern portion. To ensure proper service pressures throughout the system, the Town has enacted bylaws to prevent structures over a certain base elevation from connecting to the system. While this bylaw ensures water customers receive their water at acceptable pressures, the Town is limiting the extent of its distribution system and number of customers that it can serve. Additionally, some houses towards the higher limit of the base elevation are currently experiencing low pressures. Additionally, the Town must maintain the level (i.e., elevation) of water in its storage tanks to maintain the required minimum pressures in West Wrentham. Under this operating scenario, the Town cannot maintain adequate available storage volumes for fire protection and peak demands (i.e., equalization) storage as referenced in Section 4.

To address these issues, the Town may consider expanding the distribution system and creating a high service area to serve customers at a higher grade line than the current system. To better assess and understand the feasibility and limits of this proposed high pressure zone, EP recommends that the Town evaluate potential options for developing a new pressure zone to improve supply in this area of the system and supply water to more residents. Because some isolated areas in West Wrentham are located at lower elevations, design of the new pressure zone will need to consider the potential for excessively high pressures at these locations. By creating this high service zone, the Town could also increase the available storage volumes in their existing storage tanks for both peak demand and fire protection in the existing pressure zone. Overall, this evaluation will provide the Town with enough information to make a decision on whether or not a high service area would be appropriate for Wrentham.

6.5.3. Water Main Replacement: Unlined Cast Iron Replacement Phase I

Replacing older water mains within the distribution system is critical to reducing the risk of breaks and maintaining adequate flows. The highest priority for replacement is unlined cast iron mains. These mains are at an additional risk of breaks due to their rigidity, internal corrosion and external pitting due to corrosive soils. Additionally, these mains are prone to tuberculation, which occurs when unlined cast iron pipes chemically react with the water to form deposits on the pipe wall, reducing the actual diameter of the pipe and increasing friction.

The Town's distribution system is about 18 percent unlined cast iron. Although the Town should make their best effort to replace all of these mains, EP recommends beginning with the mains that have the greatest impact. These include water mains that connect tanks and supply sources to the rest of the system as well as mains where a break could lead to a large number of isolated customers. Using those criteria, EP recommends approximately 4.0 miles of high priority cast iron main replacement as outlined in Table 6.5 below:

Table 6.5 – Proposed Cast Iron Main Replacement – Phase I

Street Name	Current Main	Length (feet)	Proposed Main
Beach Street	6" CI	5,050	12" DI
East Street (Rt. 140) (East of Thurston Street)	6" CI	6,800	8" DI
Creek Street	6"/12" CI	6,000	8" DI
Woolford Road	6" CI	3,000	8" DI

6.5.4. Opinion of Probable Cost

For the projects listed above in Phase III, EP has come to the following opinion on probable costs:

Table 6.6 - Phase III Opinion of Probable Costs

Phase III Improvements - Years 2031-2035		
1	Knuckup Hill Tank	$8,094,000
2	Boosted Pressure Zone Study	$75,000
3	Water Main Replacement - Unlined CI Phase I	$6,450,000
	Phase III Improvements Total :	**$14,169,000**

6.6. PHASE IV (2036 – 2040)

6.6.1. Water Main Replacement: Unlined Cast Iron Replacement Phase II

Continuing the unlined cast iron main replacement from Phase III, EP recommends replacing another mile of higher priority cast iron main as outlined in Table 6.7 below:

Table 6.7 – Proposed Cast Iron Main Replacement – Phase II

Street Name	Current Main	Length (feet)	Proposed Main
Forest Grove Avenue	6" CI	800	8" DI
Lake Street	6" CI	1,650	8" DI
Archer Street	6" CI	1,550	8" DI

In addition to these mains and the other cast iron mains identified as needing improvement for fire protection, there are significant amounts of older cast iron mains in the distribution system that have newer mains installed alongside them in parallel. This is especially true along major roads like East Street, Franklin Street, Dedham Street, South Street, and West Street. Because these roads are highly trafficked, replacing these mains is cost prohibitive and likely unnecessary given the existing parallel main. Instead, the Town may consider a program to switch all remaining services and hydrants on these cast iron mains over to the newer mains (if not done so already). Then, as needed, the Town can abandon the existing cast iron mains in place following the transfer of customer services and hydrant connections. This approach will minimize roadway impacts while simultaneously allowing the Town to isolate mains easily if any breaks or leaks occur while also abandoning aging infrastructure, which is beyond its useful life expectancy.

6.6.2. Water System Master Plan

A Water System Master Plan is essential for the effective and efficient management of the Town's water system. A Master Plan serves as a road map for the implementation of distribution system improvements as well as a management tool for addressing day-to-day operational issues and decisions. While it is important to adhere to the capital improvements program to address issues within the water system, the issues that water suppliers face are highly dynamic. Changes to the Town's water system such as an increase in demand, concern about emerging contaminants, or the loss of sources can change the relative importance of improvements. As such, it is critical to regularly review infrastructure needs and develop a new master plan as needed. Generally, this means updating a master plan every 10 years if needed and having a new master plan developed every 20 years.

6.6.3. Opinion of Probable Cost

For the projects listed above in Phase IV, EP has come to the following opinion on probable costs:

Table 6.8 - Phase IV Opinion of Probable Costs

Phase IV Improvements - Years 2036-2040		
1	Water Main Replacement - Unlined CI Phase II	$1,240,000
2	Water System Master Plan	$125,000
	Phase IV Improvements Total :	**$1,365,000**

6.7. CAPITAL IMPROVEMENTS PLAN

Figure 6.1 identifies all of EP's recommended improvements throughout the Town's water system. Table 6.9 list the OPPC associated with all four phases of the Town's CIP.

