

WATER SYSTEM MASTER PLAN

Final February 2018



TOWN OF WESTFORD
INCORPORATED SEPT. 23, 1729.

Westford Water Department



Water System Master Plan

prepared

for the

Westford Water Department

by

Tighe&Bond

Engineers | Environmental Specialists

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Contents

Section 1 Introduction

1.1 Plan Purpose and Goals 2-1
1.2 Periodic Updates 2-2
1.3 Coordination with Other Town Planning 2-2

Section 2 Water System Overview

2.1 System History 2-1
2.2 Overview of Operations 2-4
2.3 Sources, Treatment, and Distribution 2-5
2.4 Wellhead Protection Areas 2-9
2.5 Source Water Protection Program 2-11
2.6 Water Management Act Permit & Registration 2-13
2.7 Sustainable Water Management Act (SWMI) 2-14
2.8 Water Conservation and Demand Management 2-15
2.9 Water Quality Assessment and Regulatory Review 2-16
2.9.1 Drinking Water Regulations 2-16
2.9.2 Water Quality Assessment 2-27

Section 3 Evaluation of Existing Facilities

3.1 Forge Village Water Treatment Plant 3-1
3.1.1 Forge Village No. 1 Pumping Station 3-4
3.1.2 Forge Village No. 2 Pumping Station 3-5
3.1.3 Country Road No. 2 Pumping Station 3-5
3.1.4 Fletcher Pumping Station 3-6
3.1.5 Howard Road Pumping Station 3-7
3.2 Nutting Road Water Treatment Plant 3-8
3.2.1 Nutting Road Pumping Station 3-9
3.2.2 Depot Road Pumping Station 3-10
3.2.3 Cote Pumping Station 3-11
3.2.4 Stepinski Pumping Station 3-12
3.3 Perchlorate Treatment Facility 3-13
3.4 Storage Facilities 3-14
3.4.1 Prospect Hill 3-14
3.4.2 Town Farm Road 3-14
3.4.3 Francis Hill 3-16
3.4.4 Hildreth Hills 3-17
3.4.5 Twin Peaks 3-18
3.5 Booster Pumping Stations 3-18
3.5.1 Hitchin Post Greens (Booster Pump Station No.1) 3-19
3.5.2 Boston Road (Booster Pump Station No. 2) 3-19

3.5.3 Booster Pump Station No. 3 3-19

Section 4 Evaluation of Distribution System through Hydraulic Model

4.1 System Map Update 4-1
4.2 Model Development and Calibration 4-1
4.3 Model Demand Allocation Update 4-5
4.4 Hydraulic Analysis of Distribution System 4-6
4.5 Specific Modeling Iterations 4-8
4.5.1 Westford Center Fire 4-8
4.5.2 Pressure Concerns in East Prescott/Story Street Area 4-8
4.5.3 Evaluation of High Service Area and Low Service Area Borders .. 4-9
4.5.4 Water Age 4-9

Section 5 Water Supply Requirements

5.1 Historical and Current Water Demand 5-1
5.1.1 Unnaccounted for Water 5-1
5.1.2 Residential Gallons per Capita per Day and Services 5-4
5.2 Projected Demands 5-4
5.2.1 Short-Term Demands 5-5
5.2.2 Long-Term Demands 5-5
5.2.3 Summary of Projected Demands 5-13
5.2.4 DCR Water Needs Forecast 5-15

Section 6 Water Capacity Analysis

6.1 Supply Capacity and Adequacy 6-1
6.1.1 Short-Term Considerations 6-3
6.2 Distribution Storage 6-4
6.2.1 Low Service Zone Usable Volume 6-4
6.2.2 High Service Zone Usable Volume 6-6
6.3 Potential Future Sources 6-9
6.3.1 Interconnections 6-9
6.3.2 New Sources 6-10

Section 7 Capital Improvement Plan

7.1 Facility and Distribution System Improvements and Opinions of Costs .. 7-1
7.2 Ten Year CIP 7-1

Section 8 Conclusions and Recommendations

List of Figures

Figure 1-1 Entrance to Westford Water Department 2-1
Figure 2-1 Water Distribution System 2-2
Figure 2-2 Distribution of Pipes by Diameter 2-7
Figure 2-3 Distribution of Pipes by Material 2-8
Figure 2-4 Distribution of Development in Westford by Decade based on Definitive Subdivision and As-Built Plans 2-9
Figure 2-5 Water Quality Testing Results (1 of 2) 2-28
Figure 2-6 Water Quality Testing Results (2 of 2) 2-29
Figure 2-7 Lead and Copper Sampling Results 2-30
Figure 3-1 Forge Village Water Treatment Plant and U.V. Reactors 3-1
Figure 3-2 Greensand Filter and piping at Forge Village Treatment Plant 3-2
Figure 3-3 Forge Village No. 1 Pumping Station 3-4
Figure 3-4 Forge Village No. 2 Pumping Station 3-5
Figure 3-5 Country Road No. 2 Pumping Station 3-6
Figure 3-6 Fletcher Well and Pumping Station 3-6
Figure 3-7 Howard Road Pumping Station 3-7
Figure 3-8 Nutting Treatment Plant and U.V. Reactors 3-8
Figure 3-9 Nutting Road Pumping Station 3-9
Figure 3-10 Depot Road Pumping Station 3-10
Figure 3-11 Cote Pumping Station 3-11
Figure 3-12 Stepinski Well Pumping Station 3-12
Figure 3-13 Stepinski Meter Building 3-12
Figure 3-14 Perchlorate Treatment Facility 3-13
Figure 3-15 Prospect Hill Tank 3-14
Figure 3-16 Town Farm Road Tank (Photo: UST, 2015) 3-14
Figure 3-17 Francis Hill Tank 3-16
Figure 3-18 Hildreth Hills Tank 3-17
Figure 3-19 Twin Peaks Tank (Photo: Google Earth 3D Aerial, 2017) 3-18
Figure 3-20 Boston Road Booster Pump Station 3-19
Figure 4-1 High Service Area Boundary 4-12
Figure 4-2 Maximum System Pressure 4-13
Figure 4-3 Minimum System Pressure 4-14
Figure 4-4 Average System Pressure 4-15
Figure 4-5 GIS Pipe Diameter Error 4-16
Figure 4-6 Existing Model Predicted Available Fire Flow 4-17
Figure 4-7 Existing Average Pressure 4-18
Figure 4-8 Average Pressure with Redrawn Pressure Zone Boundary 4-19
Figure 4-9 Predicted AFF with Redrawn Pressure Zone Boundary 4-20
Figure 4-10 Predicted AFF with Redrawn Pressure Zone Boundary and Water Main Upgrade 4-21
Figure 4-11 Existing Water Age 4-22
Figure 4-12 Existing Source Contribution 4-23
Figure 4-13 Alternative 1 – Predicted Water Age 4-24
Figure 4-14 Alternative 1 – Predicted AFF 4-25
Figure 4-15 Alternative 1 – Predicted AFF in Nabnasset and Greystone 4-26
Figure 4-16 Alternative 2 – Predicted Water Age 4-27
Figure 4-17 Alternative 2 – Predicted AFF 4-28
Figure 4-18 Alternative 2 – Predicted Water Age 4-29
Figure 4-19 Alternative 3 – Predicted AFF 4-30

Figure 4-20 Alternative 4 – Predicted Water Age 4-31
Figure 4-21 Alternative 4 – Predicted AFF 4-32
Figure 5-1 Historical Annual Water Usage and UAW 5-2
Figure 5-2 Historical ADD and MDD 5-3
Figure 5-3 Historical and Projected Population for Town of Westford 5-7
Figure 5-4 Potential Service Area Expansion 5-10
Figure 5-5 Westford's Open Space 5-12
Figure 5-6 Projected Average Daily Demand and Maximum Daily Demand 5-14
Figure 5-7 Water Use Projection Comparison 5-16
Figure 7-1 Map of Water Distribution System Improvements 7-8

List of Tables

Table 2-1 Water Supply Wells 2-6
Table 2-2 Well Pumping Stations 2-6
Table 2-3 Water Storage Facilities 2-7
Table 2-4 Distribution System Pipe Diameters 2-7
Table 2-5 Distribution System Pipe Materials 2-8
Table 2-6 Record Drawings in Westford per Decade 2-9
Table 2-7 Potential Sources of Contamination and Threat Level 2-11
Table 2-8 Susceptibility of Westford's Water Supplies 2-12
Table 2-9 Maximum Daily Withdrawal Volumes 2-14
Table 2-10 Required TOC Removal Efficiencies by Enhanced Coagulation 2-18
Table 2-11 Regulated Contaminants Under the Radionuclides Rule 2-20
Table 2-12 Regulatory Guidelines for 1,4 Dioxane in Drinking Water 2-24
Table 2-13 Example PFC Regulations 2-26
Table 2-14 Westford Water Department UCMR3 Results (1/14/2015) 2-31
Table 4-1 Hydraulic Model Calibrated C-Factors 4-3
Table 4-2 Westford Water Department Hydraulic Model Calibration 4-4
Table 4-3 Daily Demand Pattern Multipliers 4-5
Table 4-4 Predicted AFF vs. NFF 4-7
Table 4-5 Results of Water Quality Modeling 4-10
Table 5-1 Historical RGPCD 5-4
Table 5-2 Summary of Water Usage for Prospective Developments in Westford 5-6
Table 5-3 Town-Wide Average Population Growth 5-8
Table 5-4 Projected Demands Based on Population Growth 5-8
Table 5-5 Potential Service Area Expansion 5-9
Table 5-6 Summary of Projected Demands 5-13
Table 5-7 Population and Employment Projections 5-15
Table 5-8 DCR Water Needs Forecast 5-16
Table 6-1 Water Withdrawal Limits 6-2
Table 6-2 Capacity vs. Predicted Maximum Daily Demand 6-2
Table 6-3 Normal Daily Output vs Predicted ADD 6-3
Table 6-4 Available Equalization and Emergency Storage in the Low Service Zone 6-5
Table 6-5 Available Equalization and Emergency Storage in the High Service Zone 6-6
Table 6-6 High Service Zone Storage Capacity Analysis 6-8
Table 7-1 Water System Facility Improvements 7-2
Table 7-2 Water Distribution System Improvements 7-4
Table 7-3 10 Year Capital Improvement Plan 7-7
Table 8-1 Summary of Projected Demands 8-2

Appendices

Appendix A Water Distribution System Map

Appendix B *Water Management Act & Sustainable Water Management Initiative Planning Report*, January 2015

Appendix C Facility Evaluation Reports

Section 1

Section 1
Introduction

The Town of Westford ("Town") is served by a municipally-owned and operated water department that provides drinking water to approximately 75% of the Town's population and serves residential, municipal, commercial, and industrial customers.

The Westford Water Department (PWS ID 3330000) is entrusted with providing a safe, high quality, adequate water supply and uninterrupted service at a reasonable pressure and reasonable cost, to protect public health, meet fire protection needs, and address Federal and State regulatory requirements. To meet this mission, the Water Department periodically undertakes comprehensive planning in the form of a Water System Master Plan ("Plan").



Figure 1-1 Entrance to Westford Water Department

This Plan includes an evaluation of the existing water system and facilities, an estimate of the future water supply requirements and demand, an analysis of the adequacy of the existing water supply to meet demand, an update to the water distribution system GIS map, an update to the water system model, and a Capital Improvement Plan that projects facility and distribution system improvement needs and budgets.

1.1 Plan Purpose and Goals

The purpose of this Water System Master Plan is to present a strategic and sustainable plan that will guide the Water Department in meeting its water quantity, water quality, and operations and maintenance goals while simultaneously addressing economic needs and environmental requirements. The overall plan is meant to allow the Water Department to continue to:

- Provide a sustainable, high-quality **drinking water** source for residents, businesses, and industry.
- **Operate and maintain Westford's drinking water system**, which includes three water treatment plants, nine water supply wells and pumping stations, five water storage tanks, two water booster pumping stations, and over 133 miles of water distribution system piping and associated valves, hydrants, services, and meters.
- **Comply with Federal and State environmental regulations** such as the Safe Drinking Water Act, Drinking Water Regulations, the Water Management Act (WMA) Regulations and the Water Department's WMA permit requirements, and the Sustainable Water Management Initiative (SWMI).
- Identify **annual capital plans, budgets, and spending recommendations**.

1.2 Periodic Updates

The Water System Master Plan is intended to represent an ongoing process; it is not intended to be a static document. The Plan presents a broad range of recommended projects, some critical (to be completed in the short-term) and some lower priority (to be completed in the long-term). Changes in scope, details and scheduling of certain projects may be required over time to respond to emergencies, new regulations, emerging technologies, and other factors. Although this Plan maps out major expenditures for the water system for many years, conditions change and flexibility is important. The Capital Improvement Plan is intended to be reviewed annually by Water Department Staff and will be revised periodically to reflect new initiatives and/or major changes in priorities. A complete Master Plan review/update is recommended to be performed every five to ten years, or as needed to address any significant changes in the water system and/or growth in the community.

1.3 Coordination with Other Town Planning

Westford residents and Town staff alike have made protection and preservation of the Town's natural resources are a priority. The Town undertakes various planning and monitoring efforts that relate to and are integrated with this Plan:

Stormwater Management Master Plan: Westford's stormwater discharges are regulated under the Environmental Protection Agency's National Pollutant Discharge Elimination System (NPDES) Phase II small municipal separate storm sewer system (MS4) general permit. To meet this permit, the Town performs numerous stormwater management activities. A Stormwater Management Master Plan (SWMMP) was developed from 2014 through 2017 that focuses the future of Westford's stormwater management program. A major driver for the plan is preserving water quality in the local water resources, which includes the drinking water supply sources for the Town.

Specifically, components of the Stormwater Management Master Plan that incorporate drinking water quality and quantity issues include public education and outreach, public involvement, illicit discharge detection and elimination (IDDE), construction and post-construction stormwater runoff, and municipal operation and maintenance as further described in the NPDES Stormwater Program Compliance Plan, the Town-wide Operation & Maintenance Plan, and the Long-Term Capital Improvements Plan. Section 8 of this Plan includes recommendations that coordinate elements of the Water System Master Plan with the Stormwater Management Master Plan.

The Water Department will need to coordinate with the stormwater group to ensure that the recommendations in the SWMMP are implemented in a manner to preserve the quality of the water bodies, and subsequently the quality of the Town's drinking water.

Open Space and Recreation Planning: The 2010 – 2015 Open Space and Recreation Plan (OSRP) expired at the end of January 2015. This Plan needs to be updated and be approved by the Commonwealth. The OSRP presents background and a framework for planning and decision making regarding the Town's open space and recreation needs The major components of the Plan include a review and analysis of Westford' natural, cultural and recreational resources, goals and objectives for open space and recreation planning, 5-year action plan, and an appendix containing lists of flora and fauna, a list of permanently protected open space, a list of privately held

open space, a list of town-owned recreation facilities, and a Section 504 review of Westford recreation facilities. Goals identified in the current 2010-2015 OSRP that relate to drinking water include protection of Westford's ground and surface water resources and protection and management of Westford's remaining open spaces and natural resources. Protecting open space helps keep rainfall and snowmelt on site, recharging the groundwater, and limits the potential for activities that have potential to contaminate surface and groundwater. Section 8 of this Plan includes a recommendation related to providing input on the goals and 5-year action plan as a new OSRP is prepared.

Healthy Lakes and Ponds Initiative: There is an active Healthy Lakes and Ponds Collaborative made up of local Town parties with the goal of preserving Westford's important natural resources and protecting the Town's bodies of water. In 2014, ESS Group, Inc. (ESS) was contracted by the Town to prepare a Lakes and Ponds Management and Preservation Program Plan (Lakes Management Plan) for the nine ponds located within the Town that offer some degree of public access and use. The goals of this Plan were to Provide for the ongoing assessment of the health of the ponds; identify any threats or issues which may compromise the short-term or long-term health of the ponds; and develop recommendations for management strategies and/or future studies that will ensure the preservation and/or enhancement of the ponds. Section 8 of this Plan includes recommendations that relate to the Healthy Lakes and Ponds Initiative.

Section 2

Section 2
Water System Overview

The Westford Water Department water system operates and maintains the following facilities and infrastructure:

- Two (2) 3.0 MGD greensand water treatment plants;
- One perchlorate treatment facility;
- Nine (9) active wells with associated pumping stations;
- Five (5) water storage tanks that contain 4.8 MG of finished water storage;
- Two (2) water booster pumping stations;
- Approximately 133 miles of water mains;
- Approximately 1,200 fire hydrants;
- Approximately 3,500 gate valves;
- 5,365 service connections[1]; and
- One (1) operations and maintenance facility.

A map of the existing water distribution system is shown in Figure 2-1. Appendix A includes large scale maps with additional detail.

2.1 System History

The 2007 Water System Master Plan included a history of Westford's water supply, which is reproduced below.

"At the turn of the last century, many Westford residents were plagued with failing wells and poor water quality. In the 1905 Annual Report of the Town of Westford, the Board of Health reported several cases of typhoid fever, most prevalent "at the Centre." Samples of residential wells revealed "but few fit for domestic use." The following year, the Committee on Public Water Supply recommended the Town appropriate $65,000 to construct a public water supply; however, the subsequent article was dismissed at the March 1907 Annual Town Meeting.

That same year, The Westford Water Company was founded by eleven local businessmen. The first Board of Directors included George T. Day, Sherman H. Fletcher, Julian A. Cameron, John C. Abbot and Edmund Blake. Having collected $40,000 in stock, the first action of the board was to borrow an additional $35,000. The capital was used to lay 8.16 miles of water main and to build a water storage tank on Prospect Hill, which would service 217 water takers in the center, and another on Town Farm Hill, to supply Graniteville and Forge Village.

[1] Number of service connections per 2016 ASR, GIS map shows around 5,150 mapped services

DUNSTABLE
TYNGSBOROUGH
DRACUT
LOWELL
GROTON
CHELMSFORD
AYER
LITTLETON
BOXBOROUGH
CARLISLE
ACTON
Route 3
Sawmill Road
Tenney Road
Tyngsboro Road
Tyngsboro Road
Tyngsboro Road
Kayla Drive
Keyes Road
Wing Road
Gould Road
Groton Road
Holly Lane
Depot Street
Millstone Hill Road
Groton Road
West Street
WTP/TP
WTP
PS
Pine Hill Road
Chippewa Road
Interstate 495
Interstate 495
Interstate 495
Interstate 495
Flagg Road
Flagg Road
Woodland Drive
Vose Road
Jefferson Road
Gage Road
Banbury Drive
Snow Drive
Griffin Road
Acton Road
Acton Road
Acton Road
Old Road
Abbey Lane
Vose Hill Road

Legend

- Ponds
- Rivers and Streams
- Impervious Surface
- Water Main
- Public Water Supplies
- Treatment Plant
- Tank
- Pump Station
- Hydrants
- Private Wells
- High Service Pressure Zone Boundary

1:48,000
0 2,000 4,000
Feet

N

FIGURE 2-1
WATER DISTRIBUTION SYSTEM

Westford, Massachusetts

November 2017

Tighe&Bond
Consulting Engineers
Environmental Specialists

G:\GIS\MA\WestfordMA\avproj\WaterSystem_11x17_v2.mxd

W-4787

The Board of Health wrote in the 1908 Annual Report, "We now have one of the best water systems in our Commonwealth ...We truly believe it is one great secret to health."

The Town of Westford contracted with the Westford Water Company to purchase fire protection in 1937 at a rate of $35.00 per year per hydrant. The contract was, "subject to the right of said Town to take over the franchise and property of said company ..."

The Westford Water Company was expanded in 1944 when the Company purchased the small water system that serviced Brookside Mill and parts of Nabnasset. We're told the Brookside water system had been established by the original owner of the mill and was purchased along with the mill by the Abbot Worsted Company in the early 1940's. The purchase included "land, pumping station, water mains, standpipe, and all equipment..." used to service 60 "subscribers."

Towards mid-century, during the first building boom in Westford, the Company found itself under the constraints of laws applying to private water companies. The Company was required to purchase water mains installed by developers within "one year at a cost of 3 times the first year's income." With several new developments planned, the Board of Directors and later, the stockholders voted to sell the Westford Water Company to the Town. Town Meeting voted in 1955 to purchase the Westford Water Company for the sum of $281,000 to be paid entirely from water revenues.

Over time, environmental changes began to alter water quality. In the 1970s, a chemical was added to the water for the first time in order to raise the pH to counter the corrosive effects of acid rain. Iron and manganese, though not a health threat, discolored clothing and appliances and department employees were kept busy flushing services and dispensing Iron Out. In the 1980s, a phosphate was added to the water which aided in sequestering iron and manganese. In the 1990s, in accordance with a Town Meeting vote, fluoride was added to the drinking water to promote dental health.

In 1999, E. coli was discovered during routine sampling of one of the wells. This contamination necessitated immediate and permanent chlorine disinfection of the entire system. The water treatment initiative then became top priority. The Water Department then began the process of implementing full-scale treatment of its entire water supply. The Water Department was awarded an interest free $14 million State Revolving Fund loan from the Massachusetts Water Pollution Abatement Trust to assist with the financing of the project. In May of 2004, two new greensand water treatment facilities went on-line which have the capacity to treat up to 6.0 MGD.

Over its entire history, the Westford Water Department has had only six superintendents. The first was Alonzo H. Southerland with the Westford Water Company. He was employed from 1907 until he died in 1948. At that time, Albert E. Mountain took over until his retirement in 1969. Harold A. Fletcher, Sr., who started with the Water Department in 1956, was appointed superintendent and remained in this position until his retirement in 1991. The position was then given to Warren E. Sweetser who served the Water Department for 17 years until he retired in 2009. Warren then turned over the keys to Robert Worthley who had been originally hired to operate the new treatment facilities. Bob’s tenure as superintendent was the shortest, having served for only three years before taking a similar position in another community in 2012. Stephen Cronin, who was hired to replace Robert Worthley as the Treatment Manager, was then promoted to superintendent and remains in that position today.

2.2 Overview of Operations

The general operation of the Westford water system is described in this section. Typically, the system operates as follows:

- Raw water is pumped from nine groundwater sources located throughout the distribution system to the two identical treatment facilities located at Forge Village Road and Nutting Road. Five sources pump to the Forge Village treatment plant, and four sources pump to the Nutting Road treatment plant.
- Raw water is pumped through the greensand filters located in each plant, then to the top of the aeration towers, where treated water then drains into below ground clearwells. Chlorine is injected prior to the clearwell so that sufficient contact time is provided as water travels through a series of baffles within the clearwells.
- Treated water is pumped from the clearwells through a series of low pressure ultraviolet light reactors for final disinfection prior to entering the distribution system and the five water storage tanks.
- The operation and monitoring of the water system is automated by a computerized Supervisory Control and Data Acquisition (SCADA) System. The master controls for the SCADA System is located at the Forge Village Treatment Plant.
- The SCADA System sends signals to the wells to turn on when the water level in the clearwell drops. The high head pumps are operated based on water levels in the storage tanks.
- Water service to the High Service Zone is pumped from the Low Service Zone into the High Service Zone based on the water level in the Prospect Hill tank. Water for this service zone is supplied by two booster pumping stations located in the Forge Village Water Treatment Plant and on Boston Road near the Minot's Corner intersection. There is a pressure reducing valve at this pump station that will allow water to flow from the High Service Zone back into the Low Service Zone if needed for fire protection purposes.
- Two privately operated booster pump stations are located in the distribution system to provide water service to residents in the Graniteville Woods development, Hitchin' Post Greens subdivision. A third small booster pump station is located on the entrance to the Highway Department off North Main Street to provide water service to this facility.

The water treatment plants provide treatment for all of the groundwater sources for the following:

- Groundwater under the influence of surface water;
- Iron and manganese removal;
- Organic color removal;
- Corrosion control/pH adjustment;
- Disinfection; and
- Fluoridation

Chemical feed pumps are controlled by flow through the treatment process and are used to add potassium hydroxide (KOH) for pH adjustment, potassium permanganate ($KMNO_4$) for oxidation, calcium hypochlorite (MIOX) for disinfection and chlorine residual, and a polymer to enhance the filter performance. Fluoride is also added for dental health.

The greensand media filter system is operated in the continuous regeneration (CR) mode, due to the high iron levels present. In the CR mode, MIOX/calcium hypochlorite, KOH, $KMnO_4$, and polymer are added to the water before filtration.

Chemically dosed water flows through a static mixer prior to the filters, and the soluble iron and manganese is precipitated to solid form. Water then flows through a distribution header to the inlet in the upper level of each of four filter cells per filter unit. The water is distributed evenly by means of an inlet distributor, on the top of the cell filter media bed through the Simulwash trough.

As the water flows through the filter, the precipitated (oxidized) iron and manganese are filtered out by the media, which is composed of anthracite, manganese greensand and support gravel. The particle matter is deposited on the filter surface and any non-oxidized manganese is removed through a chemical reaction with the greensand.

The filtered water continues through the vessel by flowing through the under-drain laterals and exits the filters through the lower sidewall piping. The filtered water piping directs the water to the packed aeration tower for carbon dioxide and radon gas removal.

After aeration, water flow through the baffled clearwell and is then pumped through the low pressure ultraviolet (UV) disinfection system as final treatment prior to entering the distribution system. Water quality is also continuously monitored for chlorine residual, pH, permanganate and turbidity prior to entering the distribution system.

The water distribution system is maintained by Water Department staff by repairing leaks, replacing water services, and maintaining hydrants and valves. The system is flushed annually to improve water quality.

2.3 Sources, Treatment, and Distribution

All of the Water Department's drinking water is supplied by groundwater wells. Each source is a gravel-packed type well. Table 2-1 provides details about each source and is organized by the treatment plant it supplies. The specific capacity of each well is generally tested every other year to determine the efficiency of the well. As required, wells are rehabilitated to restore the well to at or near its original capacity. The Water Department has made a significant effort to ensure all of their wells have been regularly maintained so that they continue to pump at capacity. Table 2-2 provide basic details regarding each well pumping station.

Table 2-1
Water Supply Wells

Well Name	Number of Wells	Source ID	Size (inches)	Depth (ft)	Approved Rate (MGD/gpm)
Forge Village Water Treatment Plant					
Forge Village No.1 Wellfield (No. 1.1 through 1.5)	5	3330000-01G, 09G, 10G, 11G, 12G	10 x 16	35	0.34 / 236
Forge Village No. 2 Well	1	3330000-05G	24 x 48	62	0.59 / 410
Country Road Well No. 2	1	3330000-19G	10 x 16	70	0.61 / 425
Fletcher Well	1	3330000-08G	24 x 48	78	0.69 / 480
Howard Road Wellfield (No. 6.1 through 6.5)	5	3330000-06G, 13G, 14G, 15G, 16G	10 x 16	24	0.43 / 300
Nutting Road Water Treatment Plant					
Nutting Road Well Satellite Wells No. 1 and 2	3	3330000-02G 3330000-17G, 18G	12 x 18	47	0.65 / 450
Depot Road Well	1	3330000-03G	24 x 48	51	0.72 / 500
Cote Well	1	3330000-07G	24 x 42	38	0.65 / 450
Stepinski Well	1	3330000-20G	24 x 18	75	1.22 / 850

Table 2-2
Well Pumping Stations

Well Pumping Station	Dimension and Type	Maximum Capacity (gpm)	Typical Summer Flow (gpm)	Auxiliary Power
Forge Village Water Treatment Plant				
Forge Village No. 1	Brick and Block	236.1	120	None
Forge Village No. 2	17.5' x 16' Block	409.72	375	Direct Drive
Country Road No. 2	Precast concrete	425	275	Generator
Fletcher	24' x 34' Brick and Block	479.2	325	Generator
Howard Road	19' x 18' Block	300	230	Direct Drive
Nutting Road Water Treatment Plant				
Nutting Road	18' x 15.5' Block	450	170 - 250	Generator
Depot Road	Conc. Frame, Metal Panel	500	350	Generator
Cote	27' x 18.5' Block	450	50	Direct Drive
Stepinski	Precast concrete	850	350	Generator

The Water Department operates five water storage tanks that are located throughout the distribution system and have a total storage capacity of 4.85 MG. Finished water from the Forge Village and Nutting Road Treatment Plants supply four water storage tanks located in the Low Service Zone of the distribution system. These tanks are located at Hildreth Hills (2.0 MG), Twin Peaks (1.0 MG), Francis Hill (1.25 MG) and Town Farm (0.43 MG). In addition, the Water Department has a single tank located at Prospect Hill (0.17 MG) that provides the only storage in the High Service Zone. This tank is scheduled to be replaced in 2018 with a new composite elevated tank that will have a storage capacity of 600,000 gallons. Table 2-3 provides additional details on each water storage facility.

Table 2-3
Water Storage Facilities

	Prospect Hill[1]	Town Farm	Francis Hill	Hildreth Hills	Twin Peaks
Service Zone	**High**	**Low**	**Low**	**Low**	**Low**
Tank Style	Standpipe	Standpipe	Standpipe	Reservoir	Reservoir
Construction Material	Riveted Steel	Riveted Steel	Welded Steel	Precast Concrete	Precast Concrete
Year Constructed	**1907**	**1907**	**1970**	**1982**	**1998**
Diameter (feet)	18	35	60	130	65
Height (feet)	90	60	60	20	39
Overflow Elevation (feet)	558.4	407.6	407.6	407.6	407.6
Capacity (gallons)	**172,000**	**430,000**	**1,250,000**	**2,000,000**	**1,000,000**
Gallons per Vertical Foot	1,910	7,170	20,830	100,000	24,800

[1] Prospect Hill tank will be replaced in 2018 with a new 0.60 MG composite elevated tank.

There are approximately 136 miles of pipe in the water distribution network. Water main sizes range from 4 to 16 inches in diameter. The pipe material includes cast iron (unlined), copper, ductile iron (cement-lined), asbestos cement (transite), steel, and several isolated areas of polyvinyl chloride pipe (PVC). Table 2-4 and Figure 2-2 show the length of pipe by diameter. The majority of the system consist of 8" diameter mains. Table 2-5 and Figure 2-3 show the length of pipe by material.

Table 2-4
Distribution System Pipe Diameters

Pipe Diameter (in)	Length (LF)
4	6,710
6	102,610
8	226,620
10	19,560
12	130,550
16	15,520

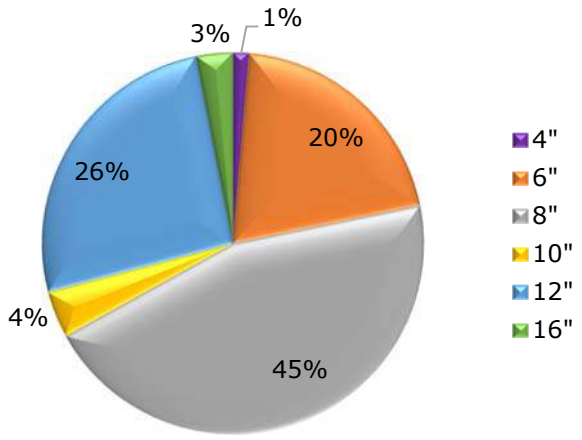


Figure 2-2 Distribution of Pipes by Diameter

Table 2-5
Distribution System Pipe Materials

Pipe Material	Length (LF)
Asbestos Cement	140,780
Cast Iron	120,230
Copper	520
Ductile Iron	425,720
PVC	33,920
Steel	5,940
Unknown	8,410

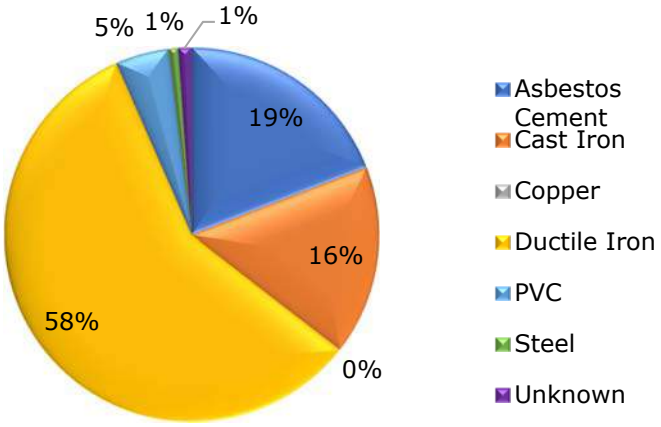


Figure 2-3 Distribution of Pipes by Material

In addition, there are approximately 1,200 fire hydrants, 3,500 gate valves, and 5,360 service connections[2] within the distribution system. The Town's Geographic Information System (GIS) mapping indicates there are approximately 935 private wells located throughout town. A large map of the distribution system is included in Appendix A.

The information included in the GIS water system database does not include data on pipe age or installation date. This information, along with material, is the way to generally understand when the pipe needs to be maintained or replaced, based on the expected service life. As part of developing the Town's Stormwater Management Master Plan (SWMMP), Tighe & Bond looked at the overall distribution of development in Westford by decade. Figure 2-4 and Table 2-6 present the breakdown of subdivision and as-built plans by decade. The majority of development has occurred in Westford since the early 1980s, and over 70% of the subdivisions in Westford were constructed in the 1980s and 1990s. This is also reflected in the population growth chart presented as Figure 5-3 in Section 5 of this report. While areas of town may have water mains that are over 100 years old (e.g. the area around Prospect Hill and Town center, and the area around Town Farm Hill that supplies Graniteville and Forge Village), development trends would indicate a substantial portion of the system is only around 40 years old.

[2] Number of service connections per 2016 ASR, GIS map shows around 5,150 mapped services

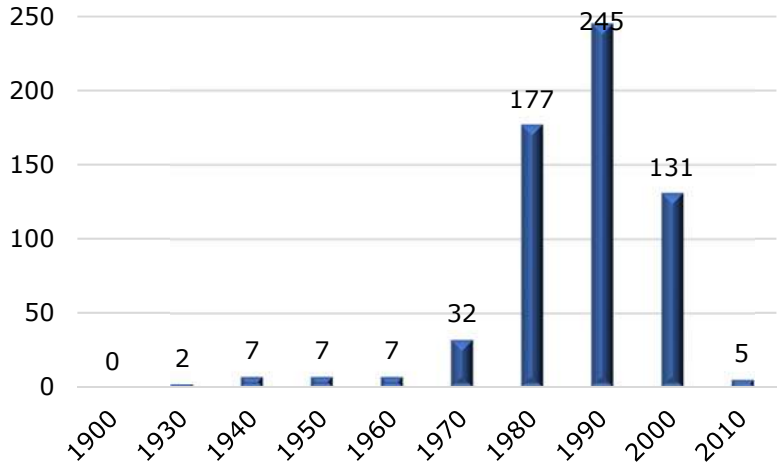


Figure 2-4 Distribution of Development in Westford by Decade based on Definitive Subdivision and As-Built Plans

Table 2-6
Record Drawings in Westford per Decade

Decade	Approximate Percentage of Overall Development
1930s	<1%
1940s	1%
1950s	1%
1960s	1%
1970s	5%
1980s	29%
1990s	40%
2000s	21%
2010s	1%

2.4 Wellhead Protection Areas

Wellhead protection areas are important for protecting the recharge area around a public water supply's groundwater sources. MassDEP defines the following areas per the Drinking Water Regulations at 310 CMR 22.02:

Zone I: *The protective radius required around a public water supply well or wellfield. For public water system wells with approved yields of 100,000 gpd or greater, the protective radius is 400 feet. Tubular wellfields require a 250-foot protective radius. Protective radii for all other public water system wells are determined by the following equation: Zone I radius in feet = (150 x log of pumping rate in gpd) - 350. This equation is equivalent to the chart in the Guidelines and Policies for Public Water Systems. A default Zone I radius or a Zone I radius otherwise computed and determined by the Department shall be applied to transient non-community and non-transient non-community wells when there is no metered rate of withdrawal or no approved pumping rate. In no case shall the Zone I radius be less than 100 feet.*

For Westford's system, the Zone I radius for all wells is 400 feet.

Zone II: *That area of an aquifer which contributes water to a well under the most severe pumping and recharge conditions that can be realistically anticipated (180 days of pumping at approved yield, with no recharge from precipitation). It is bounded by the groundwater divides which result from pumping the well and by the contact of the aquifer with less permeable materials such as till or bedrock. In some cases, streams or lakes may act as recharge boundaries. In all cases, Zone II shall extend upgradient to its point of intersection with prevailing hydrogeologic boundaries (a groundwater flow divide, a contact with till or bedrock, or a recharge boundary).*

Zone IIs have been delineated for Westford's sources and include the following per the 2016 Annual Statistical Report:

- ID#128 for Nutting Road and Depot Road
- ID#278 for Fletcher Well
- ID#658 for Forge Village, Country Road, Fletcher and Howard Road
- ID#434 for Forage Village, Country Road, and Howard Road
- ID#612 for Cote and Stepinksi

Interim Wellhead Protection Area (IWPA): *For public water systems using wells or wellfields that lack a Department approved Zone II, MassDEP will apply an interim wellhead protection area. This interim wellhead protection area is a one-half mile radius measured from the well or wellfield for sources whose approved pumping rate is 100,000 gpd or greater. For wells or wellfields that pump less than 100,000 gpd, the IWPA radius is proportional to the approved pumping rate which may be calculated according to the following equation: IWPA radius in feet = (32 x pumping rate in gallons per minute) + 400. A default IWPA radius or an IWPA radius otherwise computed and determined by the Department shall be applied to transient non-community and non-transient non-community wells when there is no metered rate of withdrawal or no approved pumping rate.*

In the Town of Westford, all IPWAs are for private wells and do not apply to the public water supply wells.

Zone III: *The land area beyond the area of Zone II from which surface water and groundwater drain into Zone II. The surface drainage area as determined by topography is commonly coincident with the groundwater drainage area and will be used to delineate Zone III. In some locations, where surface and groundwater drainage are not coincident, Zone III shall consist of both the surface drainage and the groundwater drainage areas.*

Water Resource Protection District: In 1996, the Town of Westford adopted a new Water Resource Protection District bylaw that protects not only existing public water supplies, but also the Stony Brook aquifer from which all of the public water supply is currently withdrawn. The bylaw delineates three water protection sub-districts. Within these districts, the Town prohibits uses that may threaten the aquifer and limits some uses to a special permit from the Planning Board.

- District 1: equates to existing MassDEP Zone I recharge areas;
- District 2: consists of all MassDEP Zone II and Interim Wellhead Protection Areas for municipal wells (including municipal wells in neighboring communities) along with surrounding high- and medium-yield aquifers; and
- District 3: consists of areas beyond District 2 that drain into a Zone II.

These sub districts, as well as additional source water protection activities, help to protect against potential contaminants from reaching the water supply sources.

2.5 Source Water Protection Program

In 2003, the State of Massachusetts created a Source Water Assessment and Protection (SWAP) report for the Water Department, which aims to inventory land uses within recharge areas of public water supply sources, assess the susceptibility of drinking water sources to contamination from land uses, and publicize these results in the report.

The Water Department's wells are located in protected Zone I and II lands. The only activities allowed in the Zone I must be related to water supply, as required by State regulations. The intent of a Zone I is to remove the possibility for contamination of the water supply source by non-drinking water supply land uses.

Most of the Water Department's wellheads have only water supply activities and land uses within their Zone I. At the time the regulations were implemented, the existing Country Road Well No.1 and pump station was located within twenty feet of the roadway. Since the development of the SWAP report, Country Road Well No. 1 well was decommissioned, the pump station was demolished and the new Country Road Well No. 2 and pump station were constructed. The Zone I for Country Road Well No. 2 extends to Country Road, however the well was constructed a significant distance from the roadway. The Stepinski Well was developed after the SWAP report, and only has water supply land uses within its Zone I.

The Zone II for the Water Department wells include a mostly residential, wetland, and forested land uses, as well as small areas of commercial and light industrial land uses. A list of land uses and activities that may use, produce, or store contaminants within the Zones I and II for each well, which, if managed improperly, are potential source of contamination, is included in Table 2-7.

Table 2-7
Potential Sources of Contamination and Threat Level

Land Use	Threat Level	Potential Contaminant Source
Residential Lawn Care/Gardening	Moderate	Pesticides: over-application or improper storage and disposal
Residential Septic Systems/Cesspools	Moderate	Hazardous chemicals: microbial contaminants, and improper disposal
Livestock Operations	Moderate	Manure (microbial contaminants): improper handling
Cemeteries	Moderate	Over-application of pesticides: leaks, spills, improper handling; historic embalming fluids
Railroad Tracks and Yards	High	Herbicides: over-application or improper handling; fuel storage, transported chemicals, and maintenance chemicals: leaks or spills
Sand and Gravel Mining/Washing	Moderate	Heavy equipment, fuel storage, clandestine dumping: spills or leaks
Foundries or Metal Fabricators	High	Solvents and other chemicals: spills, leaks, or improper handling or storage
Residential Fuel Oil Storage	Moderate	Fuel oil: spills, leaks, or improper handling
Aboveground Storage Tanks	Moderate	Materials stored in tanks: spills, leaks, or improper handling

Land Use	Threat Level	Potential Contaminant Source
Underground Storage Tanks	High	Stored materials: spills, leaks, or improper handling
Aquatic Wildlife	Low	Microbial contaminants
Fishing/Boating	Low	Fuel and other chemical spills, microbial contaminants
Landfills and Dumps	High	Seepage of leachate
Schools, Colleges, or Universities	Moderate	Fuel oil, laboratory, art, photographic, machine shop, and other chemicals: spills, leaks, or improper handling or storage
Small Quantity Hazardous Waste Generators	Moderate	Hazardous materials and waste: spills, leaks, or improper handling or storage
Very Small Quantity Hazardous Waste Generators	Moderate	Hazardous materials and waste: spills, leaks, or improper handling or storage
Stormwater Drains/Retention Basins	Low	Debris, pet waste, and chemicals in stormwater from roads, parking lots, and lawns
Tire Dumps	Moderate	Tires: improper handling or management
Transmission Line Right-of-Way	Low	Corridor maintenance pesticides: over-application or improper handling; construction
Transportation Corridors	Moderate	Fuels and other hazardous materials: accidental leaks or spills; pesticides: over-application or improper handling
Waste Transfer/Recycling Center	Moderate	Water contacting waste materials: improper management, seepage, and runoff
Wastewater Treatment Plant	Moderate	Treatment chemicals or equipment maintenance materials: improper handling or storage; wastewater: improper management

Susceptibility of a water supply to contamination due to land uses within its Zone II is classified as "low", "moderate", or "high" for each well. A "high" ranking of susceptibility to contamination is based on the presence of at least one high threat land use within the water supply protection areas. Table 2-8 includes the susceptibility level of each of the Water Department's water supplies.

Table 2-8
Susceptibility of Westford's Water Supplies

Well	Zone II No.	Susceptibility
Nutting Road and Satellite Wells	128	High
Depot Road	128	High
Cote[1]	612	High
Fletcher[2]	278, 658	High
Forge Village No. 1[3]	434, 658	High
Country Road No. 1[3]	434, 658	High
Forge Village No. 2[3]	434, 658	High
Howard Road[3]	434, 658	High
Country Road No. 2[3]	434, 658	High
Stepinski	612	High

(1) Zone II No. 612 was identified as No. 115 in the SWAP report. It is identified as No. 612 in the Annual Statistical Reports (ASRs) submitted to MassDEP as well as in MassGIS.
(2) Fletcher well is listed in two separate Zone IIs in the ASRs. MassGIS lists the well as located in Zone II No. 658.
(3) These wells are listed in two different Zone IIs in the ASRs. MassGIS lists the wells as located in Zone II No. 658.

As shown in Table 2-8, all of the Water Department's wells classified as high susceptibility to contaminants. According to MassDEP, the wells are at a high risk of contamination due to the types of soil in the area, which do not contain hydrogeologic barriers, such as clay, to prevent the movement of contaminants through groundwater.

The 2003 SWAP report includes recommendations that can be implemented by the Water Department to reduce the risk of potential contaminants from residential land uses, transportation corridors, hazardous materials storage and use, and agricultural activities. Protection planning, which protects drinking water by managing the land area that supplies water to a well, is also recommended in the report.

2.6 Water Management Act Permit & Registration

The Water Department currently has a Water Management Act (WMA) Permit that is in effect through November 30, 2018. This permit authorizes the Water Department to withdraw water from the Merrimack River Basin. The current WMA permit includes a permitted capacity of 1.26 MGD. The volume reflected by this rate is in addition to the 1.18 million gallons per day previously authorized to the Water Department under their Water Management Act Registration #3-13-330.01 for withdrawal from the Merrimack River Basin. Therefore, the total authorized withdrawal for the Westford Water Department through November 2018 is 2.44 MGD. The permitted volume is expressed both as an annual average daily withdrawal rate (million gallons per day or MOD), and as a total annual withdrawal volume (million gallons per year or MOY) for each five-year period of the permit term. Table 2-9 summarizes pertinent information regarding the authorized withdrawal capacity of the Water Department's supply sources.

The following are key points from the Water Department's existing Water Management Act Permit:

- Residential per capita water use (RGPCD) shall be 65 gallons per day or less by December 30, 2016 and each year thereafter.
- Unaccounted for water (UAW) shall be less than 10% of the total amount pumped.
- Nonessential outdoor water use shall be limited through mandatory restrictions from May 1st through September 30th.
- Leak detection surveys shall be conducted a minimum of every three. Approximately 50% of the system was surveyed during 2015. If UAW increases by 5% or more, the areas not surveyed in the previous year are required to be surveyed.

Table 2-9 Maximum Daily Withdrawal Volumes

Source	Source ID (PWS ID 3330000)	Sub-basin	WMA Permit Limit Maximum Day (MGD)	WMA Permit + Registration Annual Average (MGD)
Nutting Road Well and Satellite Wells	02G, 17G, 18G	13044	0.65[1]	1.26 (Permit) 1.18 (Registration)
Depot Road Well	03G	13048	0.72	
Forge Village Wellfield	01G, 09G, 10G, 11G, 12G	13049		
Forge Village Well No. 2	05G	13049		
Stepinski Well	20G	13049	1.22	
Cote Well	07G	13049	0.65	
Howard Road Wellfield	06G, 13G, 14G, 15G, 16G	13054	0.43[2]	
Fletcher Well	08G	13054	0.69	
Country Road Well No. 2	04G	13054	0.61	
Total Authorized Withdrawal Volume				**2.44**

[1] The combined rate of the Nutting Road Well and Satellite Wells No. 1 and 2 is not to exceed this daily rate.
[2] The combined rate of the five Howard Road Wells is not to exceed this daily rate.

2.7 Sustainable Water Management Act (SWMI)

MassDEP revised the WMA regulations (310 CMR 36.00) in November 2014 to implement its Sustainable Water Management Initiative (SWMI) framework, which significantly changes the WMA permitting process for new permits as well as permit renewals. SWMI sets a baseline for water suppliers based on the average of 2003 to 2005 reported water withdrawals, and then requires mitigation for withdrawals above that baseline in the next 20-year permit period. This mitigation is required even if the public water supplier's proposed withdrawal is within its previously permitted water withdrawal rate. The permit cycle for the Merrimack River Basin, where Westford's groundwater withdrawals are located, is scheduled for 2018.

Tighe & Bond completed an evaluation of the SWMI regulations to determine how they will affect Westford. To meet the new WMA regulations and the SWMI framework, the Water Department will have to complete extensive planning efforts as part of the permit renewal process. See Appendix B for the full analysis and review of WMA and SWMI regulations in Tighe & Bond's report entitled "Water Management Act & Sustainable Water Management Initiative Planning Report" from January 2015.

The Water Department's baseline as determined by MassDEP is 1.79 MGD. Based on previous water demand projections, 2035 average day demands are estimated to be over the baseline. However, the sub-basins from which Westford is withdrawing water are mapped as Category 5 (highest impact) for both Groundwater Level (GWL) and Biological Category (BC), so the increased withdrawal above the baseline will not increase the categories.