Table 6.9 - Capital Cost Summary

Capital Improvement Plan Phase	Capital Cost
Phase I	$5,779,000
Phase II	$4,428,000
Phase III	$14,169,000
Phase IV	$1,365,000
TOTAL	**$25,741,000**

Figure 1.1:

Existing Distribution System Map

Water Mains by Diameter

Town of Wrentham, Massachusetts

November 2021

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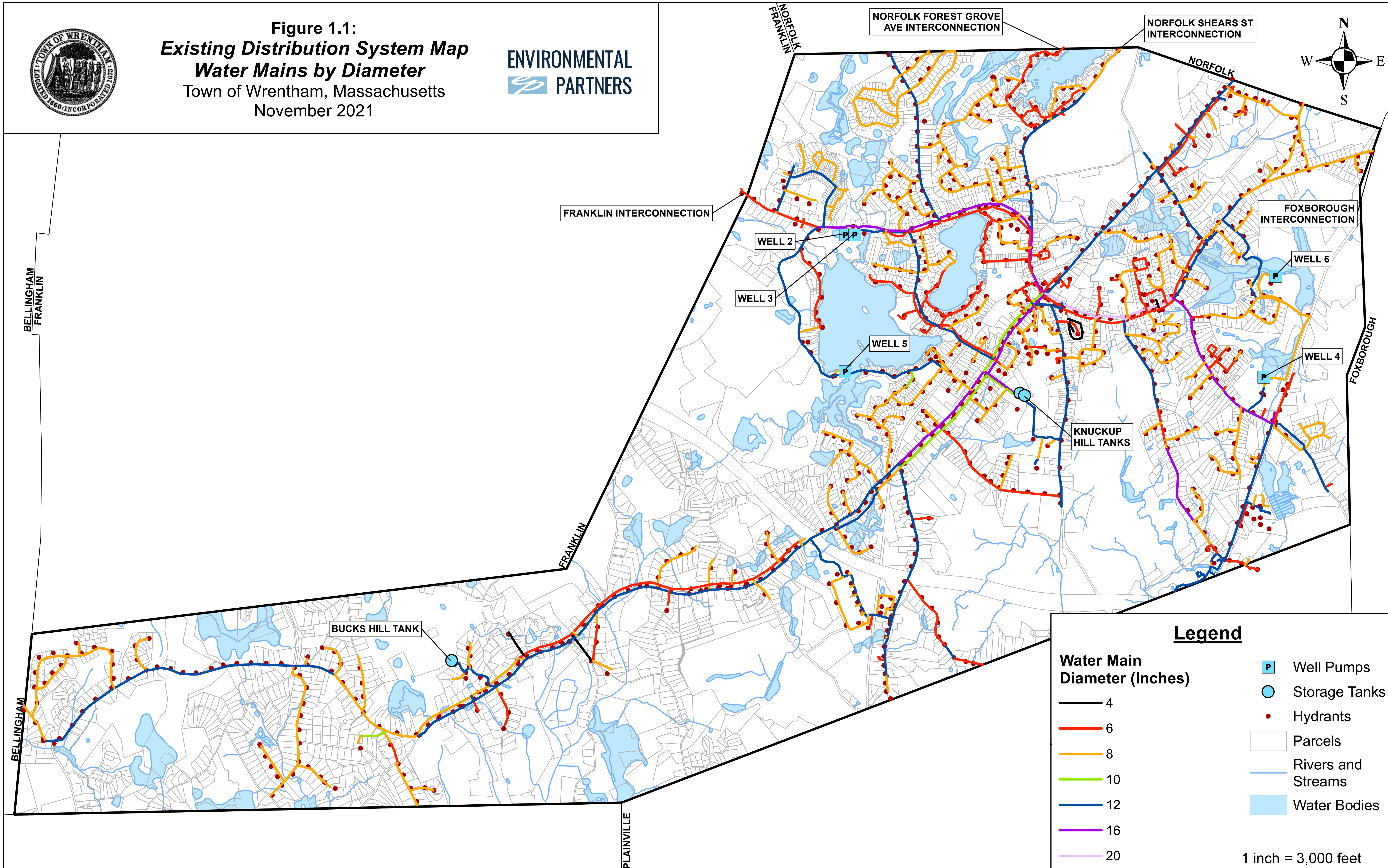

Figure 1.2:

Existing Distribution System Map

Water Mains by Material

Town of Wrentham, Massachusetts

November 2021

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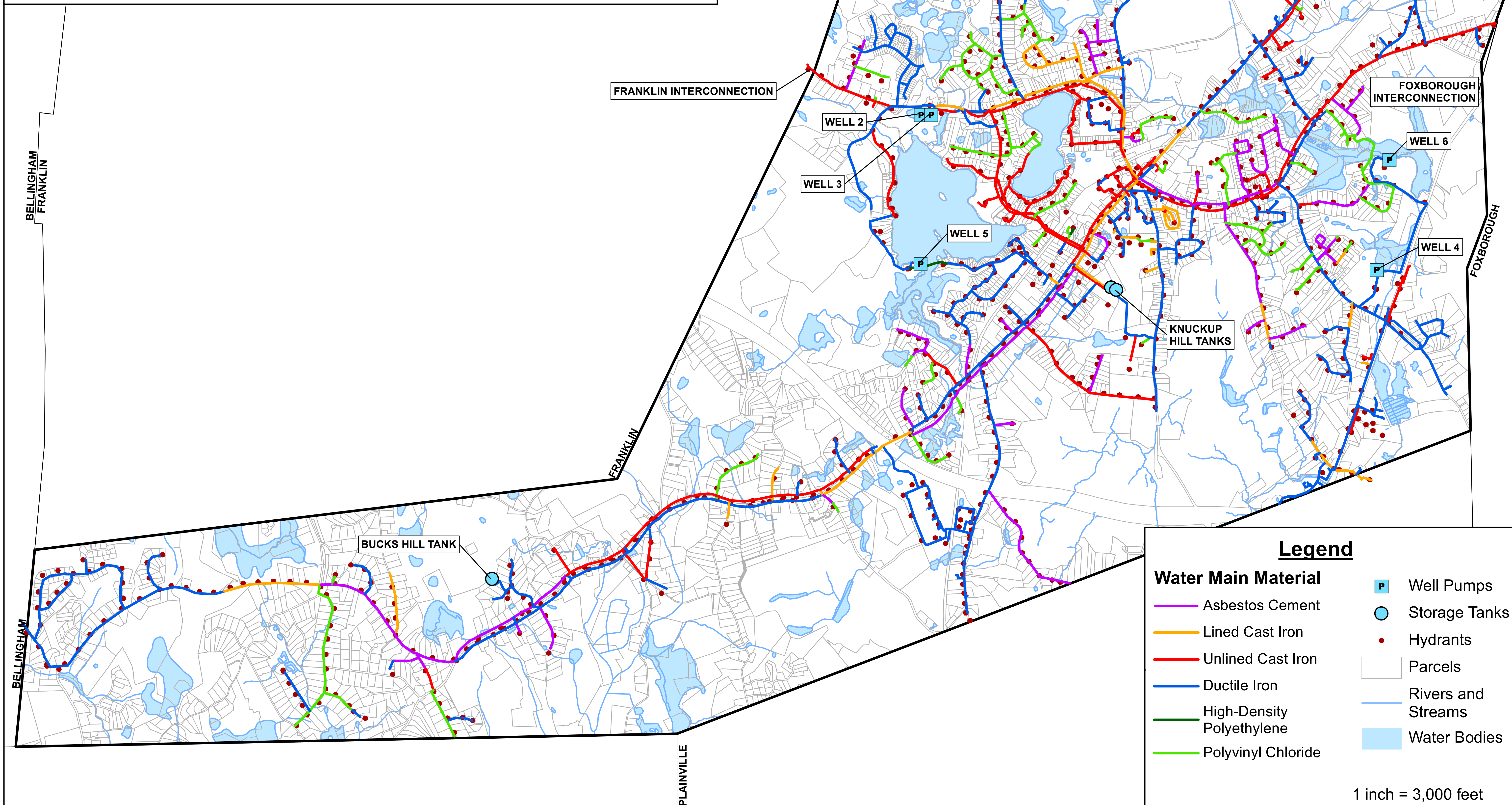

Figure 5.1:

Fire Flow Analysis

Available Fire Flow at 20 PSI

Town of Wrentham, Massachusetts

November 2021

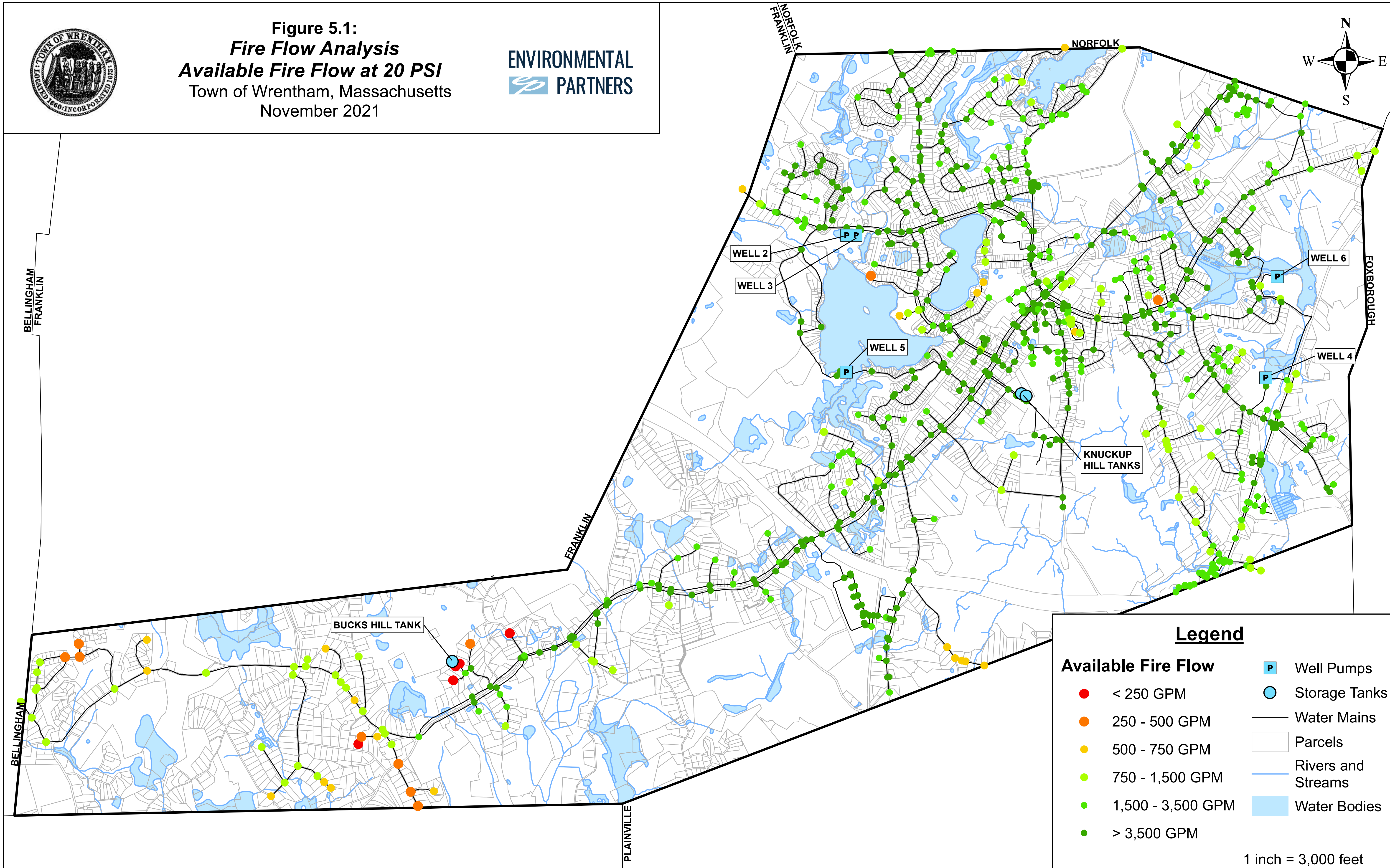

Figure 5.2:

Extended Period Analysis

Maximum System Pressures

Town of Wrentham, Massachusetts

November 2021

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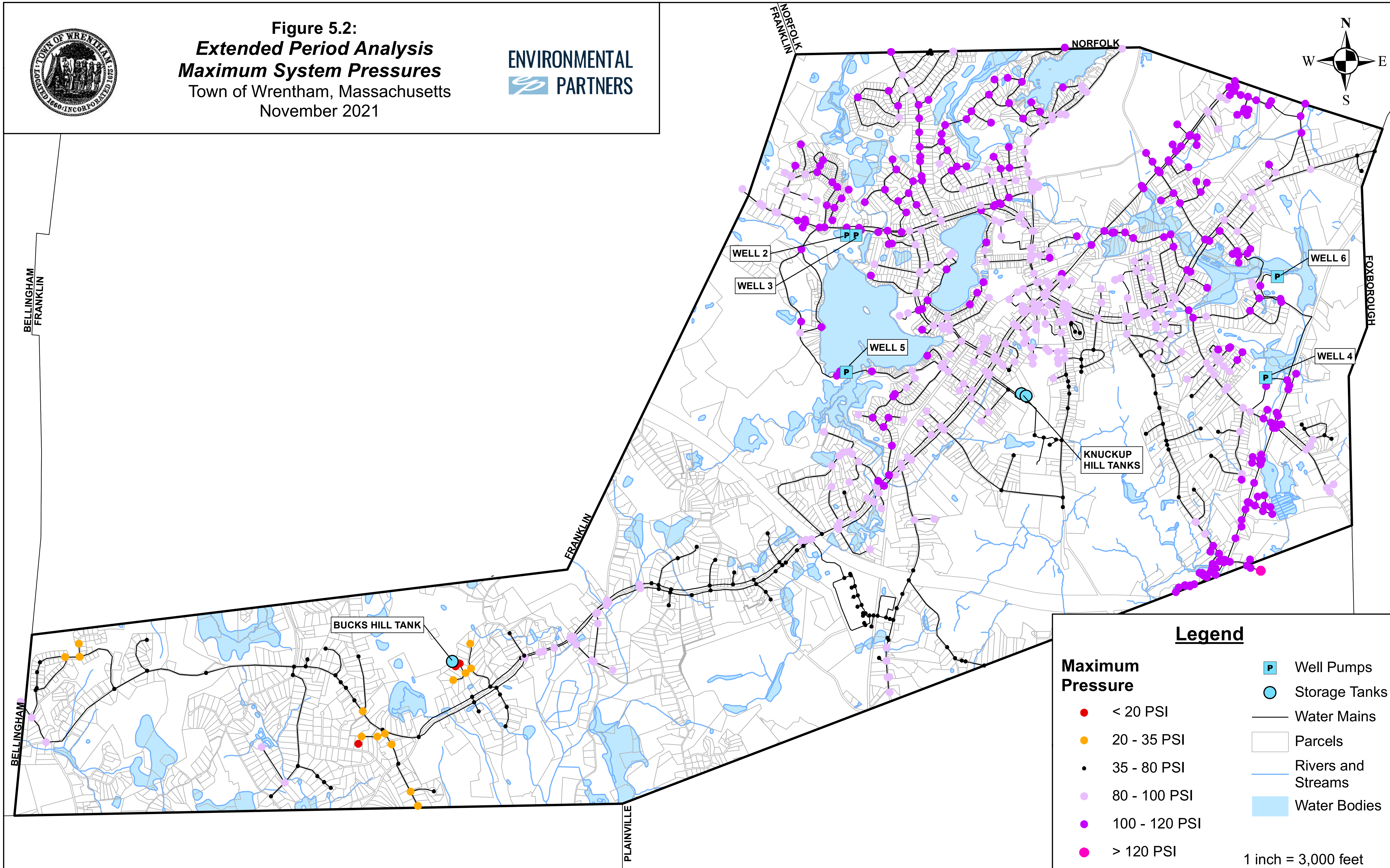


Figure 5.3:
Extended Period Analysis Minimum System Pressures
Town of Wrentham, Massachusetts
November 2021