Based on this information, it is expected that the Water Department would be permitted under Tier 2, which is for water suppliers requesting an additional withdrawal above baseline that does not result in a change to the GWL or BC. The Water Department will therefore be required to:

- Meet the eight Standard Permit Conditions of the WMA process (e.g. source protection, residential gallons per capita day (RGPCD) less than 65, unaccounted for water less than 10%, seasonal limits, etc.) and to minimize impacts of existing withdrawals and implement mitigation measures.
- Develop a written minimization plan that explores how to modify withdrawal operations such as changing timing of withdrawals or shifting operations between wells as needed seasonally, use alternative sources such as interconnections, release water from impoundments, return water the ground via wastewater or stormwater discharges, and implement additional water conservation measures
- Renew their WMA permit in 2018 through the SWMI process.

If the Water Department pursues development of a new water supply in a sub-basin other than those in which current sources are located, the potential impacts on the WMA permit due to SWMI will need to be evaluated.

We have provided recommendations related to the impacts of SWMI in Section 8 of this report.

2.8 Water Conservation and Demand Management

Water supply management includes implementing practices to reduce demands through water conservation and reducing unaccounted for water, as well as optimizing water supplies by rotating supply operations. The Water Department has been implementing demand management and conservation activities for a number of years. These measures include the following:

- Conservation education in a semiannual newsletter since 2004
- Water saver device hand outs
- Rain barrel community programs (sold at reduced rates) since 2004
- Water Department Open House – activities include water conservation education
- Grade 4 groundwater presentation
- Encouraging residents to comply with the voluntary odd/even outdoor watering schedule and only water between the hours of 6:00 PM and 9:00 AM from May 1 through October 31 every year
- Implementing mandatory outdoor water use restrictions (above voluntary restrictions) in 2012, 2013, 2014, 2015, and 2016. These restrictions require residents to comply with a mandatory odd/even outdoor watering schedule and only water between the hours of 6 PM and 9 AM. The mandatory restrictions also limit other non-essential outdoor water use including prohibiting sprinklers and irrigation systems, vehicle washing, pool filling, washing exterior surfaces of buildings, and limiting watering to hand held hoses and watering cans only.

In addition, the Department conducts monthly water meter readings and is in the process of upgrading to a remote meter reading system. A comprehensive water audit is conducted

approximately every five years. Westford's General Bylaws and the Water Department's Rules and Regulations clarify water use along with the associated costs of consumption. They also define the Water Department's enforcement authority and penalties that can be assessed for water theft.

2.9 Water Quality Assessment and Regulatory Review

The following sections summarize the U.S. Environmental Protection Agency's (EPA's) drinking water quality regulations that may impact the Water Department's system, and include a discussion of the potential future regulations. Discussion on the system's water quality, including concerns relative to these regulations, is included at the end of this section.

2.9.1 Drinking Water Regulations

The major drinking water regulations promulgated to date that pertain to the Water Department's system include:

- Groundwater Rule (GWR)
- Stage 1 and Stage 2 Disinfectant and Disinfection By-Products Rule (DBPR)
- Total Coliform Rule (TCR) and Revised Total Coliform Rule (RTCR)
- Radionuclides and Arsenic Rules
- Lead and Copper Rule
- Secondary Drinking Water Standards for Iron and Manganese, and Drinking Water Contaminant Candidate List 4 (Draft CCL4) including Manganese
- Unregulated Contaminant Monitoring Rule (UCMR)
- Radon Rule (not finalized)
- Massachusetts Drinking Water Standards & Guidelines
- Emerging Contaminants

Groundwater Rule

The GWR was promulgated in November 2006. It applies to public water systems that use groundwater as a source of drinking water. The rule also applies to any system that delivers surface and groundwater to consumers where the groundwater is added to the distribution system without treatment. The GWR establishes a risk-based approach to target groundwater systems vulnerable to fecal contamination.

This rule relies on four major components:

1. Periodic sanitary surveys of groundwater systems that require the identification of significant deficiencies (e.g., a well located near a leaking septic system) and the evaluation of eight critical elements (source, treatment, distribution system, finished water storage, pumps/pump facilities/controls, monitoring/reporting/data verification, system management/operation, and operator compliance with state requirements).

2. Source water monitoring to test for the presence of E. coli, enterococci, or coliphage in the sample. There are two monitoring provisions:
   - Triggered monitoring for systems that do not already provide treatment that achieves at least 99.99 percent (4-log) inactivation or removal of viruses and that have a total coliform-positive routine sample under Total Coliform Rule sampling in the distribution system. To avoid having to comply with triggered source water monitoring, groundwater systems may choose to use chemical disinfection to achieve 4-log inactivation of viruses.
   - Assessment monitoring - As a complement to triggered monitoring, the State has the option to require systems, at any time, to conduct source water assessment monitoring to help identify high risk systems.
3. Corrective actions required for any system with a significant deficiency or source water fecal contamination. The system must implement one or more of the following correction action options:
   - Correct all significant deficiencies,
   - Eliminate the source of contamination,
   - Provide an alternate source of water, or
   - Provide treatment which reliably achieves 4-log inactivation or removal of viruses.
4. Compliance monitoring to ensure that treatment technology installed to treat drinking water reliably achieves at least 4-log inactivation or removal of viruses for systems providing 4-log treatment of viruses.

Disinfectants and Disinfection By-Products Rule

Stage 1 of the DBPR was finalized in December 1998. This rule established Maximum Contaminant Levels (MCLs) of 80 µg/L for total trihalomethanes (TTHMs, including chloroform, bromodichloromethane, dibromochloromethane, and bromoform) and 60 µg/L for five haloacetic acids (HAA5, including monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, bromoacetic acid, and dibromoacetic acid). The State 1 DBPR applies to community water systems and non-transient non-community systems, including those serving fewer than 10,000 people that add a disinfectant to the drinking water during any part of the treatment process.

Under the Stage 1 DBPR, most systems were required to collect quarterly DBP samples at four distribution system locations per water source. Compliance with the DBP MCLs was based on a running annual average of the quarterly averages. EPA also established a maximum contaminant level goal (MCLG) of zero for disinfection by-products.

The Stage 1 DBPR established a MCL for bromate of 10 µg/L for plants that use ozone and a MCL for chlorite of 1.0 mg/L for plants that use chlorine dioxide.

The Stage 1 DBPR set maximum residual disinfectant levels (MRDL) for chlorine and chloramines of 4.0 mg/L as Cl_2, based on a running annual average. Routine monitoring for chlorine and chloramines must be at the same sample locations and at the same sampling frequency as the Total Coliform Rule sampling.

The Stage 1 DBPR specified required levels of TOC removal for conventional treatment facilities based on source water alkalinity and TOC concentrations, in order to minimize disinfection byproduct formation. If utilities cannot meet the specified requirements, they must modify their treatment practices in order to provide "enhanced coagulation." Table 2-10 summarizes the required percent removals.

Table 2-10 Required TOC Removal Efficiencies by Enhanced Coagulation

Source Water TOC (mg/L)	Source Water Alkalinity (mg/L as $CaCO_3$)		
	0 to 60	> 60 to 120	> 120 (1)
0 to 2.0	No Action	No Action	No Action
>2.0 to 4.0	35.0%	25.0%	15.0%
>4.0 to 8.0	45.0%	35.0%	25.0%
>8.0	50.0%	40.0%	30.0%

(1) Systems practicing precipitation softening must meet the TOC removal requirements in this column.

The rule also specifies alternative compliance criteria to the required removals that depend on raw and treated water quality and disinfection by-product levels. The alternative compliance criteria are:

1. Source water TOC < 2.0 mg/L
2. Treated water TOC < 2.0 mg/L
3. Source water TOC < 4.0 mg/L, source water alkalinity > 60 mg/L and system achieves TTHMs < 40 µg/L and HAA5 < 30 µg/L
4. TTHMs < 40 µg/L and HAA5 < 30 µg/L and only chlorine is used for primary disinfection and maintenance of a distribution system residual
5. Source water SUVA prior to treatment is ≤ 2.0 L/mg-m
6. Treated water SUVA is ≤ 2.0 L/mg-m

Routine monitoring is also required as a part of the enhanced coagulation requirements under the Stage 1 DBPR. This includes sampling each month at the same time at the following locations:

- Raw water prior to any treatment for TOC and alkalinity
- Treated water (prior to oxidant addition) for TOC

Data must also be collected on plant operations to establish compliance with the regulation. Compliance is determined by a performance ratio on a running annual average basis.

The Stage 2 DBPR was proposed in the Federal Register on August 18, 2003 and promulgated in January 2006. The final rule sets forth a phased approach to implementing the Stage 2 DBPR requirements. The Stage 2 DBPR targets public water systems (PWSs) with the greatest risk.

Completion of an initial distribution system evaluation (IDSE) was required to locate high-DBP sites within the distribution system. Water systems proposed new or revised Stage 2 monitoring sites based on the IDSE study. Under the Stage 2 DBPR, MCLs for TTHMs and HAA5 remain the same as the Stage 1 running annual averages of 80 and 60 µg/L, respectively. Instead of reducing the MCLs, the Stage 2 DBPR is intended to reduce DBP occurrence peaks in the distribution system by changing the compliance monitoring provisions. Compliance with the MCLs is determined based on a locational running annual average (LRAA) at each identified sample location under the IDSE. The Stage 2 monitoring requirements went into effect in 2013.

The Stage 2 DBPR established operational evaluation requirements that are initiated by the TTHM and HAA5 levels found during the Stage 2 compliance monitoring. Systems are required to perform an operational evaluation and to submit an operational evaluation report to the State in the event that operational evaluation levels (OELs) found during compliance monitoring exceed the MCLs. The OEL for a monitoring location is determined as follows:

$$OEL = [A+B+(2 \times C)]/4$$

Where: A and B are the TTHM or HAA5 concentration observed for the previous 2 quarters, and C is the concentration for the current quarter.

OELs must be calculated each quarter for each monitoring location for TTHM and HAA5. If any of the OELs exceed the respective TTHM or HAA5 MCLs, the following actions must be taken:

- Conduct an operational evaluation to determine the source of the exceedance
- Submit a written report of the evaluation to the State within 90 days after being notified of the analytical result that caused the exceedance
- Keep a copy of the evaluation and make it available to the public upon request

The operational evaluation must include an examination of system treatment and distribution operational practices that may contribute to TTHM and HAA5 formation including storage tank operations, excess storage capacity, water main flushing, source water quality, treatment processes, and finished water quality.

Total Coliform Rule and Revised Total Coliform Rule

The TCR was promulgated on June 29, 1989. The rule sets microbial standards and requires routine microbial monitoring of distribution systems. The RTCR was promulgated on February 13, 2013 and minor corrections were promulgated on February 26, 2014. The 1989 TCR remained effective until March 31, 2016 and the RTCR became effective on April 1, 2016. Total coliforms are considered a useful indicator of other pathogens for drinking water and are used to determine the adequacy of water treatment and the integrity of distribution systems.

The RTCR includes some significant changes from the 1989 TCR. The RTCR sets a MCLG and a MCL for E. Coli; however, under the RTCR there is no longer a monthly MCL violation for multiple total coliform detections. Instead, the RTCR requires systems that have an indication of coliform contamination in the distribution system to assess the problem and take corrective action (treatment technique (TT)). The TT requirements provide that a

PWS that exceeds a specified frequency of total coliform occurrence must conduct a Level 1 or Level 2 assessment to determine if any sanitary defect exists and, if found, to correct the sanitary defect.

The number of samples taken each month depends upon the population served. If a positive total coliform test occurs, repeat total coliform samples must be taken and E. coli tests must be run on the positive total coliform sample and repeat samples. The RTCR specifies the frequency and timing of the microbial testing by water systems based on population served, system type, and source water type.

The RTCR requires public notification when there is a potential health threat as indicated by monitoring results (i.e., a positive E. coli test in conjunction with one or more positive total coliform tests), and when the system fails to identify and fix problems as required; however, multiple positive total coliform tests in and of themselves will no longer require public notification.

Systems with groundwater sources not providing 4-log virus inactivation upstream of the first distribution system customer at each source must collect samples from the groundwater source(s) in the event of a positive total coliform sample collected during routine monitoring.

Radionuclides and Arsenic Rule

The original radionuclides rule was proposed in July 1991. However, court action delayed the final promulgation of the rule until June 2001. The rule is applicable to all community water systems of all size categories, with the purpose of reducing exposure to radionuclides that are classified as carcinogens. Table 2-11 lists the existing MCLs for regulated radionuclides.

Table 2-11 Regulated Contaminants Under the Radionuclides Rule

Contaminant	MCL	MCLG
Beta/Photon Emitters (1)	4 mrem/yr	0
Gross alpha particle	15 pCi/L	0
Combined Radium 226/228	5 pCi/L	0
Uranium	30 µg/L	0

(1) A total of 168 individual beta particle and photon emitters may be used to calculate compliance with the MCL.

The final Arsenic Rule was promulgated in January 2001. The EPA lowered the arsenic standard for drinking water to 10 µg/L to protect consumers against the effects of long-term, chronic exposure to arsenic. The new standard applies to all community water systems and became effective on January 23, 2006.

Lead and Copper Rule

The Lead and Copper Rule was promulgated in June 1991 and went into effect in December 1992. The rule developed MCLGs and action levels for lead and copper in drinking water. The major difference between this regulation and most others is that the monitoring requirements apply to samples collected at the customer's tap, not the treatment plant discharge point or other distribution system points of entry. For compliance, the samples at the customer's tap must not exceed the following action levels:

- Lead: 90th percentile of all samples no greater than 0.015 mg/L
- Copper: 90th percentile of all samples no greater than 1.3 mg/L

If action levels are exceeded, water systems are required to collect source water samples and submit all data to the State with a treatment recommendation to reduce concentrations below the action level. In addition, if the lead action level is exceeded, the water system is required to present a public education program to its customers within 60 days of the action level exceedance. The education program must be continued until the samples are found to be below the lead action levels.

In 1999, minor revisions to the lead and copper rule were promulgated to streamline requirements and to reduce some burdens on water systems. No changes to the action levels or MCLGs were made. Small changes were made to reduce the frequency of monitoring for systems with low lead and copper tap levels, as well as to update the analytical methods used for compliance.

The EPA has since been working on long-term revisions to the rule. In October 2016, the EPA published the Lead and Copper Rule Revisions White Paper[3], which provides examples of regulatory options for revising the current rule. Options outlined include lead service line replacement, improving optimal corrosion control treatment requirements, consideration of a health-based benchmark, the potential role of point-of-use filters, clarifications or strengthening of tap sampling requirements, increased transparency, and public education requirements. A Draft revised rule is expected in January 2018, with promulgation of the final rule excepted after January 2019.

Iron and Manganese (Secondary Drinking Water Standard)

Although there are no enforceable national primary standards for iron or manganese, EPA has established National Secondary Drinking Water Regulations (NSDWRs) that set non-mandatory water quality standards for 15 contaminants including iron and manganese. EPA does not enforce these secondary maximum contaminant levels (SMCLs). They are established only as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor. These contaminants are not considered to present a risk to human health at the SMCL. The SMCLs are 0.05 mg/L for manganese and 0.3 mg/L for iron.

There is a concern that manganese may pose a health risk at higher concentrations. MassDEP requires monitoring for manganese, and has the authority to require action to reduce manganese to levels deemed safe. Massachusetts systems with concentrations higher than 0.3 mg/L may have to conduct additional sampling and inform customers.

Manganese is listed on the EPA draft Contaminant Candidate List 4 (CCL4), published in February 2015. Contaminants on CCL4 are under consideration for future regulation. In summary, there appears to be a trend toward future regulation of manganese due to health concerns, and a health-based MCL would likely be higher than the SMCL.

[3]https://www.epa.gov/sites/production/files/2016-10/documents/508_lcr_revisions_white_paper_final_10.26.16.pdf

Unregulated Contaminant Monitoring Rule (UCMR)

EPA uses the UCMR to collect data for contaminants that are suspected to be present in drinking water and do not have health-based standards set under the Safe Drinking Water Act (SDWA). The SDWA Amendments of 1996 provide for:

- Monitoring no more than 30 contaminants every five years
- Monitoring large systems and a representative sample of small public water systems serving less than 10,000 people
- Storing analytical results in a National Contaminant Occurrence Database (NCOD)

Occurrence data are collected through UCMR to support the EPA's determination of whether to regulate particular contaminants in the interest of protecting public health.

EPA's selection of contaminants for a particular UCMR cycle is largely based on a review of the Contaminant Candidate List (CCL), which is a list of contaminants that:

- Are not regulated by the National Primary Drinking Water Regulations
- Are known or anticipated to occur at public water systems
- May warrant regulation under the SDWA

The fourth Unregulated Contaminant Monitoring Rule (UCMR 4) was published in the Federal Register on December 20, 2016. UCMR 4 requires monitoring for 30 chemical contaminants between 2018 and 2020 using analytical methods developed by EPA and consensus organizations. This monitoring provides a basis for future regulatory actions to protect public health. Between March 2018 and November 2020, all public water supplies that serve 10,000 or more people (such as Westford's Water Department) are required to monitor for 10 cyanotoxins during a four consecutive month period. PWSs must also monitor for 20 additional contaminants ranging from metals, pesticides, brominated haloacetic acids, alcohols, semivolitile chemicals, and indicators (carbon and bromide) during a 12-month period.

Radon Rule

The 1996 Safe Drinking Water Act Amendments required EPA to establish several new, health-based drinking water regulations, including a multimedia approach to address the public health risks from radon. Radon 222 is a naturally occurring element. Upon nuclear decay, alpha particles are emitted from the decaying nucleus. Alpha particles are considered carcinogenic and therefore human exposures should be limited. While lung cancer is the main health effect attributed to radon, drinking water contaminated by radon can also cause cancer.

EPA proposed new regulations to reduce the public health risks from radon on November 2, 1999 in the Federal Register, which would apply to community water systems that regularly serve 25 or more people and that use groundwater or mixed ground and surface water. The proposed regulations would be implemented by states though a multimedia mitigation program that simultaneously addresses drinking water and indoor air issues caused by radon.

The Massachusetts Office of Research and Standards has set a guideline (Action Limit) for Radon-222 of 10,000 pCi/L. When concentrations exceed this value, indoor air should be

tested. If EPA were to promulgate the previously issued regulations, Massachusetts would be required to revise the state's requirements. Based on the delay in issuing the rule proposed in 1999, it is not anticipated EPA will move forward in the near future.

Massachusetts Drinking Water Standards & Guidelines

The Drinking Water List of Standards and Guidelines is a compendium of guidance values available for evaluating contaminants in drinking water in Massachusetts. Four primary types of guidance, designated as Standards or Guidelines, are available for assessing drinking water quality in the Commonwealth. The guidance values are contained in separate lists as follows:

- Standards
- Massachusetts Maximum Contaminant Levels (MMCLs) – Inorganic and Organic Chemicals
- Massachusetts Maximum Contaminant Levels - Radionuclides
- Massachusetts Maximum Contaminant Levels - Biologicals
- Guidelines
- Massachusetts Drinking Water Guidelines
- US EPA Secondary Maximum Contaminant Levels
- US EPA Health Advisories

In addition to the drinking water standards and guidelines, MassDEP has also derived Immediate Action Levels for routinely used water treatment chemicals to enable water treatment plant operators to identify and address serious incidents of chemical overfeed or misuse.

Emerging Contaminants

Emerging contaminants can be defined as chemical or non-chemical materials that have the reasonable ability to enter the environment and present a potential risk to human health or the environment, and either do not have a regulatory requirement to address them or the requirements are evolving as new science and detection capabilities evolve.

MassDEP oversees the Emerging Contaminants Workgroup, which started in 2007. This group is "charged with identifying and assessing public health and environmental problems associated with currently unregulated or under-regulated contaminants, and recommending agency strategies for addressing them." The Emerging Containments Workgroup developed a preliminary list of 80 containments initially, and has revised the list to eight priority emerging contaminants to actively monitor and evaluate: 1,4-dioxane, cyanobacteria (blue green algea), nanoparticles, perchlorate, Pharmaceuticals, Personal Care Products & Endocrine Blocking Compounds, Polybrominated Diphenyl Ethers (PBDEs), Tetrachloroethylene (PCE), and Trichloroethylene (TCE).

The following sections discuss emerging contaminants in more detail:

1, 4 Dioxane

As described in Water Research Foundation's 2014 White Paper,[4] "1,4-dioxane is a synthetic industrial chemical that is completely miscible in water. The largest sources of 1,4-dioxane in drinking water sources are wastewater discharge, unintended spills, leaks, and historical disposal practices of its host solvent, 1,1,1-trichloroethane (TCA). 1,4-dioxane readily dissolves into groundwater, and its movement is not retarded significantly by sorption to soil particles. It is highly mobile, recalcitrant to microbial degradation, and has a low tendency to volatilize from water. Conventional water treatment practices (e.g., coagulation, sedimentation, and filtration), aeration, GAC adsorption, ozone, UV, and biofiltration have proven to be ineffective at removing 1,4-dioxane from water. Advanced oxidation processes including a combination of hydrogen peroxide and ferrous iron, ozone and hydrogen peroxide, and UV and hydrogen peroxide have been shown to be effective for oxidizing 1,4-dioxane."

1,4 dioxane is readily absorbed through the gastrointestinal tract. Research shows that 1,4-dioxane is a probable human carcinogen. No federal maximum contaminant level (MCL) for drinking water has been established, however, 1,4-dioxane is included on the fourth drinking water contaminant candidate list and was included in the Third Unregulated Contaminant Monitoring Rule.

EPA established a 1-day health advisory of 4.0 milligrams per liter (mg/L) and a 10-day health advisory of 0.4 mg/L in drinking water for a 10-kilogram child and a lifetime health advisory of 0.2 mg/L in drinking water (EPA 2012). Most states are following EPA's 1 x 10^{-6} cancer risk level for 1,4-dioxane of 0.35 ug/L (EPA IRIS 2013). Various states have established drinking water and groundwater guidelines. Table 2-14 lists regulatory guidelines for 1,4 dioxane in drinking water in the U.S Northeast as reported in EPA's November 2017 Technical Fact Sheet for 1,4 Dioxane.

Table 2-12 Regulatory Guidelines for 1,4 Dioxane in Drinking Water

State / Agency	Regulation
EPA	0.35 ug
Connecticut	Action Level: 3 ug/L
Maine	Maximum Exposure Guideline: 4 ug/L
Massachusetts	Guideline: 0.3 ug/L
New Hampshire	Ambient groundwater quality standard: 3.0 ug/L (also drinking water standard because no MCL is developed)
New York	Drinking Water Standard: 50 ug/L
Vermont	Health Advisory: 3.0 ug/L

[4] 1,4 Dioxane White Paper prepared by Water Research Foundation, available online at: http://www.waterrf.org/resources/StateOfTheScienceReports/1,4-dioxane.pdf

Perchlorate

Perchlorate is used in rocket fuel, munitions, fireworks, flares, some blasting agents and can be a contaminant in certain drinking water disinfection products. It is an endocrine disrupter and affects thyroid hormone levels responsible for normal growth and development. Perchlorate is not a federally regulated contaminant in drinking water, but is considered an "emerging contaminant". To address this concern, in 2007 Massachusetts adopted a MCL for perchlorate of 2 ppb, which is much lower than EPA's health advisory of 15 ppb.

Pharmaceuticals and Personal Care Products (PPCPs)

Pharmaceutical and Personal Care Products (PPCPs) include medicines, insect repellents, sunscreens, perfumes, soaps, fragrances, and lotions. Some specific examples include aspirin, acetaminophen, ibuprofen, pain medications, blood pressure medications, and antibiotics. These commonly available products have the potential to enter the environment through domestic sewage and improper disposal. Some are endocrine disrupting compounds (or EDCs). When endocrine disrupting compounds (EDCs) are released into the environment, they have the potential to interfere with the normal function of the endocrine systems of living organisms that come into contact with them. The endocrine system is a complex network of glands and hormones that regulates many essential biological functions and processes in living systems including growth, development, maturation, reproduction, and metabolism in animals, including people. The endocrine glands - including the pituitary, thyroid, adrenal, thymus, pancreas, ovary and testis - release carefully-controlled amounts of hormones into the bloodstream that act as natural chemical messengers, traveling to different parts of the body to control and adjust many life functions.

Some of these PPCPs and EDCs are considered "emerging contaminants", which are defined by MassDEP as:

- a perceived or real threat to human health, public safety or the environment;
- no published health standards or guidelines;
- insufficient or limited available toxicological information or toxicity information that is evolving or being re-evaluated; or,
- significant new source, pathway, or detection limit information.

PPCPs and EDCs have been detected in water samples collected from surface waters and groundwater under the influence of surface water. PPCPs or EDCs are not completely removed by water treatment, and therefore there could be low amounts of these substances in some drinking water supplies. Although the concentrations of PPCPs and EDCs in drinking water supplies are at levels far below therapeutic doses, the potential effects from continuous low dose chronic exposure to these compounds in humans have not been well studied.

According to the American Water Works Association, given that even trace concentrations of PPCPs and EDCs may affect human health, and given these compounds' ubiquity, the observed effect on fish and amphibians, and their continued presence of some compounds after wastewater treatment processes, the consensus in the drinking water community is that they deserve close study and, possibly, mitigation efforts.

At the national level, research is underway to determine how effectively existing drinking water treatment practices such as chlorination, carbon filtration, and ozonation remove PPCPs and EDCs. The water treatment industry is developing and evaluating several promising new and innovative technologies that specifically target PPCPs and EDCs for removal. One example uses a catalyst called TAML(r) (iron plus tetra-amido macrocyclic ligand) to remove PPCPs and EDCs from wastewater. Another uses zeolite adsorption to remove PPCPs and EDCs.

Locally, MassDEP is participating in a study with the University of Massachusetts (Amherst) and AECOM to examine twelve PPCPs and EDCs to determine treatment efficiency as well as whether treatment produces potentially harmful "daughter" compounds. This study will also examine the potential of these chemicals, and any daughter products, to interfere with the endocrine system.

Per- and polyfluoroalkyl substances (PFAS)

PFASs are a group of man-made compounds that have extensive industrial and consumer product applications including carpets, clothing, furniture, non-stick cooking surfaces, food packaging, and fire fighting foams. Due to their extensive use, most people have been exposed to PFASs. PFASs are persistent in the environment and are water soluble, resulting in PFASs being found in groundwaters and surface waters across the country. In recent years, the analytical techniques for PFASs in water have improved and they can now be detected at the very low concentration of nanograms per liter, or parts per trillion. As a result, they are being more commonly detected in groundwater and drinking water supplies.

Perfluorooctanoic acid (PFOA) and Perfluorooctane-sulfonate (PFOS) are two of the most extensively produced and studied PFASs. Currently, there is no EPA Maximum Contaminant Level (MCL) for PFASs. However, EPA has developed a drinking water health advisory level of 70 ng/L for PFOA and PFOS, combined or individually, to protect the most sensitive populations from a lifetime of exposure with an appropriate margin of safety. USEPA established the health advisories for PFOA and PFOS based on the agency's assessment of the latest peer-reviewed science. Many states have also adopted PFAS regulations as shown in Table 2-13.

Table 2-13 Example PFC Regulations

State / Agency	PFC Regulation
EPA	PFOA and PFOS combined: 70 ng/L Health Advisory Level for Drinking Water
Vermont	PFOA: 20 ng/L Health Advisory Level for Drinking Water
New Jersey	PFOA: 40 ng/L Drinking Water Guidance Level PFOA: 14 ng/L Drinking Water Maximum Contaminant Level (Proposed) Perfluorononanoic acid (PFNA): 13 ng/L Drinking Water Maximum Contaminant Level (Proposed)
New Hampshire	PFOA and PFOS combined: 70 ng/L Ambient Groundwater Quality Standard
Maine	PFOA and PFOS combined: 70 ng/L Drinking Water Maximum Exposure Guidelines
Connecticut	PFOA, PFOS, PFNA, perfluorohexanesulfonate (PFHxS), and perfluoroheptanoic acid (PFHpA) combined: 70 ng/L Drinking Water Action Level

2.9.2 Water Quality Assessment

EPA's Safe Drinking Water Information System (SDWIS) database[5] was reviewed to identify if there were any water quality violations in Westford's water system. In addition, the last five years of Consumer Confidence Reports (CCRs) were reviewed as available relative to compliance with all primary and secondary drinking water standards. Information prepared by the Water Department was also reviewed to identify any recent or ongoing water quality issues.

Based on information in the SDWIS and the CCRs, the Water Department has met all applicable health standards regulated by the Commonwealth of Massachusetts and by the federal government as reported in the recent CCRs. There have been no exceedances of MCLs, Maximum Contaminant Disinfectant Levels (MDRLs), or associated goals, as shown in the charts below, with one exception as explained following Figure 2-6.

The Water Department operates a perchlorate treatment system adjacent to the Nutting Road Treatment Plant and removes low levels of perchlorate present in the raw water prior to entering the treatment plant. System sampling conducted from 2012 through 2016 reported in the CCRs indicates the highest level detected was 0.163 ppb, which is well below the 2 ppb MCL. The Water Department has recently received approval from MassDEP to bypass this treatment facility as the resin filters had become a hydraulic restriction in the raw water transmission to the Nutting Road Treatment Plant.

[5] https://www3.epa.gov/enviro/facts/sdwis/search.html

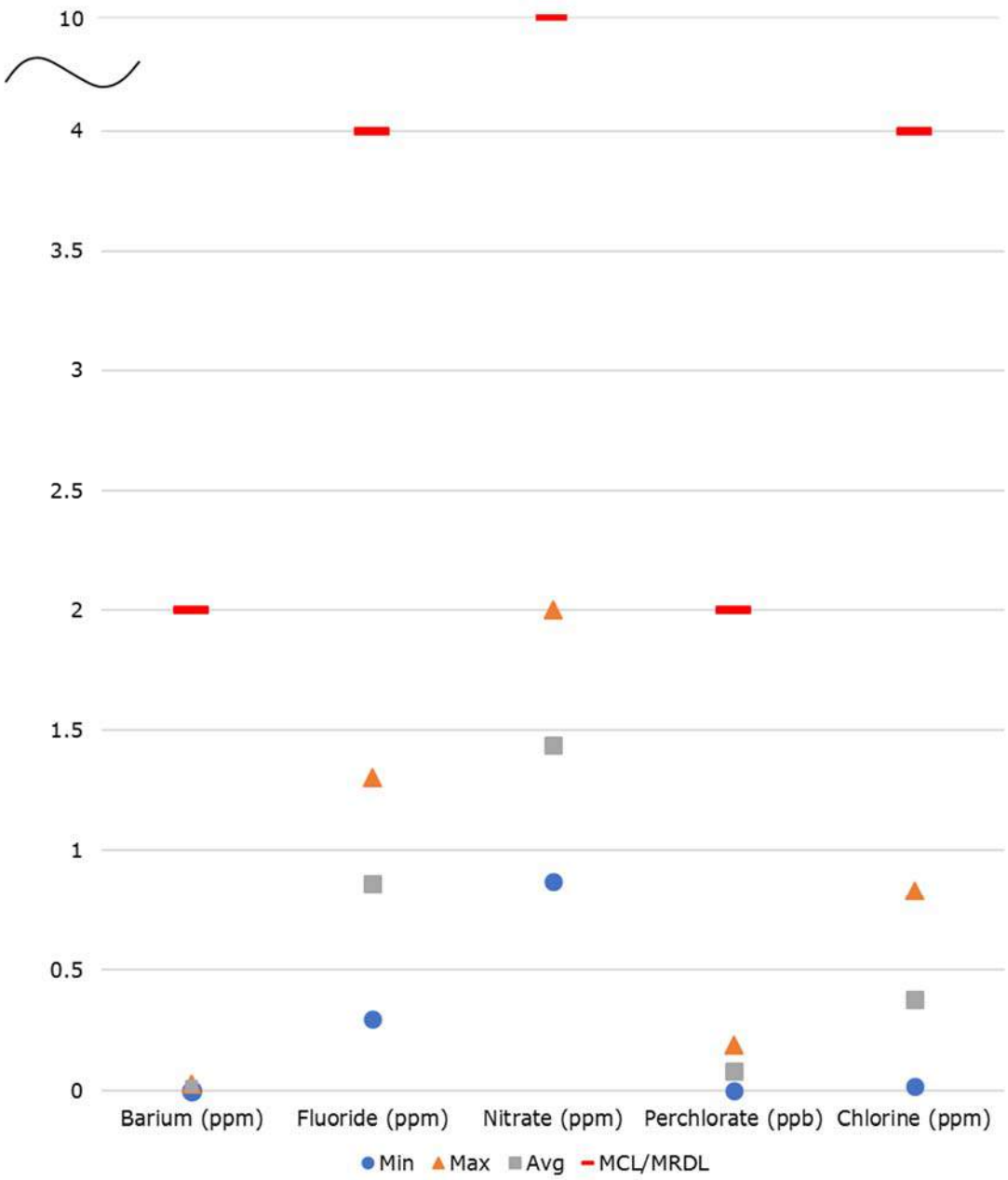


Figure 2-5 Water Quality Testing Results (1 of 2)

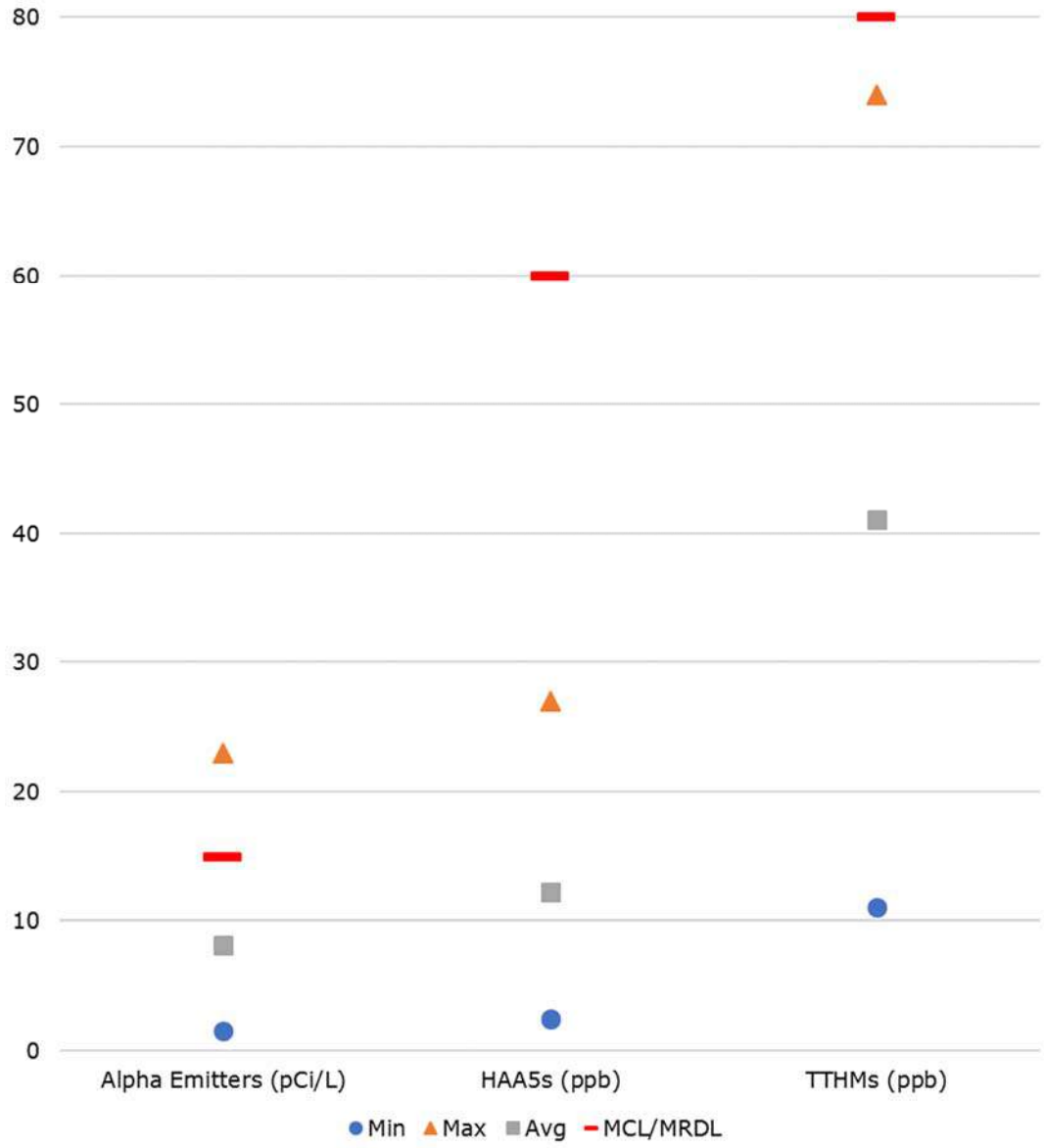


Figure 2-6 Water Quality Testing Results (2 of 2)

As noted in the 2014 CCR, "the same sample was analyzed [for Alpha Emitters] twice: the first result was 23 pCi/L and the second result was 1.6 pCi/L. The laboratory was unable to explain the discrepancy between the two results. The result of the second analysis (1.6 pCi/L) is more consistent with historical data from this location. The MassDEP used the average of the two results (12.3 pCi/L) to determine compliance with the MCL of 15 pCi/L. In addition, the MassDEP required an additional sample to be collected in the fourth quarter of 2014 to confirm acceptable water quality. The result of this additional sample was 2.1 pCi/L which was below the MCL of 15 pCi/L."

In addition, based on review of the CCRs, no SMCLs have been exceeded between 2012 and 2016. However, the ORSG of 20 ppm for sodium has been exceeded with results in the range of 35.2 to 78.4 ppm. Sodium is from natural sources, from runoff due to use

of salt on roadways for winter de-icing, and is a by-product of the treatment process. This is only a concern to sensitive individuals, such as those experiencing hypertension, kidney failure, or congestive heart failure.

The chart below demonstrates the concentrations of lead and copper found at consumer taps between 2004 and 2015. Westford has consistently been below the MCLs for both contaminants.

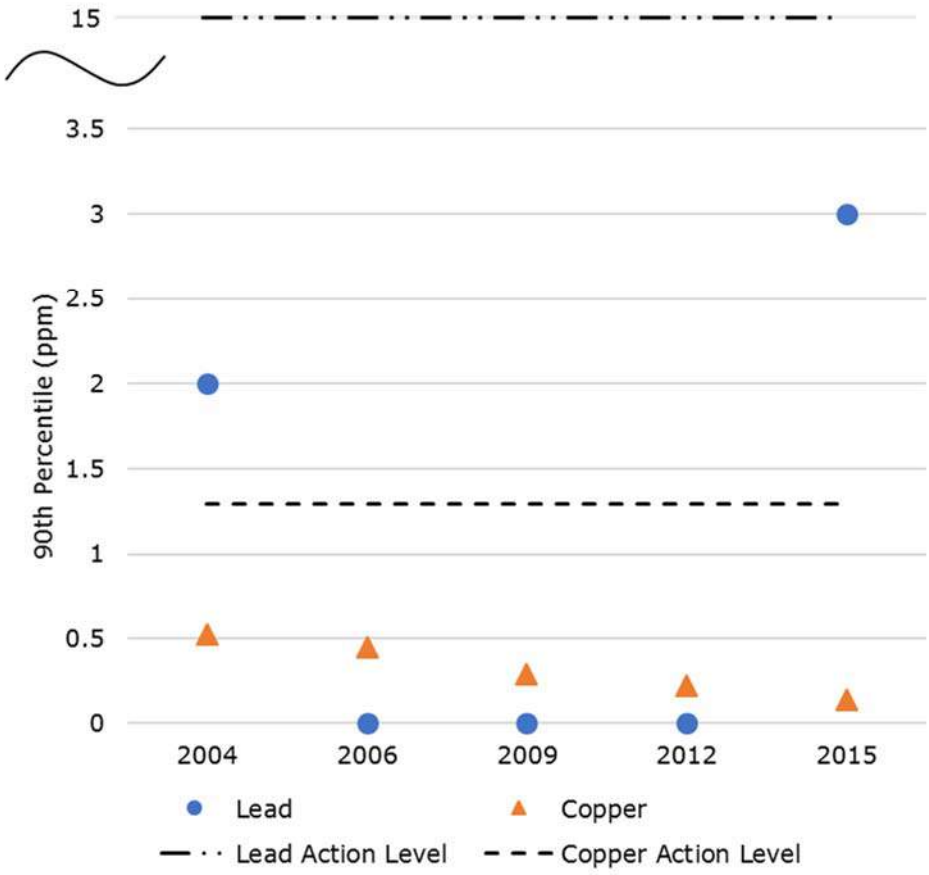


Figure 2-7 Lead and Copper Sampling Results

As reported in the SDWIS, the Department incurred a violation of a primary drinking water regulation in two instances in early 2012, one related to regular monitoring for radionuclides (e.g. radium, uranium, etc.) and one related to following up on routine tap monitoring and reporting for the lead and copper rule. Both violations have been addressed through orders issued by EPA and MassDEP and follow up work completed by the Water Department.

The most recent round of UCMR3 was completed in 2015. The following table is a summary of the results of the contaminant concentrations that were present in the drinking water above the established detection limit.

Table 2-14
Westford Water Department UCMR3 Results (1/14/2015)

Contaminant	Advisory Level[1] (ppb)	Range Detected (ppb)	Average Detected (ppb)
1,4 dioxane	0.3[2]	ND – 0.1	0.065
Perfluorooctanoic Acid	0.4	0.0072 – 0.0085	0.00785
Chlorate	210	25.4 – 72.1	58.5
Chromium	100	ND – 0.4	0.37
Chromium 6	100[3]	0.085 – 0.18	0.16
Strontium	1,500	140 – 200	179

(1) The advisory levels can vary from state to state or be set by the EPA.
(2) An advisory level set by Massachusetts.
(3) Currently included in the total Chromium standard of 100 ppb.

The Water Department's staff have had concerns about TTHMs, circulation, and residence time based on water quality issues experienced in summer 2016. As furthered described in Section 4.5.5, Tighe & Bond modeled existing water age and a series of alternative improvements which could help address these water quality concerns.

Water Department staff also want to be proactive to address and will continue to monitor emerging contaminants including PFASs. Massachusetts is underway with developing a drinking water action level for PFAS. Based on recent information, release of an action level similar to Connecticut's approach of 70 ppt for five PFAS compounds is expected to be released very shortly. In addition, laboratory methods have become more advanced since the third round of UCMR sampling so detection limits are lower and therefore the next round should provide better information on PFAS levels in the water supply.

The Water Department should continue to look for a draft of the revised lead and copper rule sometime during 2018 and should consider providing comments to EPA about the proposed rule as it has the potential to have a significant impact on current Department procedures and practices.

We anticipate that EPA will provide formal notice to public water suppliers of their obligation to address fourth Unregulated Contaminant Monitoring Rule (UCMR 4). Once notice is received, the Water Department should undertake the required monitoring.

Section 3

Section 3
Evaluation of Existing Facilities

Tighe & Bond and Water Department staff conducted site visits to all of the Water Department facilities. This Section provides a summary of conditions observed at each facility. As part of the site visits, we considered the following categories in making our general observations:

- Site/Civil/Security
- Process/Mechanical
- Structural/Architectural
- Electrical
- HVAC; and
- Instrumentation and Controls.

The individual evaluation forms that were developed for each facility are included in Appendix C.

3.1 Forge Village Water Treatment Plant

The Forge Village Water Treatment Plant is located at 60 Forge Village Road. Construction of the facility was completed in 2004 along with the Nutting Road Water Treatment Plant as part of the water treatment initiative. The facility has a capacity of 3.0 million gallons per day (MGD) and treats water from Forge Village No. 1 Wellfield, Forge Village No. 2 Well, Howard Road Well, Fletcher Well, and Country Road No. 2 Well. This facility also serves as the Water Department Operations Center. Office space is provided for the Water Superintendent, Business Manager, Environmental Manager, administration staff, and operations staff.





Figure 3-1 Forge Village Water Treatment Plant and U.V. Reactors

The treatment process for the Forge Village and Nutting Road Treatment Plants are identical and include the following:

Chemical Feed - Four chemicals are added to the raw water prior to filtration. Potassium hydroxide (KOH) for pH adjustment, calcium hypochlorite mixed oxidant (MIOX) for oxidation/pre-disinfection, potassium permanganate (KM_nO_4) for oxidation, and alum for coagulation of color.

Greensand Pressure Filtration - Three horizontal pressure filters are used for filtration of precipitated iron, manganese, and coagulated color. Each filter contains greensand media and has capacity to treat 1.0 MGD.

Aeration – Aeration towers are packed with plastic media and utilize forced draft aeration to reduce corrosiveness by reducing carbon dioxide and also reduces radon.

Clearwell – Below ground clearwell contains 275,000 gallons of storage and provides required chlorine contact time for 4 log removal of viruses. Clearwell also provide flow equalization and storage for water used in filter backwashing.



Figure 3-2 Greensand Filter and piping at Forge Village Treatment Plant

Post-Filtration Chemical Feed - Chemicals that are added post-filtration include MIOX for disinfection, KOH for pH adjustment, and fluoride for dental health.

UV Disinfection - Three ultraviolet disinfection units provide an additional barrier of bacteria and virus treatment and to reduce the MIOX demand.

Pumping Systems - Two high head vertical turbine pumps at each plant pump water from the clearwell into the distribution system. Pump speeds are controlled by variable frequency drives which allow the flow to fluctuate to meet demand.

Backwash Disposal – Backwash water at the Forge Village Treatment Plant is discharged to two on-site unlined infiltration basins. Backwash water infiltrates into the ground slowly over time. These basins require periodic maintenance including removing and disposal of the residuals buildup. Due to the site constraints at the Nutting Road Treatment Facility, a backwash recycle system is utilized at this location. Backwash wastewater is discharged into two in-plant recycle tanks. As the solids settle to the sloped bottom of the tank, the supernatant is pumped off and recycled into the raw water feed to the plant. Accumulated sludge is periodically pumped from the tank and stored in an on-site tight tank. An emergency infiltration basin is located on-site that allows the Water Department to discharge backwash water in the event that there is a malfunction of the recycle system.

SCADA Control System - A state-of-the-art Supervisory Control and Data Acquisition (SCADA) System controls the operation of each plant and the entire water system. There are also integrated controls for the chemical feed systems at each plant.

Standby Power - Each treatment plant is equipped with a standby generator and automatic transfer switch that provide standby power for the entire facility in the event of a power failure. The generators are supplied by natural gas.

Security and Alarms - Water works facilities require alarms to protect the water quality, reliability and security of the treatment plant. Each facility has the following alarms:

- High/low chemical dosage for pH, chlorine (MIOX), KM_nO_4
- High turbidity
- High/low chemical tank levels
- High/low clearwell level
- Low UV level
- High/low pressure
- Intrusion, fire, flood, temperature, humidity
- Generator failure
- Eyewash shower

General observations made during the site visit include:

- Overall the Forge Village Treatment Plant building is in excellent condition. The Water Department has made some recent repairs to the roof over the Filter Room to address structural support damage caused by excessive snow load.

- The facility is over thirteen years old and contains many of the original equipment. The greensand media is approaching the end of its useful life and should be replaced within five years. Consideration should be given to adding a double door access to the Filter Room in order to assist with the media replacement process.

- This facility was one of the first water treatment facilities in this area to utilize ultraviolet light reactors for disinfection. These reactors are low pressure units that have high operation and maintenance costs due to the energy that is used and the annual lamp replacement. Many technological advances have been made with ultraviolet light equipment since this plant went on-line and the Water Department should consider replacing the equipment within the next five to ten years. This work will require the entire treatment plant to be taken off-line for the work to occur.