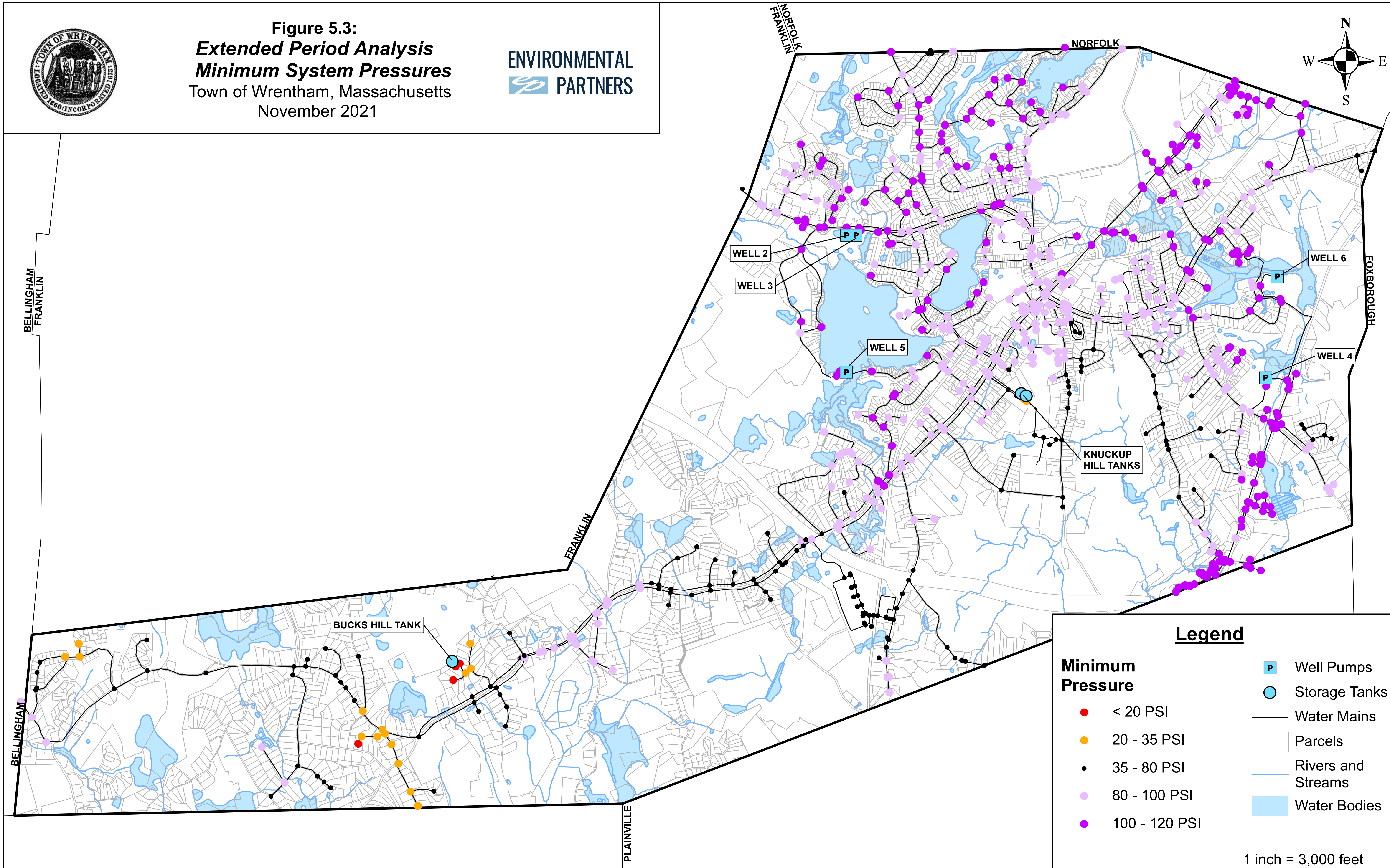
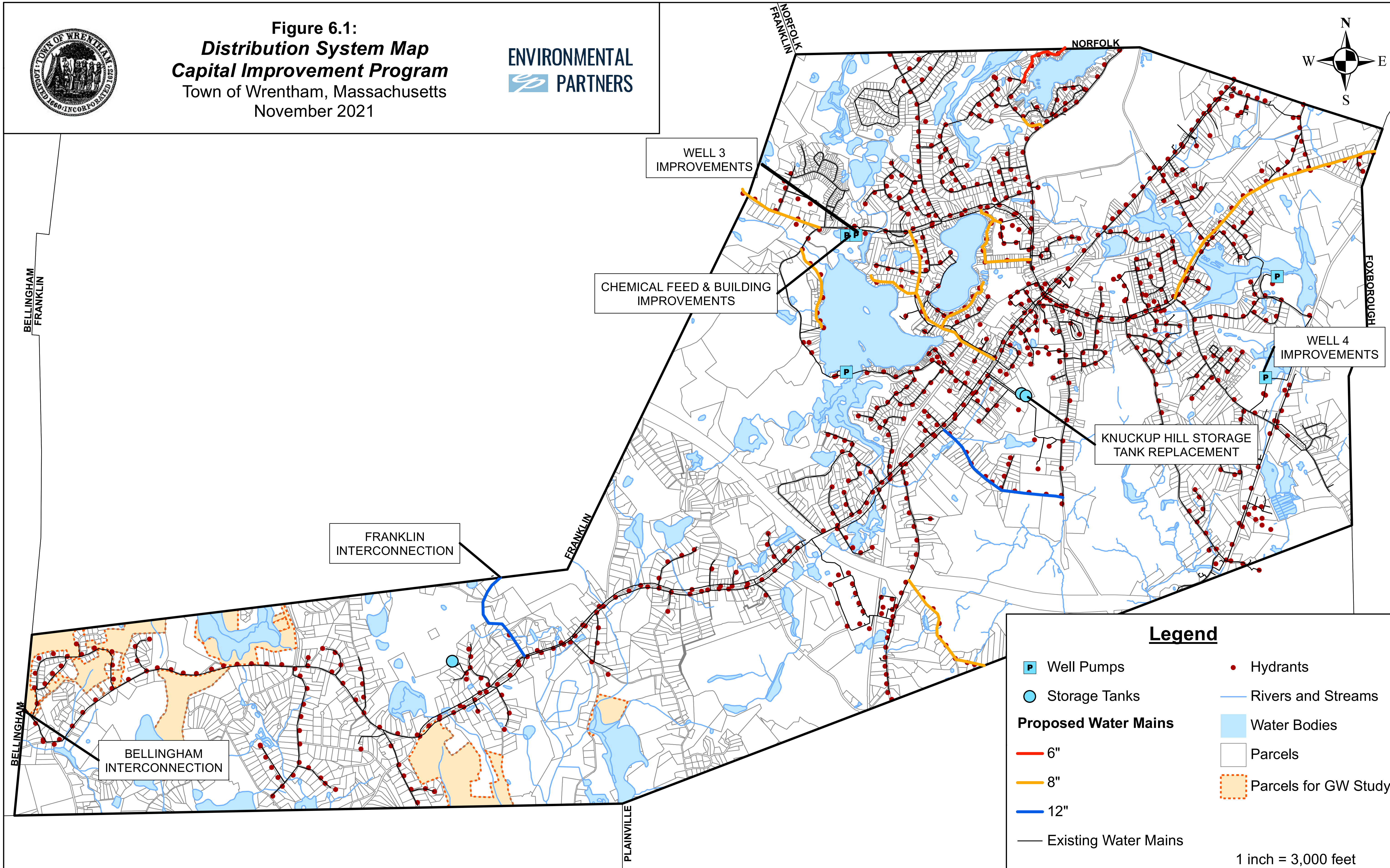