3.1.1 Forge Village No. 1 Pumping Station

The Forge Village Wellfield No. 1 and pumping station is located at 65 Forge Village Road and pumps raw water directly across the street to the Forge Village Treatment Plant. It was constructed in 1907 as the original water supply for the Westford Water Company. The original wellfield contained ten 2½-inch naturally developed wells that are approximately 30 feet deep. Five 8-inch gravel-packed wells were added later to replace the tubular wellfield. These wells were augmented by a single gravel-packed well in 2005. The pumping station is a three-room brick and block building. Two of the rooms are used for storage and the third room houses the pumping and control equipment. The main pump is a 75 HP vertical centrifugal pump with a design capacity of 350 gallons per minute (gpm). The pump typically pumps between 90 and 120 gpm. If this flow is exceeded, the main pump could overpump the wellfield and eventually lose the priming system. The Town's inactive landfill is located adjacent to the wellfield.



Figure 3-3 Forge Village No. 1 Pumping Station

General observations made include:

- Overall the building is in good condition considering its age. Building envelope and structure in good condition, but doors, windows and roof should eventually be replaced

- The pump station lacks adequate pumping control. At higher flows, the station loses the vacuum priming system. The Water Department should consider upgrading the pump and control system so that this source can deliver consistent volume.

- The pump station does not have any standby power. The Water Department should consider connecting the electrical service of this pump station to Forge Village Well No.2 so that a new standby generator at that location can provide backup power to both sources.

- There is no security fence at the site. Although the building has been targeted with minor graffiti, vandalism has generally not been a problem at this location. Security fence should be installed around the active well.

Water Department staff has reported that low levels of 1,4-dioxane have been observed in the monitoring wells at the landfill. This contaminant has not been found present in any samples taken at the wellfield. The Water Department should consider as part of any upgrades at the Forge Village Treatment Plant to include providing treatment for 1,4-dioxane.

3.1.2 Forge Village No. 2 Pumping Station

Forge Village No. 2 well and pumping station are located adjacent to the Forge Village No.1 wellfield and also pump directly to the Forge Village Treatment Plant. The well and pump station were constructed in 1970. The gravel packed well is 24" x 48" and was constructed to a depth of 62 feet. The pumping station is a single room block building with a partial basement for the below ground discharge. The well pump is a 75 HP vertical turbine pump that typically pumps between 350 and 400 gpm. Backup power is provided by an auxiliary engine. The facility is secured by a chain link fence.



Figure 3-4 Forge Village No. 2 Pumping Station

General observations made during the site visits include:

- The building envelope and exterior walls are in good condition.
- The pump packing continuously leaks on the steel grating which has caused corrosion of the grating, steel beams and piping. The Water Department should replace this when the well is rehabilitated.
- Water Department staff reported that the pump station is vulnerable to power failures. Although the auxiliary engine is operable, the Water Department should consider replacing this with a new standby generator and automatic transfer switch that will provide backup power to this pump station and Forge Village No.1.

3.1.3 Country Road No. 2 Pumping Station

The Country Road No. 2 well and pumping station was constructed in 2009 to replace the original Country Road No. 1. The station is located at 15 Country Road and pumps to the Forge Village Treatment Plant. The gravel packed well is 10" x 16" constructed to a depth of 70 feet. The well has an approved capacity of 425 gpm. The pumping station is a precast concrete building housing the pumping and control equipment. The equipment includes a deep well vertical turbine pump with a 30 HP motor. Water Department staff

reported that the pump station typically pumps approximately 275 gpm in the summer and 150 gpm in the winter. A standby generator provides backup power for the pump station. The facility is secured by a chain link fence with barbed wire.



Figure 3-5 Country Road No. 2 Pumping Station

General observations made during the 2016 site visits include:

- Building and site are in excellent condition
- Minor staining of the pipe and floor due to condensation
- Well required rehabilitation approximately every two years

3.1.4 Fletcher Pumping Station

The Fletcher Well and pumping station were constructed in 1998. This source is located on Concord Road, and pumps to the Forge Village Treatment Plant. The well is a 24" x 48"



Figure 3-6 Fletcher Well and Pumping Station

gravel packed well that is constructed to a depth of 78 feet. The well is located 120 feet from the pumping station adjacent to the Beaver Brook wetland resource area. The well is equipped with a 75 HP submersible well pump and motor with a pitless adapter wellhead. The pump has a capacity of 600 gpm. However, the Water Department typically pumps this source at 150 gpm in the winter and between 300 and 325 gpm in the summer due to the high manganese levels. The pumping station is a masonry block building that houses the pump controls, station instrumentation and controls, standby generator and automatic transfer switch. The station includes a separate containment room for chemical feed equipment, including phosphate and potassium hydroxide, which were used prior to construction of treatment facilities. The station and site are well maintained and the site includes fencing, lighting, and intrusion alarms for security.

General observations of this location include:

- The building is in good condition and is approaching twenty years old. Asphalt shingle roof will need to be replaced within next five to ten years.
- Generator exhaust pipe needs to be covered to prevent water entering exhaust system.
- Security fence should be installed around the well.
- Monitoring wells should be marked to prevent damage by plows.

3.1.5 Howard Road Pumping Station

The Howard Road pumping station is located at the end of Howard Road and is the most remote source that pumps water to the Forge Village Treatment Plant. This source contains five 10" x 16" gravel-packed wells with submersible pumps that are approximately 24 feet in deep. These wells were installed in 2005 to replace the original five 8-inch wells. The pump station includes a vertical turbine can pump with vacuum priming system. The pump typically pumps between 230 and 235 gpm in the summer and 150 gpm in the winter. The pumping station is a block building housing the pumping and control equipment. Standby power is provided with an auxiliary engine. The facility is secured by a chain link fence and an alarm system.



Figure 3-7 Howard Road Pumping Station

General observations made during the site visit include:

- Pump station building and site are in good condition
- Wellfield was recently rehabilitated
- Vacuum pump needs replacement
- Beaver activity in the area occasionally causes water levels to rise close to the facility

3.2 Nutting Road Water Treatment Plant

The Nutting Road Water Treatment Plant is located at 17 Nutting Road. It was constructed with the Forge Village Treatment Plant in 2004 and has a capacity of 3.0 MGD. This facility treats water from Nutting Satellite Wells, Depot Road Well, Cote Well, and Stepinski Well. This facility has an identical treatment process as the Forge Village Treatment Plant with the exception of the backwash residuals handling. All backwash wastewater is discharged into recycle tanks located beneath the Filter Room. After the solids settle out, the the supernatant is pumped back into the raw water at a rate of approximately 10% of the raw water flow. Solids that are collected in the bottom of the tanks are periodically pumped to an on-site tight tank and eventually hauled to a receiving facility. The Perchlorate Treatment Facility is located at this site and is used to remove low levels of perchlorate in raw water prior to entering the treatment facility.



Figure 3-8 Nutting Treatment Plant and U.V. Reactors

General observations of the treatment facility include:

- Exterior of building generally in good condition. However, wood siding requires periodic maintenance and should be repainted within the next five years.
- Clearwell exterior roof has some minor cracking and stains. Water Department should recoat this surface within the next five years.
- Some shingles (especially around vent stack) need replacement.

- The existing ultraviolet light disinfection equipment are low pressure units with high operation and maintenance costs due to annual lamp replacement. The equipment should be replaced within the next five years with new technology equipment similar to would be installed at the Forge Village Treatment Plant.

3.2.1 Nutting Road Pumping Station

The Nutting Road pumping station is located at 19 Nutting Road behind the Treatment Plant. This original well source had for years experienced poor water quality, specifically high organic color. Two satellite wells were installed approximately 150 feet from the pumping station with submersible pumps which pump directly into the original well. The pumping station is a small masonry block building, which houses the pumping and control equipment that is all located in a recessed floor. The vertical turbine pump is 40 HP. The source typically pumps approximately 100 gpm in the winter and between 200 to 250 gpm in the summer. A new standby generator was recently installed to provide backup power at this location. The pump station is secured by a chain link fence but not the satellite wells.



Figure 3-9 Nutting Road Pumping Station

General observations made include:

- The metal roof was in need of replacement and the Water Department has completed this work since our visit.
- Some corrosion was evident on the pump base support
- Exterior lighting and door lock need replacement
- Exterior vent needs to be replaced
- Wooden platform and stairs should be replaced
- Security fencing should be installed around the satellite wells

3.2.2 Depot Road Pumping Station

The Depot Road pumping station is also connected to the Nutting Road Treatment Plant. It contains a 24" x 48" gravel packed well that is 51 feet deep. The pump station is a small concrete and aluminum panel building which houses the pumping, and control equipment. The deep well vertical turbine pump is 60 HP and typically pumps 175 gpm in the winter and 300 to 350 gpm in the summer. Recently, electrical improvements were completed at the station that include a standby generator. The facility is secured by a chain link fence.



Figure 3-10 Depot Road Pumping Station

General observations made during the 2016 site visits include:

- The building structure is in good condition. Water Department staff noted that the roof experiences minor leakage at times. The entire roof should be replaced within the next five to ten years.

3.2.3 Cote Pumping Station

The Cote Pumping Station is located along the gravel access road known as the "Car Line" between Beacon Street and Nutting Road. It includes a 24" x 42" gravel-packed well that is constructed to a depth of 38 feet. The well pump is 60 HP and has a capacity of 450 gpm. This well pumps to the Nutting Road Treatment Plant and was contaminated with perchlorate from blasting operations during construction of the new Highway Department. An ion exchange treatment and ultraviolet light system were installed to remove the contaminant at this source. Once the new perchlorate treatment facility was constructed at Nutting Road, these systems were taken offline. The station includes an auxiliary engine for backup power. The pump station facility is secured by a chain link fence, however there is no gate at the entrance to the access road.



Figure 3-11 Cote Pumping Station

General observations made during our site visit include:

- Building and site are in good condition.
- Water Department should secure entrance to site with a bar gate.
- Backup power is provided by an auxiliary engine. A fixed standby generator may not be required at this site as the Stepinski well is located nearby and has full backup power. However, the Water Department is considering installing a portable generator with a manual transfer switch.

3.2.4 Stepinski Pumping Station

The Stepinski Pumping Station is the Water Department's newest source. The facility was constructed in 2011 and includes contains a 75 deep gravel packed well 75 feet deep that was constructed on the south side of Stony Brook, behind the American Legion Ball Fields. The well is located in a small precast concrete building that pumps through a transmission main under Stony Brook to a new Meter Building located off of the Car Line at 31 Beacon Street. The Meter Building is also a small precast concrete building that houses the master meter for the source and the monitoring equipment. The well pump has a maximum capacity of 850 gpm, however, the Water Department has been operating it at a reduced capacity in order to reduce the risk of perchlorate contamination. The well pump was recently replaced due to corrosion of the shaft. A standby generator is located at the Meter Building and provides backup power for both buildings. Both facilities are secured by a chain link fence. The facilities are in excellent condition and do not need upgrades.





Figure 3-12 Stepinski Well Pumping Station



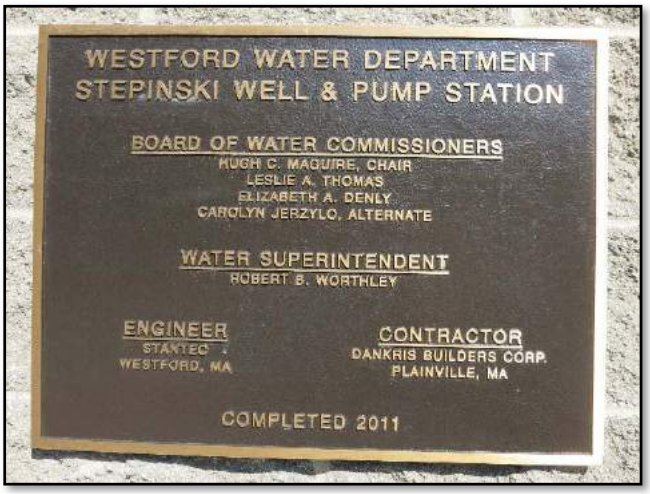


Figure 3-13 Stepinski Meter Building

3.3 Perchlorate Treatment Facility

The Perchlorate Treatment Facility was constructed in 2011 at the site of the Nutting Road Treatment Plant. The treatment facility is designed to remove low levels of perchlorate that may be present in the raw water from the wells that supply the Treatment Plant. Perchlorate was detected in the Cote Well beginning in 2004 and was caused by the blasting operations during the construction of the new Highway Department off of North Main Street.



Figure 3-14 Perchlorate Treatment Facility

The treatment facility was constructed with a pre-engineered metal building and utilizes four ion exchange resin filters to remove the perchlorate. The resin must be periodically replaced when breakthrough is approached. Because the facility is located on the raw water side of the treatment plant, the filters would frequently bind up from the high concentrations of iron and manganese. This would cause frequent hydraulic issues for the Water Department as it would limit the treatment and pumping capacity for the area of the distribution system served by the Nutting Road Treatment Plant. The resin required replacement on a frequent basis and at a significant expense. Due to these issues and the low concentrations of perchlorate that were present, the Water Department requested permission from MassDEP to bypass the facility and blend with non-contaminated sources. In addition, perchlorate concentrations remained below the EPA action levels. In 2017, MassDEP granted the Water Department permission to bypass the facility indefinitely. As the facility is fairly new and will be used only on a limited basis, no improvements are recommended at this time.

3.4 Storage Facilities

3.4.1 Prospect Hill

The Prospect Hill water storage tank is a 172,000-gallon riveted steel standpipe. It was built in 1907 and is located off of Main Street near the center of town. The tank is 18 feet in diameter and 90 feet high. It provides the only storage in the High Service Zone and has an overflow elevation of 558.4 feet. The tank is used for multiple live antennae for the Town's Water, Fire, and Police Departments, as well as the telecommunications company AT&T. The building on site is owned by AT&T, but the Department can utilize the generator within the building in the event of a power outage. The water storage tank and building are enclosed by a chain link fence with barbed wire. This tank was last rehabilitated in 2002. On May 4, 2015, Utility Service Group (USG) completed a full inspection of the tank and provided a list of recommendations for rehabilitation of this structure.



Figure 3-15 Prospect Hill Tank

Replacement of the Prospect Hill Tank was first recommended in the 2007 Water System Master Plan Update. A recent fire in the Town Center highlighted the lack of fire protection storage that this tank provides. The Water Department has since proceeded with the design and construction of a new 600,000 gallon composite elevated tank that will be construction adjacent to this tank. Construction of the new tank is scheduled to be completed in late 2018. The existing standpipe will be demolished after the new tank is placed into service.

3.4.2 Town Farm Road

The Town Farm Road water storage tank is a 430,000-gallon riveted steel standpipe that was also constructed in 1907 off of East Prescott Street across from Town Farm Road. The tank is 35 feet in diameter and 60 feet tall. There is limited access to the tank and site and there is no security fencing. The tank was last painted in 2000.



Figure 3-16 Town Farm Road Tank (Photo: UST, 2015)

On May 5, 2015, USG conducted an inspection of the tank. The purpose of the inspection was to determine the current coating condition and evaluate the tank for compliance with current sanitation guidelines, safety and security regulations, and guidelines. The following observations and recommendations were provided:

- Rehabilitate the exterior coating by pressure washing all exterior surfaces to remove chalk, dirt, mildew and foreign contaminants, then spot prepare any paint

failed/corroded areas and apply a suitable spot primer before the formation of any rust bloom. Apply a full coat of acrylic polyurethane.

- Consider cleaning the roof, remove the loose caulking, applying another layer of fiberglass matting and a gel coat, then re-caulking all of the seams. There are weathered areas on the fiberglass where light is shining through to the interior indicating thin areas.
- All interior surfaces should be completely abrasive blast cleaned followed by the application of a coating system. Sediment was present on the floor at time of this inspection.
- Remove all of the loose and cracked flexible sealant between the base plate and the foundation then apply a new flexible sealant around the entire circumference of the tank.
- Install a screen/flapper combination valve on the overflow termination to keep birds and insects from entering the water chamber.
- Perform regular washout inspections to remove sediment and to fully evaluate the interior on a frequent regular basis.
- The tank interior should be drained and chemically cleaned on a regular basis to remove staining and possible biofilm buildup to ensure the best sanitary condition.
- Install an active mixing system to keep a consistent chlorine residual, reduce thermal stratification and help prevent winter ice damage to the coatings and structure.
- Remove the 15" X 11' manway and replace with a 24" bolted manway to comply with OSHA confined space requirements.

The Water Department should consider completing a full rehabilitation of this tank within the next five years. This should include improvements to the access road, site, full rehabilitation of the interior and exterior coatings, and other general structural and safety improvements.

3.4.3 Francis Hill

The Francis Hill water storage tank is a 1.25 MG welded steel standpipe that was built in 1970. The tank is located off of Hunt Road, with an access road between Francis Hill Road and the Westford/Chelmsford town line. The tank is 60 feet in diameter and 60 feet high with an overflow elevation of 407.6 feet. The tank and site has no security fencing. This tank was last painted in 2002.



Figure 3-17 Francis Hill Tank

USG conducted an inspection of this tank also on May 5, 2015. The following is a summary of their observations and recommendations that were included in their inspection report:

- Rehabilitate the exterior coating by pressure washing all exterior surfaces to remove chalk, dirt, mildew and foreign contaminants, then spot prepare any paint failed/corroded areas and apply a suitable spot primer before the formation of any rust bloom. Apply a full coat of acrylic polyurethane.
- The interior coatings are in overall good condition with no signs or blistering or significant deterioration. Staining is present, it is recommended to chemical clean and evaluate coating conditions for possible repair or failed areas at that time. Visible surface rust and corrosion are occurring on the roof beams and roof to shell junction. Annual inspections are recommended to keep records of any further deterioration of the coating and metal loss and perform rehabilitation prior to any significant damage occurs to the tank.
- Remove all of the loose and cracked flexible sealant between the base plate and the foundation then apply a new flexible sealant around the entire circumference of the tank.
- Replace the existing vent with a welded receiver flange to which a properly sized aluminum freeze resistant, vacuum/pressure relief type vent can be bolted into place.
- Install a properly sized air gap in the current overflow pipe.
- Perform regular washout inspections to remove sediment and to fully evaluate the interior on a frequent regular basis.
- The tank interior should be drained and chemically cleaned on a regular basis to remove staining and possible biofilm buildup to ensure the best sanitary condition.
- Install an active mixing system to keep a consistent chlorine residual, reduce thermal stratification and help prevent winter ice damage to the coatings and structure.
- Install 6 feet of handrail on either size of the shell access ladder on the roof edge.
- Install a site perimeter fence with locking access gate.

- Remove the ladder cage and install a locking anti-climb ladder gate to prevent unauthorized access.
- Install locks on all roof access hatches. Repair one of the lock hasps by bending it back in alignment.

In addition, the following general observations were made during our site visit:

- Tank exterior is stained and should be power washed
- Tank experienced freezing during the winter of 2015/2016
- Power loss is an issue at this site
- Programmable logic controller is currently in a pit below grade, and should be raised above ground
- Security hatch should be installed at the bottom of the ladder
- Minor vandalism and graffiti were present on the tank

3.4.4 Hildreth Hills

The Hildreth Hills water storage tank is a 2.0 MG concrete reservoir that is partially buried. It was built in 1982 and is located on Monadnock Drive. The tank is 130 feet in diameter and 20 feet high. The overflow elevation is 407.6 feet. The Water Department rehabilitated the exterior coating approximately 10 years ago. There is no security fence around the tank, only around the small monitoring building.



Figure 3-18 Hildreth Hills Tank

On May 4, 2015, USG conducted an inspection of this tank. The following observations and recommendations were made:

- Exterior coatings are showing some mild weathering; some hairline cracks are visible with some mild calcium buildup along the cracks. Recommend over coating the exterior with a two-coat breathable acrylic coating to restore the aesthetics and to protect the concrete.
- The interior appears to not have a coating applied to it. There does appear to be some minor surface erosion occurring. In order to protect the concrete and to reduce possible bacteria growth, clean the concrete and apply a 100% solids epoxy liner.
- The tank interior should be drained and chemically cleaned on a regular basis to remove staining and possible biofilm buildup to ensure the best sanitary condition.
- Perform biannual washouts to remove sediment and regularly inspect the sanitary conditions. There was a substantial amount of sediment present in this tank during the inspection.

- Consider installing an active mixing system to keep a consistent chlorine residual, reduce thermal stratification and help prevent winter ice damage.
- Replace the overflow screen with a finer mesh stainless screen.

In addition, the following observations were made during our visit:

- Some staining on roof dome
- Monitoring building doors are showing some corrosion
- Site is wet
- Recent cleaning effort removed 12" of sediment from the tank
- Considering installing a mixing system to improve water turn over

3.4.5 Twin Peaks

The Twin Peaks water storage tank is a 1.0 MG concrete reservoir that was built in 1998 as part of the Greystone Estates subdivision. The tank is 65 feet in diameter and 39 feet tall. The access road to the tank is located off of Russells Way. There is no electrical service to the tank. The SCADA System is powered by a solar panel. The tank and site are enclosed with a chain link fence. This tank is the newest in the system.



Figure 3-19 Twin Peaks Tank
(Photo: Google Earth 3D Aerial, 2017)

On May 26, 2016, USG conducted an inspection of this tank. The following observations and recommendations were made:

- Both the interior and exterior surfaces were found to be in excellent condition.
- Minor degradation and cracking was observed on the roof.
- Corrosion of the interior overflow pipe and silt stop were observed.
- Vent screen required minor repairs
- The tank should be re-inspected in 2021 and if the corrosion has increased, the tank should be drained and the piping should be repaired and recoated.

In addition, the Water Department should consider installing a new mixing system when the tank is taken off-line for service.

3.5 Booster Pumping Stations

There are six booster pumping stations located throughout the water distribution system. Two booster stations (Station No. 2 and No. 3) are owned and operated by the Water Department. Booster Station No. 1 is located in the Hitchin Post Greens subdivision and is privately owned by the homeowners association. There is also a private booster pump station that services the Graniteville Woods Development off North Main Street. The

Water Department does not operate this pump station. The fifth booster station is located on the entrance to the Highway Department off North Street. This is a small pump station that provides water service to the facility. The Hildreth Hills private booster pump station serves some of the townhouses located in the condominium complex. For the purposes of this report, only Pump Station Nos. 1, 2, and 3 are described more in detail.

3.5.1 Hitchin Post Greens (Booster Pump Station No.1)

The Hitchin Post Green is an underground prefabricated booster pumping station (Booster Pump Station 1) that was installed in 1994 and is owned and operated by the Hitchin Post Greens Homeowners Association. The Water Department monitors the operation of this station. The pump station services the houses on Chicory Road and Rosebud Lane, which are constructed at the highest elevations of the subdivision. The pump station contains two active centrifugal-style pumps and one standby pump. The suction head is 85 feet. There is no standby power at this location.

3.5.2 Boston Road (Booster Pump Station No. 2)

Booster Pump Station No. 2 was constructed in 1995 on Boston Road near the Littleton Road intersection. There are three centrifugal-style skid-mounted pumps, with a total design capacity of 700 gpm. This pump station pumps water from the Low Service Zone to the High Service Zone. There is also a pressure reducing valve that allows water to



Figure 3-20 Boston Road Booster Pump Station

flow back from the High Service Zone to the Low Service Zone in the event of a large demand (i.e. fire). A standby generator is located inside the pump station that provides full backup power. The building is in good condition and requires minimal maintenance. The Water Department does not operate this station on a regular basis.

3.5.3 Booster Pump Station No. 3

Booster Pump Station No. 3 was constructed in 2004 as part of the Forge Village Treatment Plant. This pump station also pumps water from the Low Service Zone to the High Service Zone. The station is skid-mounted and contains two 30 HP centrifugal-style pumps, each with a design capacity of 500 gpm. It is located adjacent to the standby generator in the treatment plant and can operate at full capacity during a power failure.

Section 4

Section 4
Evaluation of Distribution System through Hydraulic Model

The previous hydraulic model for the Westford water distribution system was reconstructed as part of this assessment to include recent upgrades to the water distribution system. The model was also updated to include diurnal demand patterns to allow us to prepare extended period simulations. This Section describes the methods used to create the model and presents results and recommendations based on model simulations. Figures for this section are included at the end of the narrative.

4.1 System Map Update

As a precursor to updating the water system model, Tighe & Bond solicited input from Water Department staff on needed updates to the map of the distribution system. Water Department staff identified areas within the distribution system that have had extensions or improvements since the last water system map update was completed and provided corrections to incorrect or unclear information as part of their review and comment. Tighe & Bond updated the available water distribution system map in Geographic Information System (GIS) format. A copy of this map is included in Appendix A.

4.2 Model Development and Calibration

An Extended Period Simulation (EPS) hydraulic model of the Westford water distribution system was prepared and used to analyze the existing system under current and projected average and maximum demand conditions and to simulate the impacts of various improvement scenarios. The model was developed using InfoWater Suite 11.5 Software (Innovyze, Monrovia, CA), which offers modeling capabilities fully integrated with GIS. This Section describes the procedures used to import data from GIS shapefiles into InfoWater, as well as steps that were taken to resolve issues with the dataset. Westford provided relevant water system data layers in shapefile format including pipes, hydrants, valves (regulating and non-regulating), treatment plants, pumps, and services.

We used the InfoWater Import Manager Tool to import pipe, pump, and storage tank shapefiles, and performed an analysis and update of the water main shapefile to "snap" features together. Snapping pipe ends together allows the model to recognize the pipes connectivity and is necessary in establishing accurate hydraulic performance in the pipe network.

Once all relevant shapefiles were imported to the model space, nodes were added at all pipe segment junctions and termini using the Append Nodes Tool included in InfoWater. We utilized the software incorporated network review tools to identify potential errors in the model network, including nodes in close proximity, intersecting pipes, and system connectivity. Locations flagged during the network review were manually evaluated and, if necessary, edited based on our experience and understanding of the distribution system.

Pump curves for the high service pumps at the Forge Village and Nutting Water Treatment Plants and Forge Village and Boston Road Booster Pump Stations were exported from the previous hydraulic model, updated in 2007, for use in the updated model. The operating

range of the Boston Road Pressure Reducing Valve was also exported from the previous model.

Elevations were applied to all nodes, tanks, and pumps using the Elevation Extractor Tool to extract vertical elevations from 2010 and 2012 digital elevation models obtained from the MassGIS database.

Pressure Zone Boundaries for the High Service Zone (controlled by the Prospect Hill Tank) were drawn based on a system map included in the 2007 Master Plan, provided by Westford Water Department. The map indicated the "current" pressure zone boundary and a "recommended pressure zone boundary" marked as a "high priority" item. We included the "recommended pressure zone boundary" in the hydraulic model. Figure 4-1 highlights this boundary.

We used both observed "static" and residual pressures to estimate pipe roughness coefficients (C-factors). "Static" pressure refers to the pressure under normal demand conditions, and residual pressure refers to the pressure with a flowing hydrant. Pipe roughness can vary based on pipe age, material, lining, and flow velocity. While estimated C-factors in one system can serve as a starting point for C-factors in other systems, system specific variables require the independent calibration of C-factors in each model.

The model calibration was performed using observed conditions during hydrant flow testing. C-factors were adjusted based on pipe material and diameter to minimize error between observed and modeled conditions in the distribution system. Westford Water Department provided hydrant flow test data from 2001 to 2015. We reviewed all provided hydrant flow test data. Tests performed prior to 2004 were not included in our analysis due to age, and some tests were not used because inadequate information was available relating to test location. Preference was given to flow testing performed in 2015. Insurance Services Office (ISO) performed 18 flow tests in Westford on September 10, 2015. Eight of these flow tests, all located in the northwestern portion of the Low Service Zone, exhibited pressure changes of approximately 25 to 35 psi between static and flowing conditions while modeled flow simulations resulted in 5 to 10 psi changes. The GIS data layers provided indicate that the pipes in the vicinity of these flow tests are predominantly asbestos cement and 12-inch ductile iron, suggesting smaller head losses resulting from pipe friction than those observed during testing. This difference in observed and modeled flow testing is not present in tests performed at other times at these approximate locations. The uniformity of the error and relative locations of the tests in question suggest that the difference between these field tests and the simulated is due to system conditions during the testing event and not error in estimated pipe C-factors. Based on analysis of the model, we believe that this discrepancy may be a result of valve closures or some other temporary condition during the testing period. These tests were not included in calibration efforts.

The calibration procedure included the comparison of observed static and residual pressures with model predicted static and residual pressures for normal operating conditions and average demand. The model is considered adequately calibrated with respect to static pressure if the model predicted pressure is within 5 psi of the field-observed pressure. For cases where the difference in static pressures was >5 psi, several possible sources of error were evaluated to improve the model:

- Verify test location

- Check tank levels and pump operations
- Check elevations
- Potential closed or partially closed valve

In some instances, the error could not be corrected to <5 psi. This could be due to system upgrades not documented in information received, error associated with pressure readings, or differences in system demand between observed and modeled tests. We were unable to verify the calibration of field equipment used during testing, which is another potential source of error.

After addressing static pressure discrepancies, C-factor values were adjusted based on pipe material and size to minimize the "delta." In this report, delta is defined as the difference between pre-test (static) and flowing (residual) pressures during a fire flow test. This prevents compounding the "static error" term when evaluating the model calibration. C-factor values were adjusted to minimize the $Delta_{delta}$, or the difference between field-observed and model-predicted delta values.

The final C-factors based on pipe size and material are shown in Table 4-1.

Table 4-1
Hydraulic Model Calibrated C-Factors

Material	Diameter (in)	C-Factor
Asbestos Cement	--	110
Cast Iron	≤ 4	40
	6, 8	50
	10	70
	12	80
Ductile Iron	≤ 8	90
	10	100
	12	110
	16	120
PVC/Plastic	--	130
Steel	--	100
Unknown	--	100

Table 4-2 summarizes the hydrant flow tests used for model calibration. In all cases, $Delta_{delta}$ is <5 psi. In three locations, $Delta_{static}$ is >5 psi. This error is likely due to differences in system demand and operation conditions during the testing events. The small $Delta_{delta}$ term in these instances indicates that the system is responding appropriately to increased demand from flowing hydrants and we do not believe that the static error will significantly impact the capabilities of the model.

TABLE 4-2

Westford Water Department Hydraulic Model Calibration

Test Location	Date	Time	Static Model ID	Flow (gpm)	Field Pressure (psi)			Model Predicted Pressure (psi)			$Delta_{static}$[2]	$Delta_{delta}$[3]
					Static	Residual	Delta[1]	Static	Residual	Delta[1]		
Stonybrook @ Farmers Way	6/11/2014	10:00 PM	J5586	1,384	82	72	10	90	76	14	-8	-4
Graniteville Rd @ Cold Spring Road	11/15/2012	10:45 AM	J6588	1,175	80	72	8	79	70	9	1	-1
Beacon St @ North Main St	11/15/2012	10:15 AM	J6288	1,395	100	92	8	98	87	11	3	-3
Broadwat @ River St	11/15/2012	10:30 AM	J3906	1,148	93	78	15	87	76	11	6	4
Littleton Rd @ Tadmuck	4/22/2008	11:00 PM	J2476	996	70	62	8	72	61	11	-2	-3
South Chelmsford @Littleton	2/22/2012	NA	J5476	675	66	62	4	65	58	7	1	-3
4 Farmers Way	10/28/2014	10:00 PM	J5602	1,414	94	87	7	94	84	9	0	-2
Brookside Mills	2/24/2004	11:30 PM	J5978	1,300	105	84	21	106	87	20	-1	1
Groton Rd @ Oak Hill Rd	9/10/2015	NA	J5806	1,200	93	90	3	95	93	2	-2	1
Littleton Rd @ Concord Rd	9/10/2015	NA	J3928	1,280	75	60	15	76	65	11	-1	4
Depot St @ Beaver Dam Rd	9/10/2015	NA	J3596	1,350	80	63	17	84	65	20	-4	-3
Main St @ Depot St	9/10/2015	NA	J1836	1,210	68	54	14	73	60	13	-5	1
Court Rd @ Drawbridge Rd	9/10/2015	NA	J3606	1,300	121	63	58	133	73	60	-12	-2

1. Delta = Static - Residual

2. $Delta_{static} = Static_{field} - Static_{model}$

3. $Delta_{delta} = Delta_{field} - Delta_{model}$

4.3 Model Demand Allocation Update

As part of the model update we allocated system demand to model nodes based on customer billing data from 2015. Westford Water Department provided quarterly consumption at each service address. This data was used to determine average consumption at each address in gallons per minute. Addresses were geocoded using ArcGIS to spatially distribute consumption across the system. The consumption was then spatially joined to model nodes based on a "closest match" criterion. Spatially joined consumption values were reviewed for accuracy and adjusted as needed based on service location relative to the pipe network. Average consumption was used as the base demand at each node. System-wide average daily consumption based on metered services in 2015 was 1,038 gpm.

When building EPS hydraulic models, the development of diurnal demand patterns is necessary to reflect observed changes in demand over the course of a day. Westford Water Department provided hourly storage tank and treatment plant effluent data for January and July 2015. These data were used to identify maximum and average demand days based on total system production. We identified January 12, 2015 as an average demand day (1.40 MG) and July 13, 2015 as a maximum demand day (3.07 MG). Changes in total stored volume and flow rates from sources were used to create a mass balance of water in the system to determine hourly system demands. The hourly system demand on both average and maximum demand days was divided by base system consumption (1,038 gpm) as determined by customer billing data to obtain hourly multipliers to simulate changes in demand in the system while running EPS. Table 4-3 shows the demand multipliers for both average and maximum demand days.

Table 4-3
Daily Demand Pattern Multipliers

Time	Average Demand Multiplier	Maximum Demand Multiplier
1:00	0.015	1.752
3:00	0.300	2.052
5:00	0.574	2.242
7:00	1.344	3.868
9:00	0.923	2.319
11:00	1.496	1.298
13:00	1.085	0.324
15:00	0.719	1.536
17:00	0.547	0.999
19:00	0.919	1.211
21:00	0.814	2.663
23:00	0.896	1.838

4.4 Hydraulic Analysis of Distribution System

A hydraulic analysis of the distribution system was performed to assess conditions for average day, maximum day, and peak hour demand scenarios. Analysis of the system included reviewing these scenarios for the following:

- Areas of high pressure (>125 psi)
- Areas of low pressure (<35 psi)
- High pipe velocity (>5 fps)
- High head losses (>10 ft/1,000 ft)

In addition to the above analyses, available fire flows (AFF) in the system were determined under maximum demand conditions (peak hour on maximum demand day). AFF is defined as the flow available at a residual pressure of 20 psi without reducing pressure at any point in the system to below 20 psi. The results of these analyses were used to identify hydraulic deficiencies in the distribution system and evaluated potential upgrades.

Overall, pressure in the Westford distribution system is high, with approximately two-thirds of the system yielding maximum pressures >80 psi. This pressure is unlikely to cause issues related to high pressure, such as water main breaks, but these pipes will be subject to an increasing risk of failure as they age. Figures 4-2, 4-3, and 4-4 show maximum, minimum, and average system pressures, respectively, over the modeled 2015 maximum demand day EPS.

Highest pressure is modeled at lower elevation nodes within the High Service Zone. Node elevations in the High Service Zone range from 204 feet MSL to 465 feet MSL. Review of the model indicates that the high-pressure nodes located in the eastern side of this pressure zone may benefit from redrawing the pressure zone boundary. Adjusting the boundaries of the High Service Pressure Zone to locate some of the low-elevation nodes in the eastern portion of the existing High Service Zone may help to decrease high pressure areas. However, adjusting this pressure zone boundary can have a negative impact on AFF. Adjusting the existing boundary between the high and low pressure zone is discussed further in Section 5.5.

Low pressure areas (<35 psi) are located at system dead ends and adjacent to atmospheric storage tanks. Nodes proximal to atmospheric storage tanks typically exhibit low pressure due to the limited elevation change between tank level and system node. This is typically not an issue unless there are significant demand and/or fire protection needs in this vicinity. In the Westford distribution system, services near the Francis Hill tank along Baldwin Road and Hunt Road exhibit low average pressures of approximately 30 to 35 psi. Model results indicate that during high demand periods pressures may drop as low as 20 psi in this area. We recommend monitoring system pressure near the Francis Hill Tank to determine whether a booster pump is needed to improve water service in this area.

Our analysis of pipe velocities and head loss did not identify any areas of concern. Pipes contiguous to both Nutting Hill and Forge Village High Service pumps and Forge Village Booster pumps have modeled pipe velocities >5 fps (5.5 to 11.3 fps) and modeled head losses > 10 ft/1,000 ft (10.6 to 39.5 ft/1,000 ft); however, this is expected due to proximity to the pumps. One 2.3-ft segment of 1.5-in diameter PVC pipe was identified

as an error in the GIS data and we updated the pipe segment to match that of adjacent pipes. The location of this pipe segment is shown in Figure 4-5.

Results of model Predicted AFF are shown in Figure 4-6. The analysis was performed on all system nodes with the exception of nodes with low static pressures (<25 psi). The exclusion of low pressure nodes in the AFF model calculations is essential to run the model calculations for available flow in other locations. As stated above, AFF is defined as the flow available at a residual pressure of 20 psi, with no node in the system dropping to below 20 psi. The AFF analysis was done at the peak hour of the modeled maximum demand day (3.87 multiplier). Table 4-4 compares model predicted AFF to Needed Fire Flow (NFF) as determined by ISO in 2015.

Table 4-4
Predicted AFF vs. NFF

ISO Test No.	ISO Test Location	Model ID	ISO NFF (GPM)	Model Predicted AFF (GPM)
Low Service Zone				
1	Broadway @ Beacon St	J3118	2,500	2,608
2	Lyberty Way @ Carlisle Rd	J2282	3,000	1,224
3	Technology Park Dr @ Littleton Rd	J2560	3,500	917 [1]
5	Littleton Rd @ Nashoba Technical High School	J6270	3,000	969 [1]
6	Littleton Rd @ Concord Rd	J3928	3,500	2,064
7	Groton Rd @ Oak Hill Rd	J5806	2,500	7,812
8	Allie Ln @ Groton Rd	J3758	750	1,986
9	Nutting Rd @ Depot St	J5684	750	4,488
10	Plain Rd @ Poplar Rd	J3382	1,500	4,772
11	Hutchins Way @ Concord Rd	J3078	2,500	4,258
12	W Prescott St @ Coolidge St	J3890	1,250	2,942
14	Nabnassett St @ Oak Hill Rd	J6186	1,000	3,220
16	Patten Rd @ Cold Springs Rd	J1702	3,500	3,086
17	Lake Shore Rd @ Elm Rd	J2694	750	2,144
18	Graniteville Rd @ Cold Springs Rd	J3286	2,000	1,636
High Service Zone				
4	Depot St @ Beaver Dam Rd	J3596	3,500	2,361
13	Court Rd @ Drawbridge Rd	J3606	750	1,625
15	Main St @ Depot St	J1836	2,000	2,438

[1] The low predicted AFF in these areas is limited by high elevation nodes on the northern end of the technology park. A more localized model analysis, excluding these nodes, yields AFF of 1,700 gpm at Test 3 and 1,900 gpm at Test 5.

Overall, AFF in the system is adequate. Predicted AFF in several locations did not meet NFF as recommended by ISO Guidelines. We reviewed pipe characteristics in the locations with inadequate AFF when compared with NFF. In all locations, pipe materials used were 8-inch to 12-inch ductile iron or asbestos cement. Both of these pipe materials have been calibrated to have C-factors of at least 90. Simulating the flow tests in these locations did not highlight pipes with significant increases in head loss, and simulations of potential distribution system improvements by increasing pipe diamete2s and C-factors in these locations did not significantly improve AFF. This is because the AFF in these locations is limited by the topographical variability in both pressure zones, with pressure drop at system nodes at high elevation limiting flow to lower elevation nodes.

We identified areas of both high (>125 psi) and low (<35 psi) in both pressure zones, and concluded that these deficiencies are a result of variable topography in both pressure zones.

4.5 Specific Modeling Iterations

At the request of Department staff, Tighe & Bond completed various modeling iterations to understand specific hydraulic issues that have been encountered in the system.

4.5.1 Westford Center Fire

In March 2016, a fire occurred in center of town. The Fire Department connected to two hydrants, one was to a main receiving water from Prospect Hill tank, and the other one was to a hydrant that is fed by a 4" line coming from the east of the fire. The Water Department was considering replacing the 4" water line with a 12" water line. To evaluate benefit of this, we modeled this fire scenario by applying a demand of 2,500 gpm to the western hydrant on Main Street (the hydrant that was utilized during the fire). This hydrant is fed by a 12" ductile iron main receiving water from the Prospect Hill Tank. This flow yielded a pressure of 21 psi at the hydrant during system maximum demand conditions (maximum hour on maximum demand day, 3,960 gpm). Pressure at the eastern, adjacent hydrant that did not produce sufficient flow was monitored during this simulation, dropping to 22 psi. This hydrant is also fed by the Prospect Hill Tank, but when the western hydrant is flowing at this rate, water must reach the eastern hydrant by traveling around this portion of Main Street via Boston, Drawbridge, and Providence Roads, eventually feeding the hydrant from a 4-inch cast iron main.

We modeled replacing this 4" main with 12" ductile iron to see if removing this hydraulic constriction would have a significant impact on AFF on Main Street. Model results do not show a significant improvement in AFF with the new 12" main and existing pressure zone boundaries. If pressure zone boundaries are redrawn, as discussed in Section 5.5.3, this improvement would be necessary to maintain good AFF on Main Street.

4.5.2 Pressure Concerns in East Prescott/Story Street Area

We evaluated head losses in the existing water mains in the area just north of Forge Pond near East Prescott and Story Streets as indicated by Westford Water Department. Head loss in pipes in this location is low (<0.3 ft/1,000 ft). Low pressure in this part of the distribution system is due to elevation, not pipe hydraulics. Installing new pipes in this location will have very little or no impact on improving pressure.

4.5.3 Evaluation of High Service Area and Low Service Area Borders

At the request of the Water Department, Tighe & Bond evaluated changing the HAS and LSA boundaries, including assessing if the boundary is moved could the pressure be increased and if the tank is raised, could it be filled with the existing pumps.

Various alterations to the existing pressure zone boundary were evaluated, focusing on moving the eastern boundary to the west to remove areas with maximum pressure >135 psi along Providence Road from the high service area. Moving Providence Road from the High Service Zone to the Low Service Zone decreases average pressures from approximately 140 psi to 70 psi. Figure 4-7 and Figure 4-8 show changes in average pressure with the existing boundary and proposed boundary, respectively. Minimum pressures modeled during EPS for maximum demand conditions are just approximate 65 psi along Providence. Services along Drew Crossing may have pressure as low as 50 psi during maximum demand conditions, but average pressure is expected to be around 57 psi.

When redefining pressure zone boundaries, AFF is important to be considered. The proposed pressure zone boundary removes a continuous loop in the high pressure zone, which may adversely impact AFF. We compared AFF in the High Service Zone with the existing and proposed pressure zone boundaries. The proposed boundary resulted in a decrease in AFF along the 4" cast iron main on the eastern portion of Main Street from approximately 800 gpm to 150 gpm (Figure 4-9). However, if this 4" main is replaced with 12" ductile iron, as proposed in Section 4.5.1, AFF along the new 12" main is calculated to be 2,400 gpm (Figure 4-10).

Raising tank elevation in the HSA is not recommended, even with the redrawn pressure zone boundary, since many system nodes still have high pressure (>125 psi).

4.5.4 Water Age

To address the Water Department Staff's concern about TTHMs, circulation, and residence time, Tighe & Bond modeled existing water age and a series of alternative improvements for improving water age.

All water age and source contribution analyses were modeled for existing conditions using the average demand day EPS for a 1,500-hour period to establish steady-state conditions within the model. Data presented are a snapshot of average system conditions at 1,500 hours. System-wide result for water age are shown in Figure 4-11. System-wide results for source contribution are shown in Figure 4-12. Table 4-5 shows model results for water age and source contribution in the water storage tanks.

Results of the water quality simulations show that there is little turnover of water in the Prospect Hill and Twin Peaks Tanks. The model shows water flowing in and out of these tanks over the course of the simulation. However, long, large diameter pipes that connect the main to the system may hold enough volume to limit the actual exchange of water that occurs between the tank and the system. Central portions of the low service zone are well mixed, while the southern portion of the system is fed almost exclusively by the Forge Village Treatment Plant. The High Service Zone experiences variable water age, depending on whether water is coming from the Prospect Hill Tank or being pumped directly into distribution system. Water in this part of the system is most likely sourced from Nutting Hill Water Treatment Plant.

Table 4-5
Results of Water Quality Modeling

Tank	Water Age (hours)	Source Contribution from Nutting Road	Source Contribution from Forge Village
Twin Peaks[1]	1,500	100%	0%
Francis Hill	536	33%	64%
Town Farm	873	52%	48%
Prospect Hill[1]	1,428	0%	100%
Hildreth Hills	433	0%	100%

(1) Twin Peaks and Prospect Hill Tanks did not experience significant water exchange over the 1,500-hour simulation

Following increased water quality issues experienced in summer 2016, Westford requested the analysis of additional alternatives for distribution system improvements aimed at improving water age. Alternatives were evaluated based on modeled water age improvements and impacts to available fire flow throughout the system.

Alternative 1: Twin Peaks Tank Offline

Under average day demand conditions, the Twin Peaks Tank has very little turnover (Table 4-5). Removing this tank from service decreases water age north of Nabnasset Pond (Figure 4-13). However, Twin Peaks storage provides a critical source of water to this portion of the system during fire flow demands. While removing the Twin Peaks Tank from service models water ages approximately half of those modeled under existing average demand conditions, available fire flow is decreased by approximately 750 gpm throughout the Nabnasset/Greystone region (Figures 4-14 and 4-15).

Alternative 2: New 12-in DI Water Main in Oak Hill Road

The existing water main in Oak Hill Rd is 6-in cast iron and 6-in asbestos cement, and is not continuous along the proposed route. This alternative would include approximately 3,300 ft of new 12-in ductile iron pipe from the intersection with Plain Road to existing 12-in DI south of the intersection with George Avenue. This proposed alternative increases the movement of water through Nabnasset to decrease water age. Figure 4-16 shows resulting water age in the system is comparable to Alternative 1. Alternative 2 results in improved AFF in Nabnasset and Greystone (Figure 4-17).