Figure 6.1:
Distribution System Map
Capital Improvement Program
Town of Wrentham, Massachusetts
November 2021



APPENDIX A

Hydraulic Model Calibration Memo

ENVIRONMENTAL PARTNERS

MEMORANDUM

Date: January 6, 2021

To Mike Lavin, Director, Wrentham Department of Public Works

From Chuck Adelsberger, PE, BCEE

CC File

Subject Final Wrentham Water System Hydraulic Model Calibration

Introduction

Environmental Partners (EP) has prepared this memorandum to describe the process and methods used to further calibrate the hydraulic model for the Town of Wrentham's (the Town's) water distribution system.

Background

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 and analyze 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.

As part of the Town's Phase I Water System Master Plan, CDM Smith created the Town's current hydraulic model in 2019 using Innovyze's software, InfoWater. To calibrate the model, they performed twenty fire flow tests across the distribution system and compared these field results with simulated fire flow results from the model. Under their requirements, a calibrated model reports a pressure drop within 10-15 percent of the observed pressure drop in the field. Where the pressure drop was below 10 psi in the field, the requirement was to model the pressure drop within 3 to 5 pounds per square inch (psi) or less. Of the twenty tests performed, CDM Smith was able to simulate results of seventeen tests within the requirements set forth above; however, the three other tests were not calibrated within the required precision.

To complete Phase II of the Water System Master Plan, EP must rely on the hydraulic model for present and future analyses of the distribution system; however, the incomplete calibration raised concerns about the reliability of the model. Therefore, to provide a greater degree of confidence in model results, EP conducted additional testing in the areas of the system that did not previously meet calibration requirements.

Calibration Effort

Modeling Software

EP received the existing model in InfoWater. Although EP typically prefers the capabilities of other modeling packages, EP continued to use InfoWater by Innovyze to avoid any loss of data or information from a conversion. This program solves for the distribution of flows and hydraulic grades using the Gradient Algorithm. This method is an iterative process 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, reservoirs, pumps simulating water supply, and storage tanks.

Hydrant Flow Tests

On November 10, 2020 with the help of Dean Johnson and Jonathan Attwood from the Town's Water Department, EP performed three hydrant flow tests. Focusing on the areas where the previous calibration was inaccurate, EP tested on the same mains as the previous CDM Smith tests:

- EP Test 1 – West Street (CDM Test 18)
- EP Test 2 – South Street (CDM Test 15)
- EP Test 3 – Park Street (CDM Test 5)

During standard hydrant flow tests, EP and the Town attached a pressure gauge to a 'gauge' hydrant and fully opened a 'flow' hydrant. The gauge hydrant is chosen upstream of the flow hydrant. Two pressure readings are taken at the gauge hydrant: one when the flow hydrant is closed and one when the flow hydrant is fully opened. These two readings are the static and residual pressure, respectively. At the flow hydrant, EP used a BigBoy Hose Monster to determine the flow rate during the test. With this information, EP simulated the flow tests in the hydraulic model and compared the model results to the field results. EP then adjusted parameters in the hydraulic model until the simulation matched the field conditions.

Table 1 (below) lists the results of the November 2020 hydrant flow tests.