Alternative 3: Closed Valve on Nutting Road

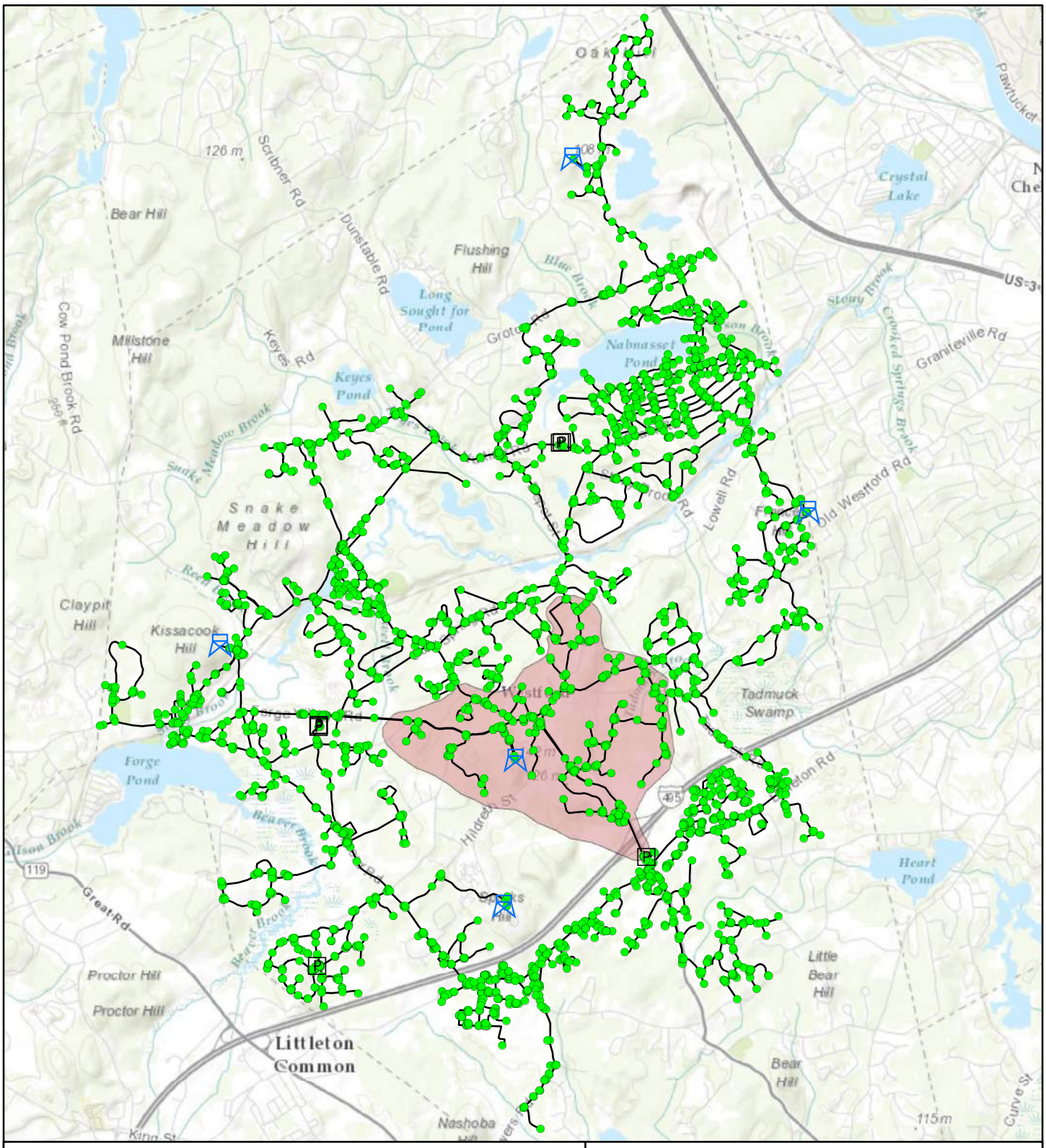
Alternative 3 includes closing a valve in Nutting Road, west of the Nutting WTP. This prevents western flow from the WTP, forcing all water through Nabnasset. This alternative improves water age in Nabnasset, but does not have a significant effect on average water age near Greystone (Figure 4-18). This alternative also results in a significant decrease in available fire flow system-wide (Figure 4-19).

Alternative 4: Town Farm Tank Offline, New 12-in DI in Groton Road

Alternative 4 includes approximately 5,300 ft of new 12-in ductile iron water main in Groton Rd from Lakeside Drive to St. Augustine Drive, while removing the Town Farm Tank from service. Together, these upgrades improve water age in the western portion of the system (Figure 4-20) while maintaining similar AFF in the System (Figure 4-21).

AFF does decrease along East Prescott Street from >3,000 gpm to approximately 1,000 gpm. Development in this portion of the system is largely residential and may not require AFF >3,000 gpm.

Water age simulations of the Westford distribution system highlight insignificant turnover in the Prospect Hill and Twin Peaks tanks, and pockets of higher water age in the northern, eastern, and western portions of the system. Four water age alternatives were modeled for evaluation of age and impact on AFF. Alternative 1 (removing Twin Peaks Tank from service) had a similar impact on water age in Nabnasset and Greystone as Alternative 2 (new water main in Oak Hill Road). However, Alternative 2 also improves AFF in Nabnasset while Alternative 1 decreases AFF in this area. Alternative 3 (closed valve on Nutting Rd) does not improve water age and results in significant decreases in AFF system-wide. Alternative 4 improves water age in the western portion of the system, and when paired with the new 12-inch water main on Groton Road, has a minimal impact on AFF.

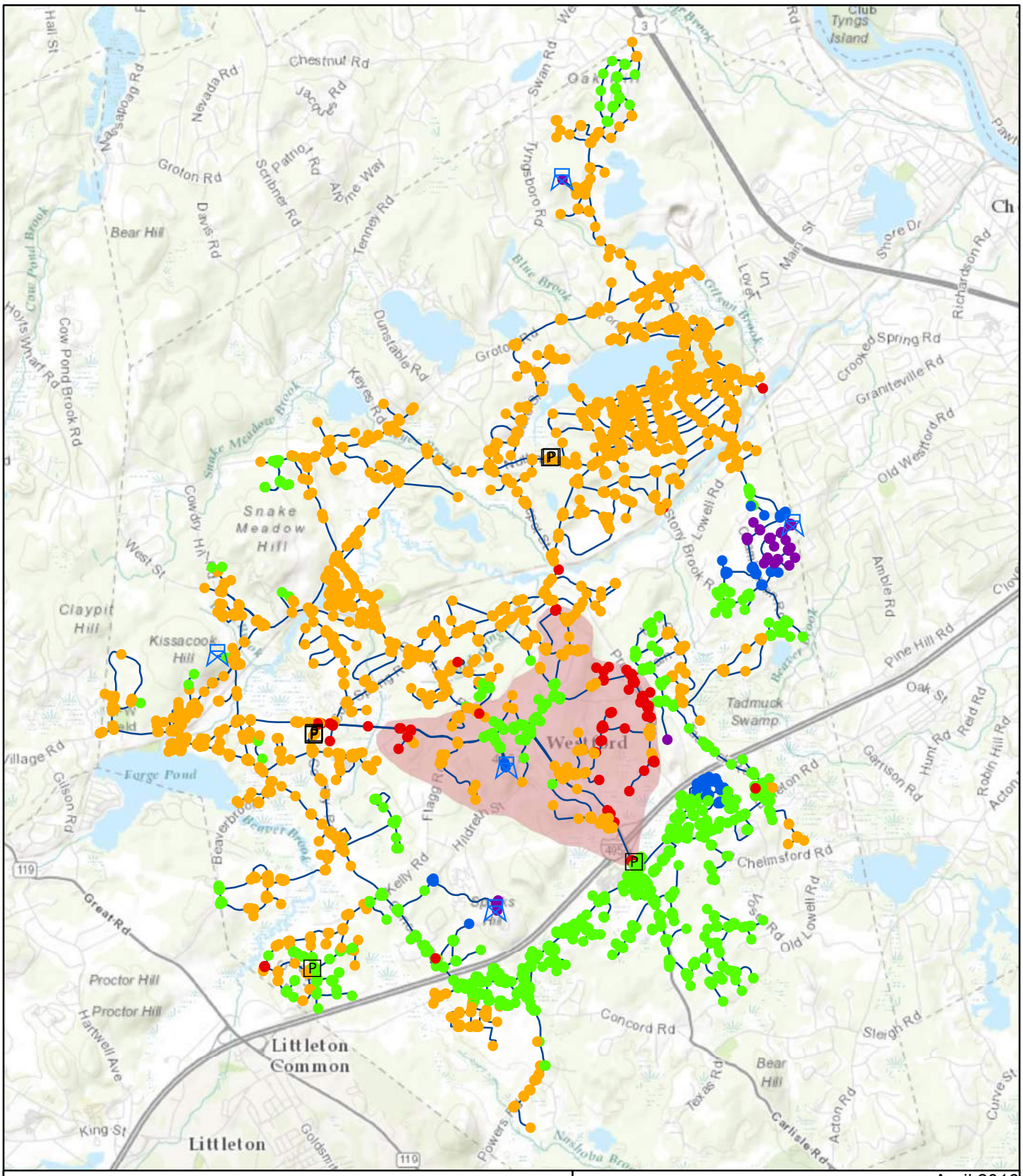


April 2016

Figure 4-1

Pressure Zone Boundary
Westford Water Department
Westford, MA

Tighe&Bond

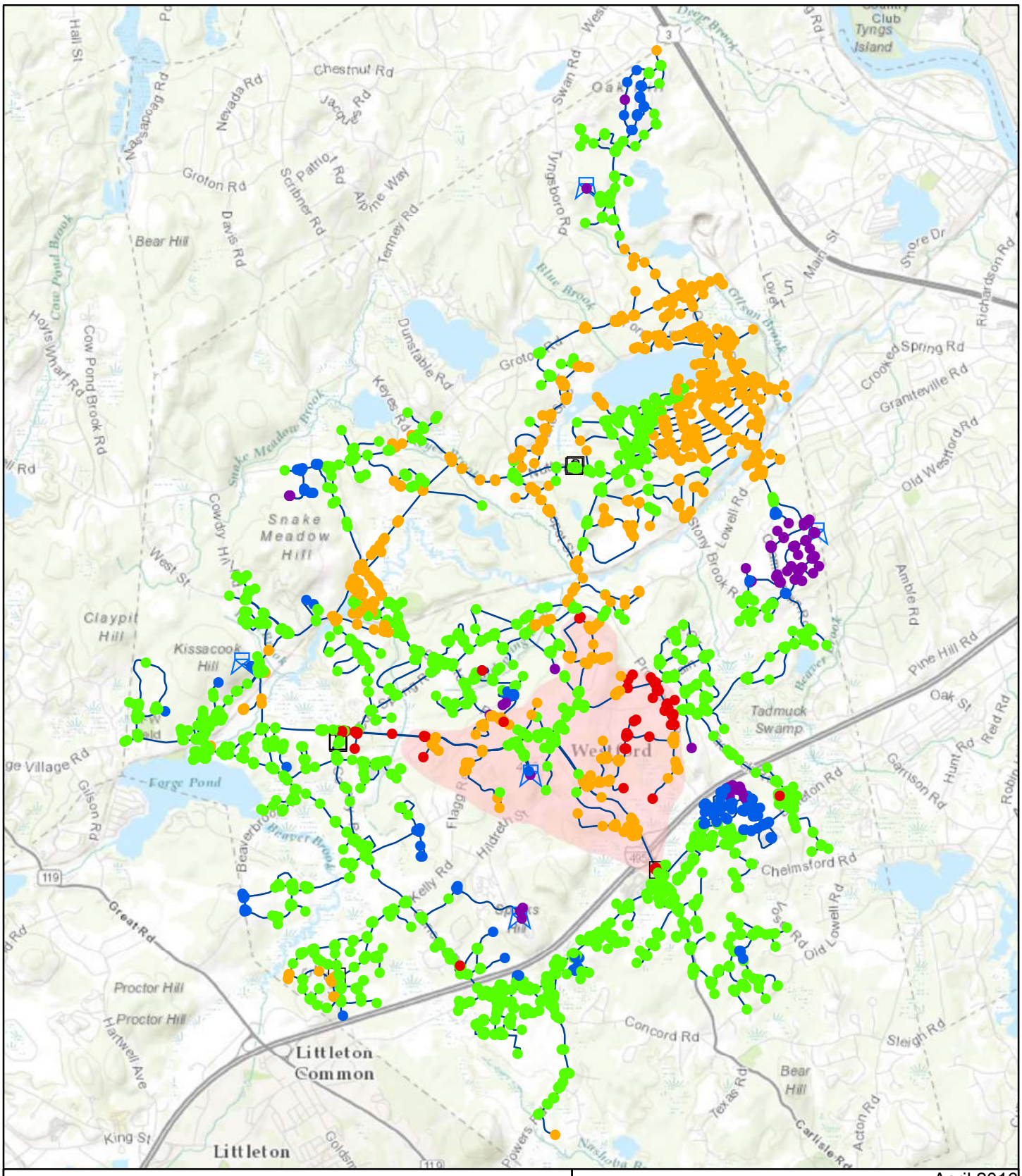


April 2016

Figure 4-2

Maximum System Pressures
During Maximum Demand Day
Westford Water Department
Westford, MA

Tighe&Bond



April 2016

Figure 4-3

Minimum System Pressures
During Maximum Demand Day
Westford Water Department
Westford, MA

Tighe&Bond

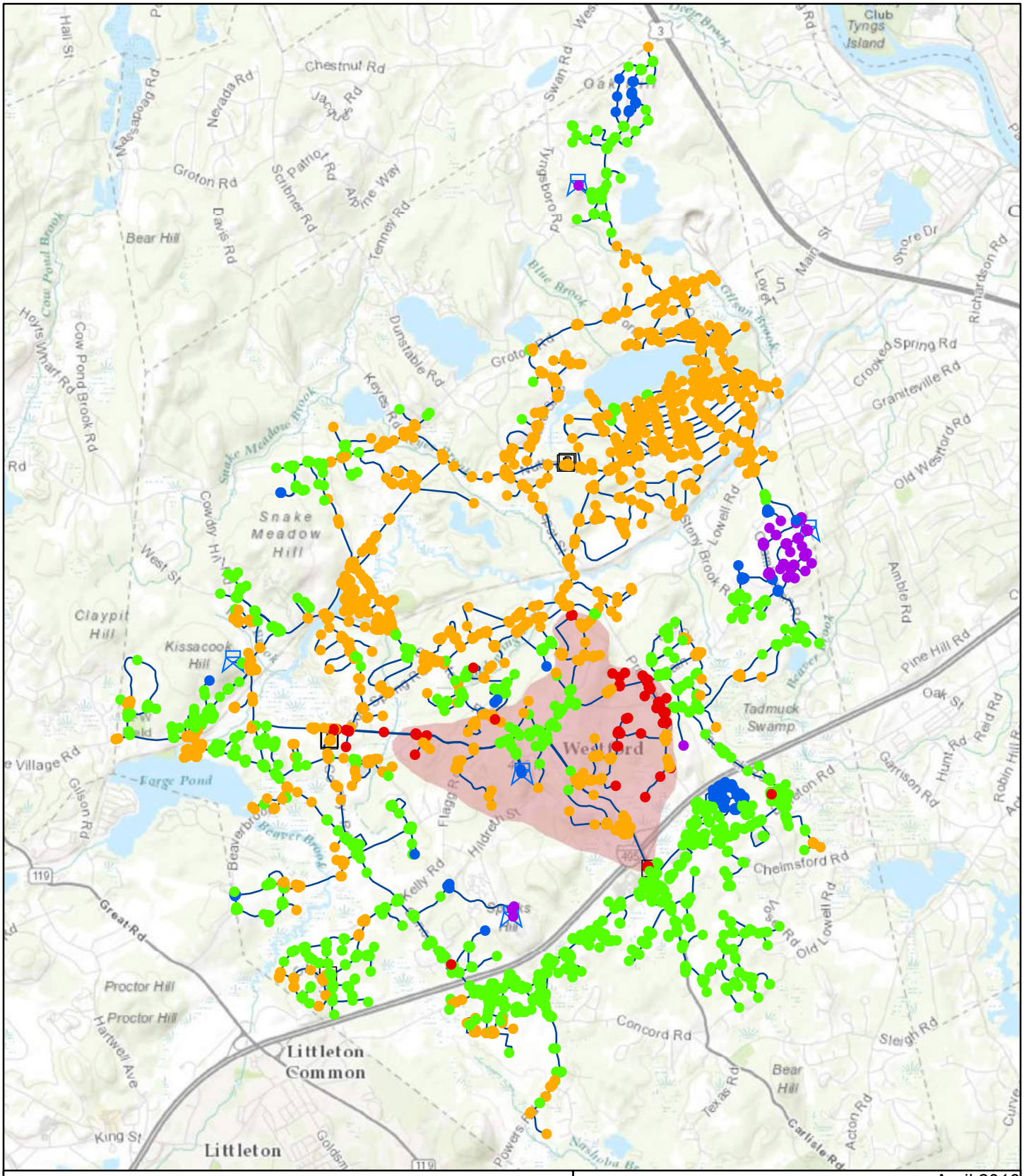
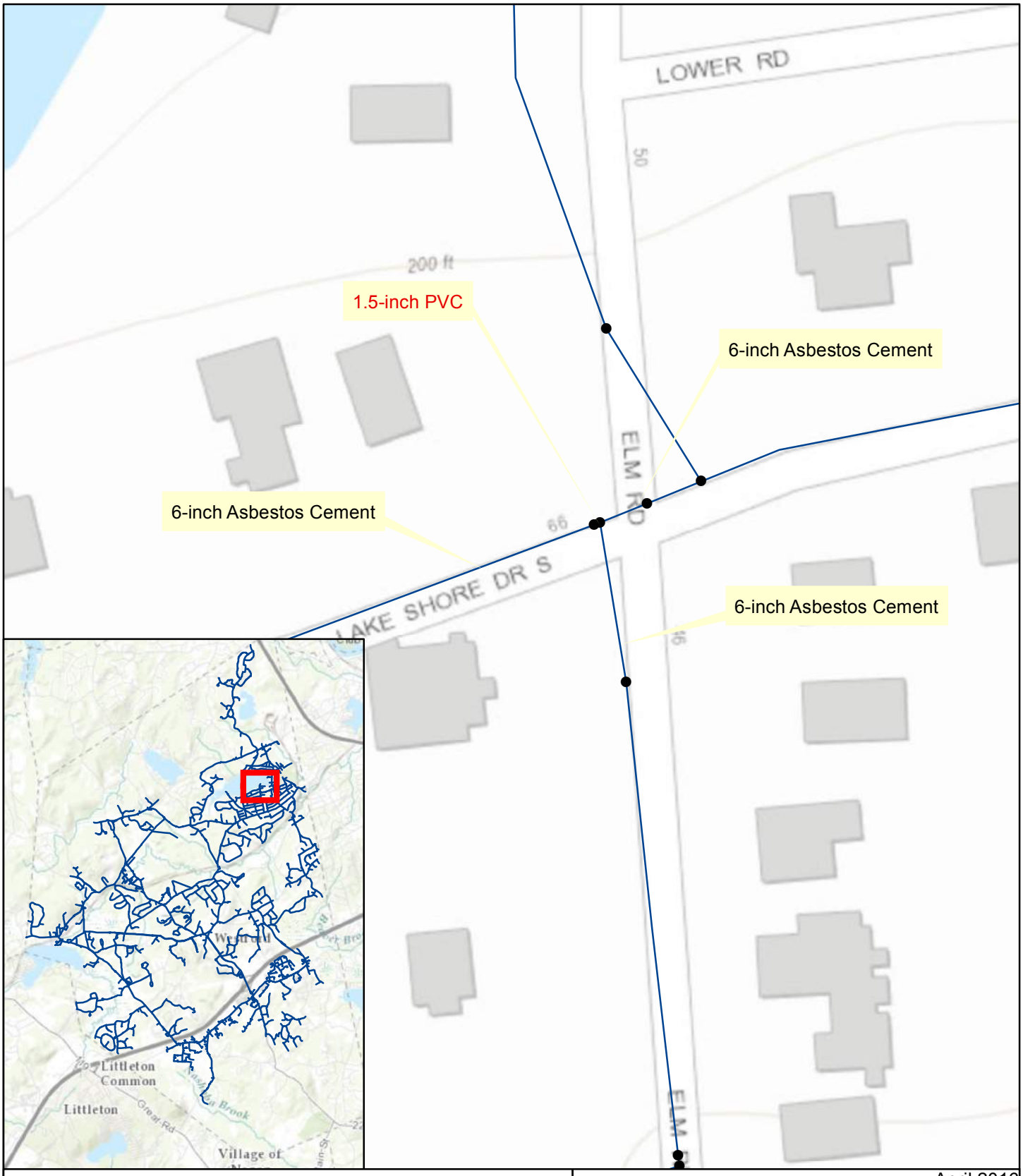


Figure 4-4

April 2016

Average System Pressures
During Maximum Demand Day
Westford Water Department
Westford, MA

Tighe&Bond

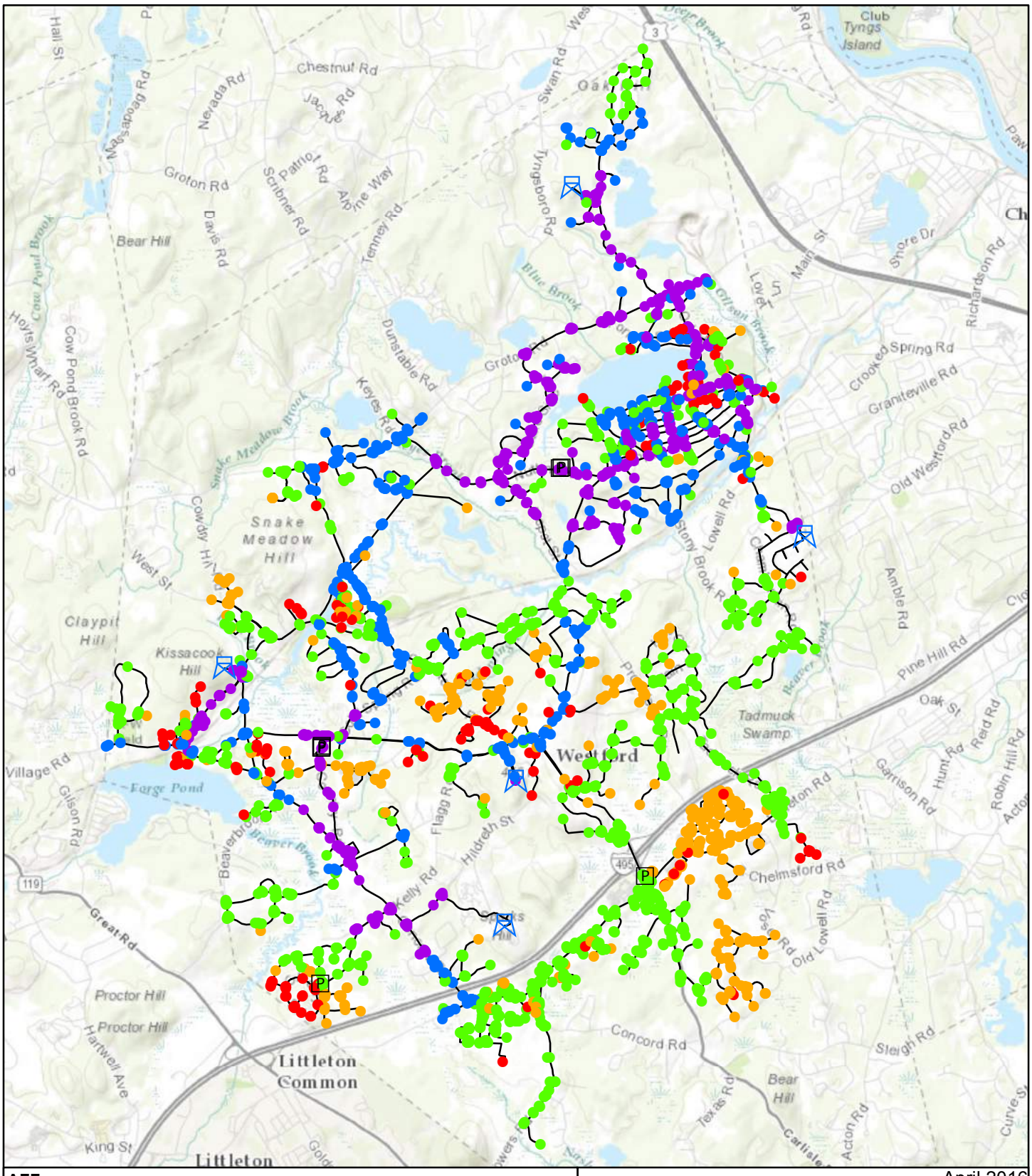


April 2016

Figure 4-5

Potential Error in GIS Data
1.5-inch PVC with High Head Loss
Westford Water Department
Westford, MA