Table 1 – Hydrant flow test field results, November 2020

Test No.	Gauge Hydrant Address	Flow Hydrant Address	Field Data			
			Static Pressure (PSI)	Residual Pressure (PSI)	Pressure Drop (PSI)	Hydrant Flow (GPM)
1	1165 West Street (Fire Station Two)	1114 West Street	81.0	74.0	7.0	1,990
2	1143 South Street	1146 South Street	78.0	72.0	6.0	1,917
3	183 Park Street	299 Park Street	109.0	99.0	10.0	2,287

Following the tests, EP collected SCADA information showing the tank levels and pump conditions at the time of the tests. During the testing, the height of water in the tanks was 32.6 feet at the Bucks Hill Tank and 47.4 feet at the Knuckup Hill Tank. Only Wells 4 and 6 were operational during the testing window, providing 500 and 115 gallons per minute (gpm), respectively. We have attached the completed hydrant flow test sheets to this memorandum.

Steady State Calibration

For this steady state calibration, EP targeted two-psi accuracy for both static pressure readings and pressure drops during the hydrant flow tests, which is within the accuracy of the pressure gauges. With this tighter window of acceptance, EP can have a high degree of confidence that the model is producing reliable simulations of our observed field conditions.

The first step in calibration is entering the actual system conditions, including tank elevations, number of pumps in operation, pumping rates, and the total system demand, during each test into the model.

EP then checked the nodal static pressures for each flow test, which are dependent upon several system conditions, including:

- Ground elevation at the node
- Tank water elevations
- System demands
- Pump status and flow rates
- Dynamic head losses.

The next calibration procedure is to check flowing or “dynamic” conditions, which is accomplished by inputting the hydrant flows measured in the field and comparing the head losses recorded in the field with those calculated by the model.

With those baseline numbers for comparison, EP then began to determine what factors were preventing the model from producing results that closely matched field conditions. Starting with the static pressure, we began by verifying the model elevations of the hydrants used in the flow tests. An incorrect elevation will affect how hydraulic grade is translated into a pressure.

Next, EP examined the water storage tank elevations. Under static conditions, the water elevation in the Town's storage tanks will typically be the largest determining factor for static pressures across the distribution system. With our first flow test located less than a mile from the Bucks Hill Tank, the static pressure should translate very closely to the water level in the tank. When the static pressures did not match, EP obtained record drawings of the tank and determine that the base elevation of the tank in the model was inconsistent with our research. In the existing model, the base elevation of the tank was 135 feet. While this matches the ground elevation surrounding the tank, the tank is partially buried and has an actual base elevation of 125 feet. With those changes, EP was able to model all of the static pressures within the two-psi threshold.

Next, EP began calibration of the dynamic conditions by analyzing the demands applied to the model. The existing calibration demands were from September 2019. Using available historic production and consumption data, we estimated the average system demand for November to be 80 percent of average September demands. Following that, with minor changes to pipe friction coefficients, EP was able to bring the three tests within the two-psi threshold.

Results

After our review of the model and all available information, EP was able to calibrate the three tests to within two-psi accuracy. Table 2 below shows four sets of values at each test including:

- flow measured in the field,
- pressures measured in the field,
- pressures calculated by the model, and
- difference between those pressures (the pressure differentials).

As shown in the table, the differences in field-measured and modeled static pressures were within one psi. Similarly, the differences in pressure drops were within two psi.

Table 2 – Calibrated model results versus field results

		Field Pressure Data (psi)			Model Pressure Data (psi)			Pressure Differential (psi)	
Test	**Flow (in GPM)**	**Static**	**Residual**	**Delta**	**Static**	**Residual**	**Delta**	**Delta Static**	**Delta-Delta**
1	1,990	81.0	74.0	7.0	82.0	76.9	5.1	-1.0	1.9
2	1,917	78.0	72.0	6.0	78.9	71.6	7.3	-0.9	-1.3
3	2,287	109.0	99.0	10.0	109.2	98.8	10.4	-0.2	-0.4

While reviewing the September 2019 and our November 2020 field results, EP determined that the largest discrepancy between the previously un-calibrated tests and our hydrant flow tests was the measured flow rates. Although tank levels and system operations can affect the available flow at a hydrant, the system conditions for both sets of tests were similar. On average, the CDM Smith flows were 1,000 gpm higher than those observed by EP. Ultimately, we believe this difference and the incorrect Bucks Hill Tank base elevation were the cause of the previous model inaccuracies.

Conclusion

As demonstrated in the results of this hydraulic model calibration memorandum, EP has refined the hydraulic model to represent the Town's actual water system more accurately. As such, we have a higher degree of confidence that the model can serve as a reliable aid when evaluating current and future hydraulic conditions, including piping upgrades and other potential system improvements.

ATTACHMENT 1

HYDRANT FLOW TEST SHEETS

	Project: Wrentham WSMP	Date: November 10, 2020
	Client: Town of Wrentham	Time: 7:27 PM
	Job No: 444-1901	Test: 1

LOCATION:

Gauge Hydrant: 1165 West Street (Fire Station Two)
Flow Hydrant: 1114 West Street

No. of Outlets:	1
Diameter Outlet (in.):	4.5
Coefficient:	-
Pitot (psi):	28
Static (psi):	81
Residual (psi):	74

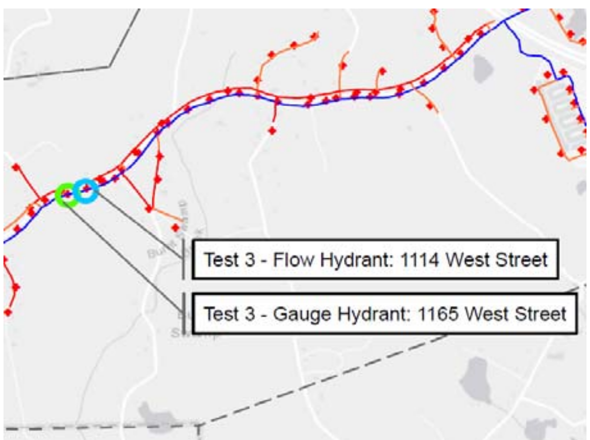
Flow

$29.83 \times D^2 \times \sqrt{Pitot} \times Coeff.$

Flow Available at 20 psi

$Flow \times (Static - 20)^{.54} / (Static - Residual)^{.54}$

Sketch of Location



Calculations

Observed Flow at Hydrant During Test

1990 GPM

Available Fire Flow with a Residual Pressure of 20 psi in the System

6406 GPM

Pump Station Status:	**Flow**	**Pressure**
Franklin St Well 2	0	-
Franklin St Well 3	0	-
Thurston Well 4	500	115
Lake Pearl Well 5	0	-
Crocker Pond Well 6	115	115

	Tank Level	
Bucks Hill Tank	32.6	ft
Knuckup Hill Tank	47.4	ft

Personnel Conducting Test:

Marcus Brunelle	EP
Alec Bacon	EP
Dean Johnson	Town of Wrentham D.P.W.
Jonathan Attwood	Town of Wrentham D.P.W.

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Woburn:
18 Commerce Way, Suite 2000,
Woburn, MA 01801
TL 781.281.2542 • FX 781.281.2543

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Project: Wrentham WSMP
Date: November 10, 2020
Client: Town of Wrentham
Time: 7:49 PM
Job No: 444-1901
Test: 2

LOCATION:
Gauge Hydrant: 1143 South Street (Across from Armitage Auto)
Flow Hydrant: 1146 South Street

No. of Outlets: 1
Diameter Outlet (in.): 4.5
Coefficient: -
Pitot (psi): 26
Static (psi): 78
Residual (psi): 72

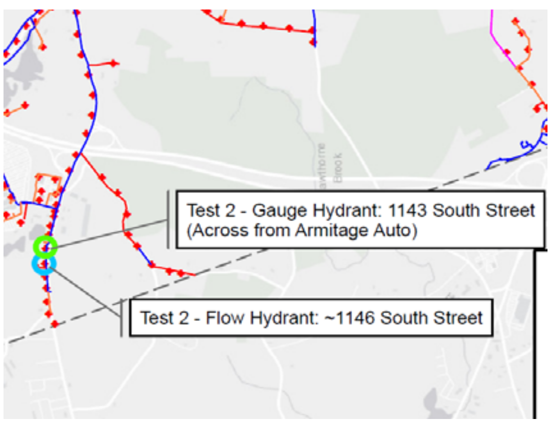
Flow

$29.83 \times D^2 \times \sqrt{Pitot} \times Coeff.$

Flow Available at 20 psi

$Flow \times (Static - 20)^{.54} / (Static - Residual)^{.54}$

Sketch of Location



Calculations

Observed Flow at Hydrant During Test

1917 GPM

Available Fire Flow with a
Residual Pressure of 20 psi in the System

6526 GPM

Pump Station Status:	Flow	Pressure
Franklin St Well 2	0	-
Franklin St Well 3	0	-
Thurston Well 4	500	115
Lake Pearl Well 5	0	-
Crocker Pond Well 6	115	115

	Tank Level	
Bucks Hill Tank	32.6	ft
Knuckup Hill Tank	47.4	ft

Personnel Conducting Test:

Marcus Brunelle	EP
Alec Bacon	EP
Dean Johnson	Town of Wrentham D.P.W.
Jonathan Attwood	Town of Wrentham D.P.W.

ENVIRONMENTAL PARTNERS

Project:	Wrentham WSMP	Date:	November 10, 2020
Client:	Town of Wrentham	Time:	8:09 PM
Job No:	444-1901	Test:	3

LOCATION:

Gauge Hydrant: 183 Park Street
Flow Hydrant: 299 Park Street

No. of Outlets:	1
Diameter Outlet (in.):	4.5
Coefficient:	-
Pitot (psi):	37
Static (psi):	109
Residual (psi):	99

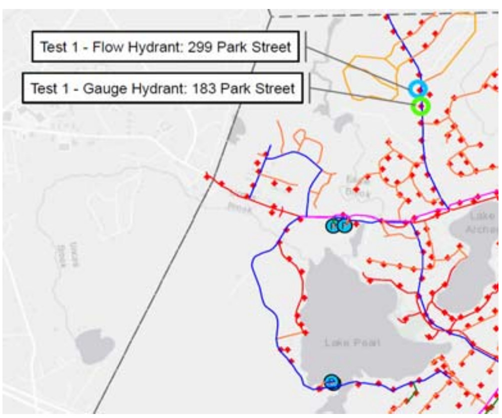
Flow

$29.83 \times D^2 \times \sqrt{Pitot} \times Coeff.$

Flow Available at 20 psi

$Flow \times (Static - 20)^{.54} / (Static - Residual)^{.54}$

Sketch of Location



Calculations

Observed Flow at Hydrant During Test

2287 GPM

Available Fire Flow with a Residual Pressure of 20 psi in the System

7446 GPM

Pump Station Status:	**Flow (GPM)**	**Pressure (PSI)**
Franklin St Well 2	0	-
Franklin St Well 3	0	-
Thurston Well 4	500	115
Lake Pearl Well 5	0	-
Crocker Pond Well 6	115	115

	Tank Level	
Bucks Hill Tank	32.6	ft
Knuckup Hill Tank	47.4	ft

Personnel Conducting Test:

Marcus Brunelle	EP
Alec Bacon	EP
Dean Johnson	Town of Wrentham D.P.W.
Jonathan Attwood	Town of Wrentham D.P.W.

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