Tighe&Bond

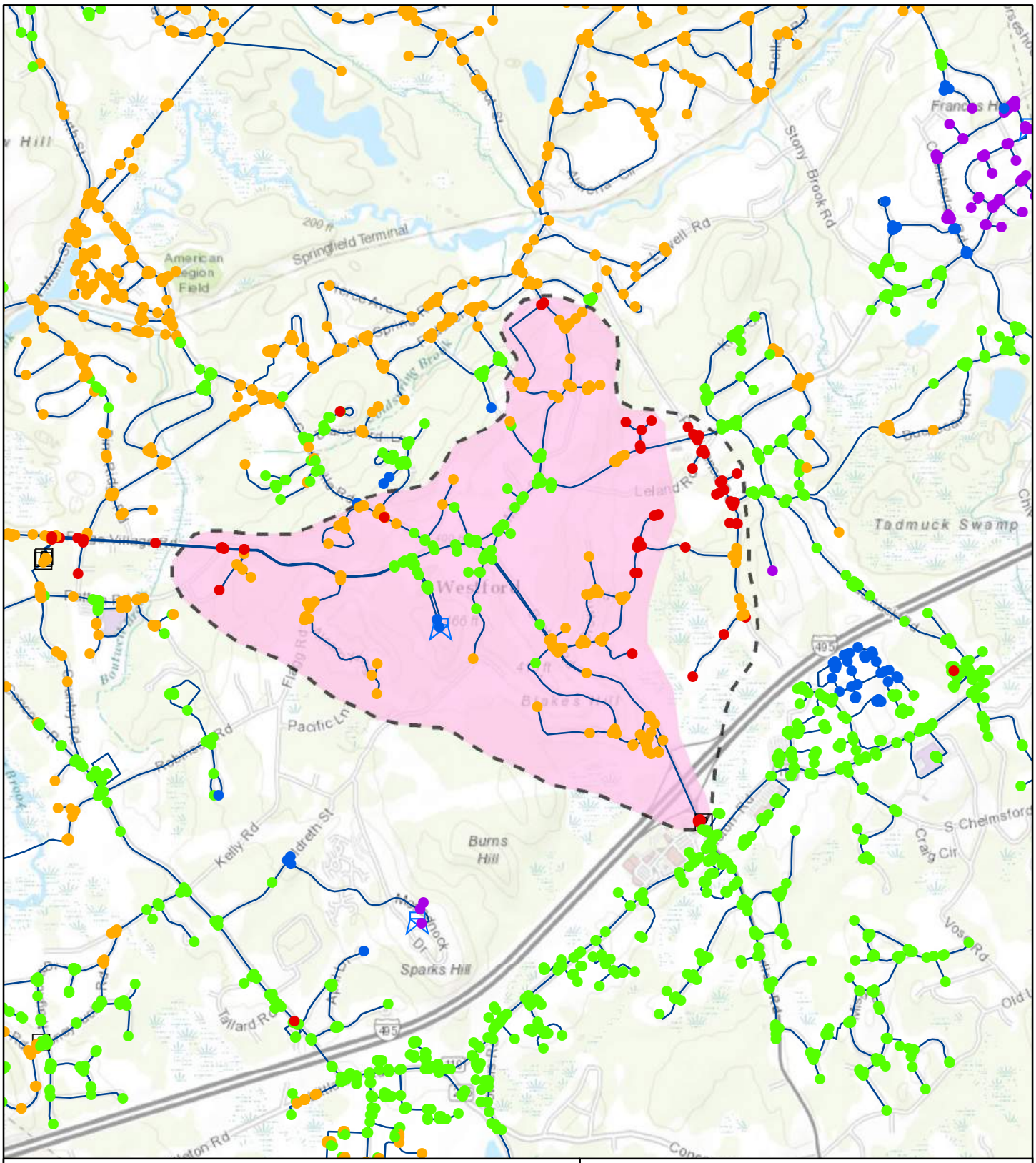


April 2016

Figure 4-6

Model Predicted Available Fire Flow
Under Maximum Demand Scenario
Westford Water Department
Westford, MA

Tighe&Bond

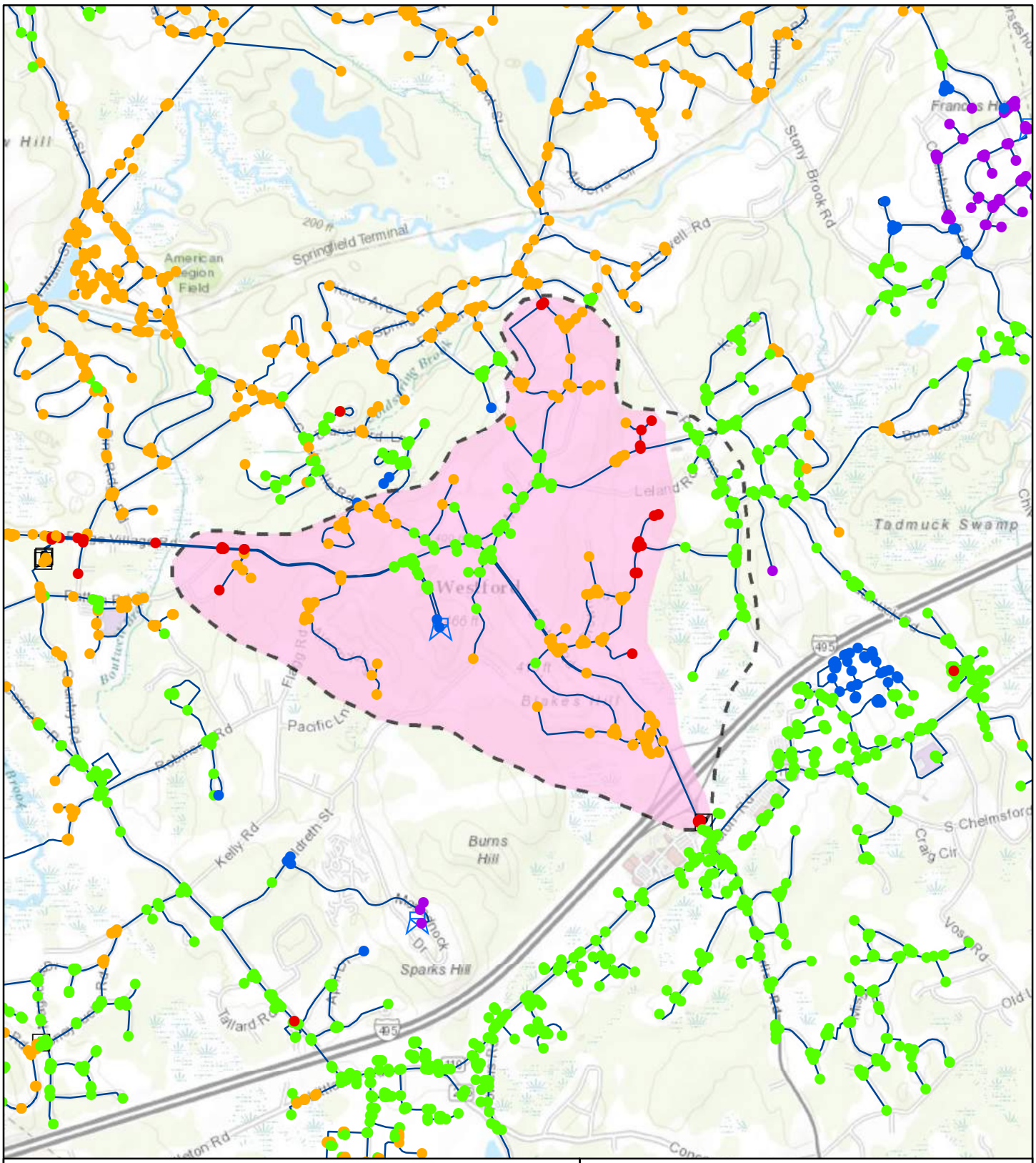


June 2016

Figure 4-7

Existing Pressure Zone Boundary
Average System Pressures
During Maximum Demand Day
Westford Water Department
Westford, MA

Tighe&Bond

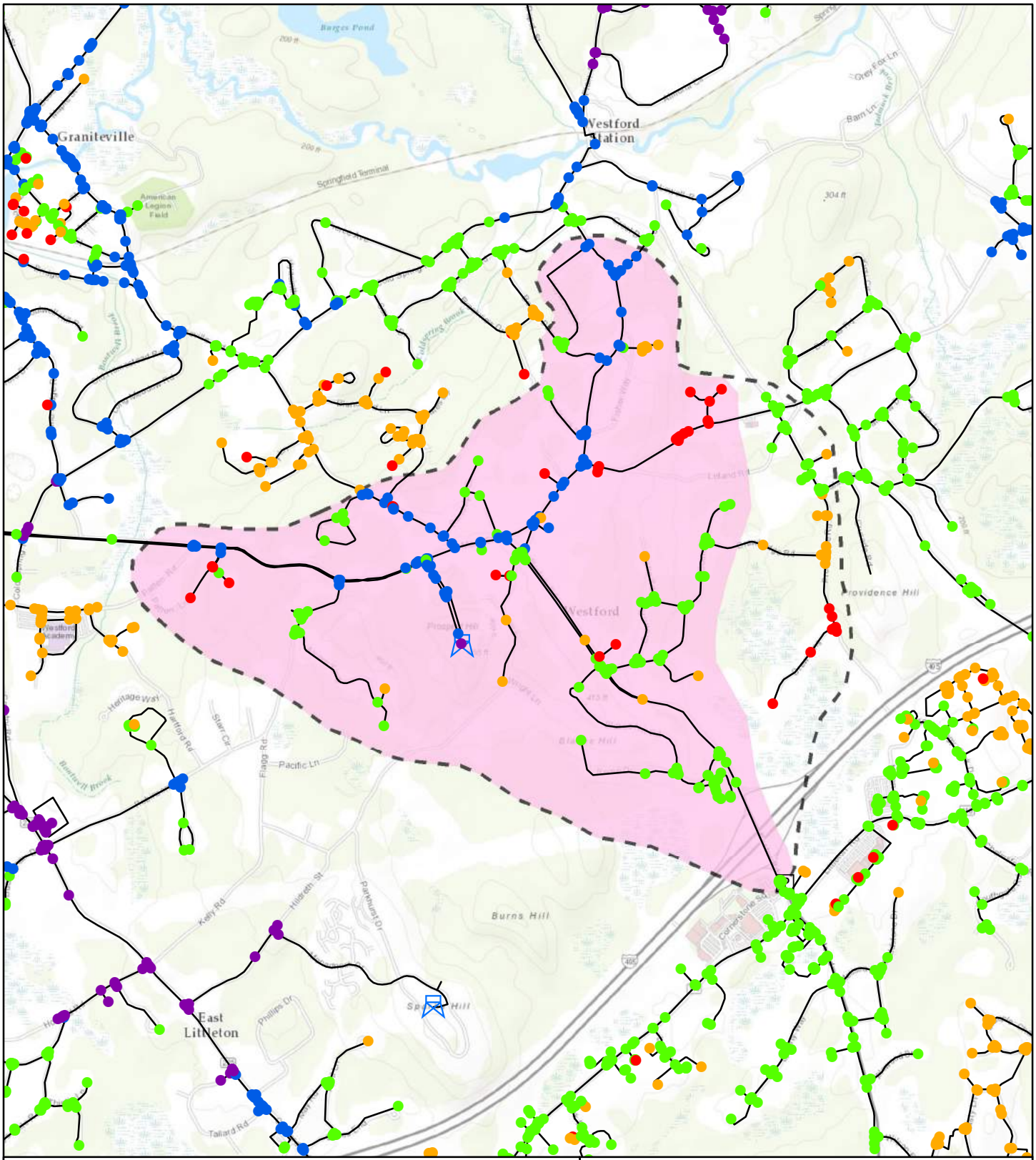


June 2016

Figure 4-8

Proposed Pressure Zone Boundary
Average System Pressures
During Maximum Demand Day
Westford Water Department
Westford, MA

Tighe&Bond

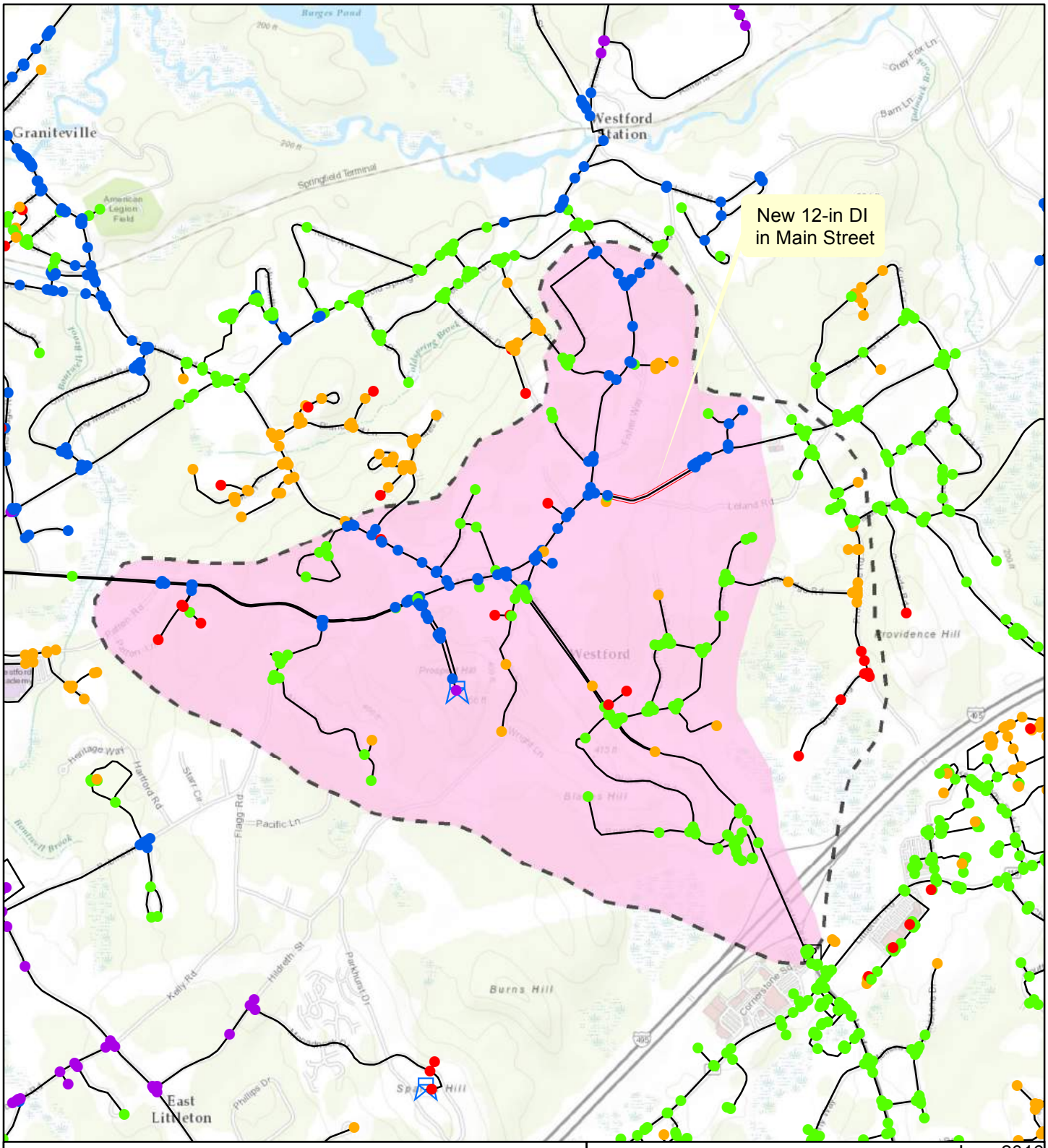


June 2016

Figure 4-9

Proposed News Pressure Zone Boundary
Predicted Available Fire Flow
Westford Water Department
Westford, MA

Tighe&Bond

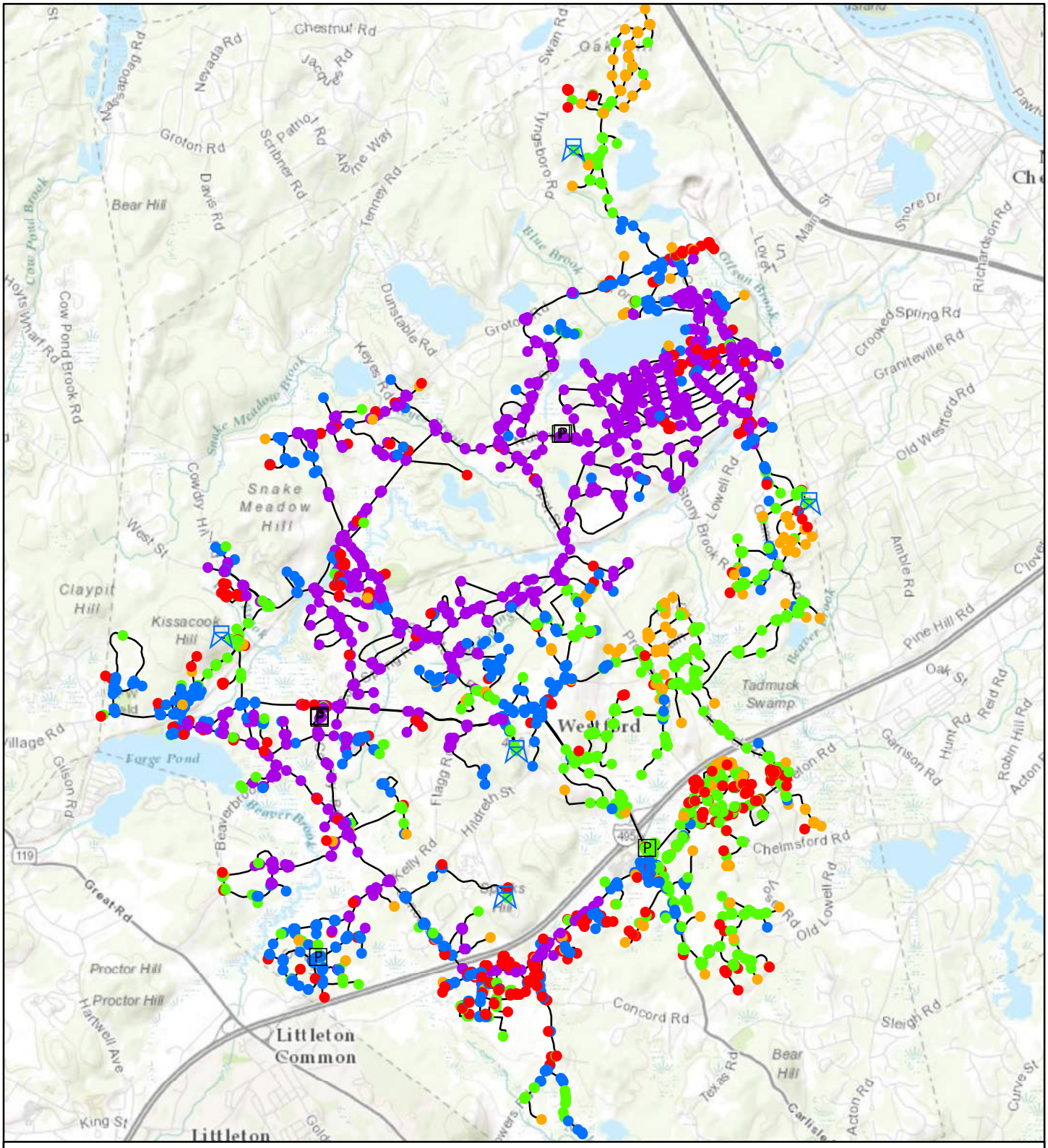


June 2016

Figure 4-10

Proposed Pressure Zone Boundary
Predicted Available Fire Flow with
New 12" Main on Main Street
Westford Water Department
Westford, MA

Tighe&Bond



Average Water Age, hours

- 4 - 55
- 56 - 114
- 115 - 182
- 183 - 309
- 310 - 412

P Pumps

Water Storage Tanks

0 0.75 1.5 Miles

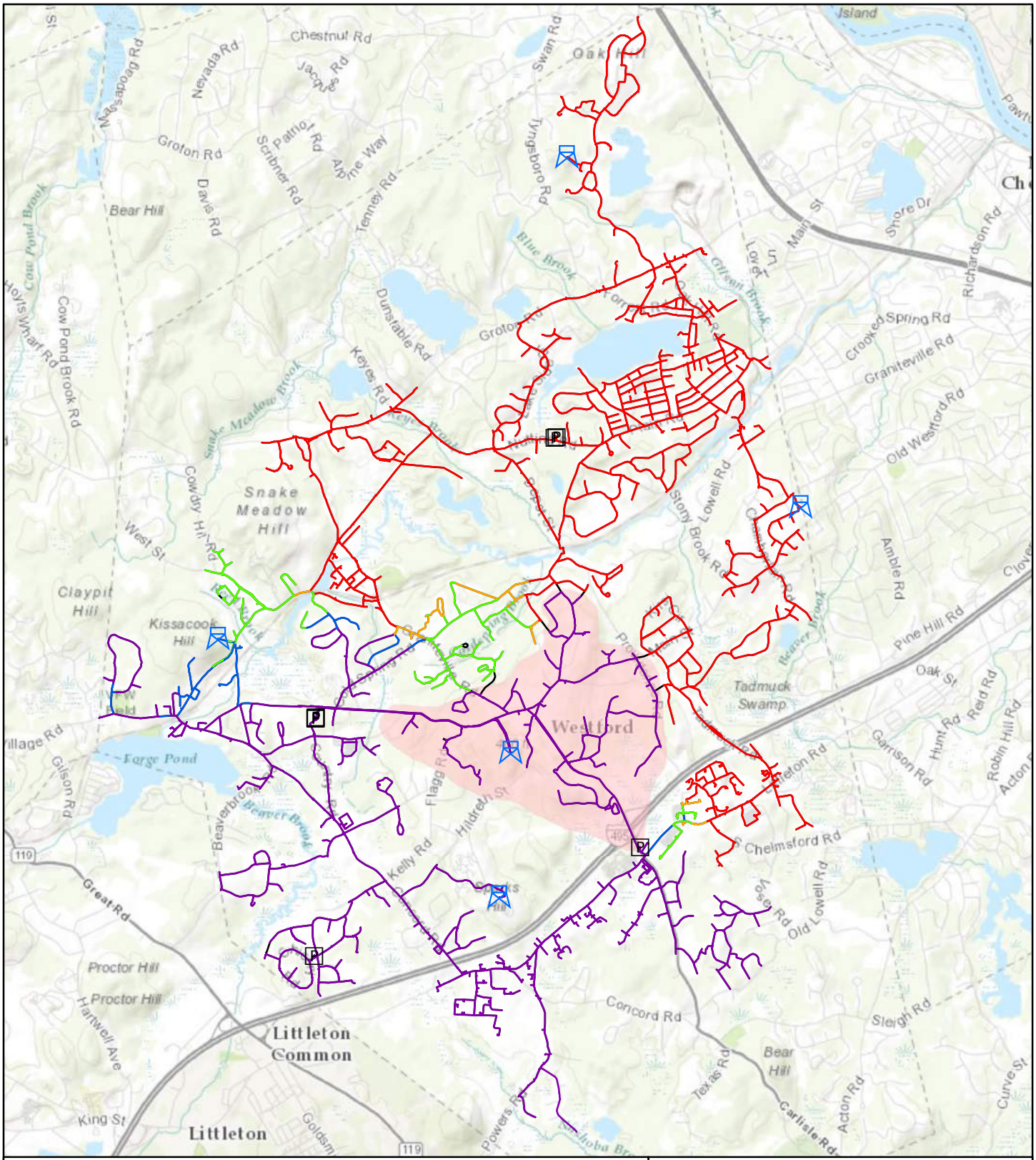
Figure 4-11

Existing Water Age
Average Demand Scenario
Westford Water Department
Westford, MA

Tighe&Bond

Document Path: J:\W\W2160 Westford Water Dept\Model\ArcMaps\WQ Alternatives 8-2016\Westford_Existing_Age_Map.mxd

October 2016



Forge Village Contribution

- 0% - 10%
- 11% - 36%
- 37% - 61%
- 62% - 86%
- 87% - 100%

- Pumps
- Water Storage Tanks
- High Service Zone

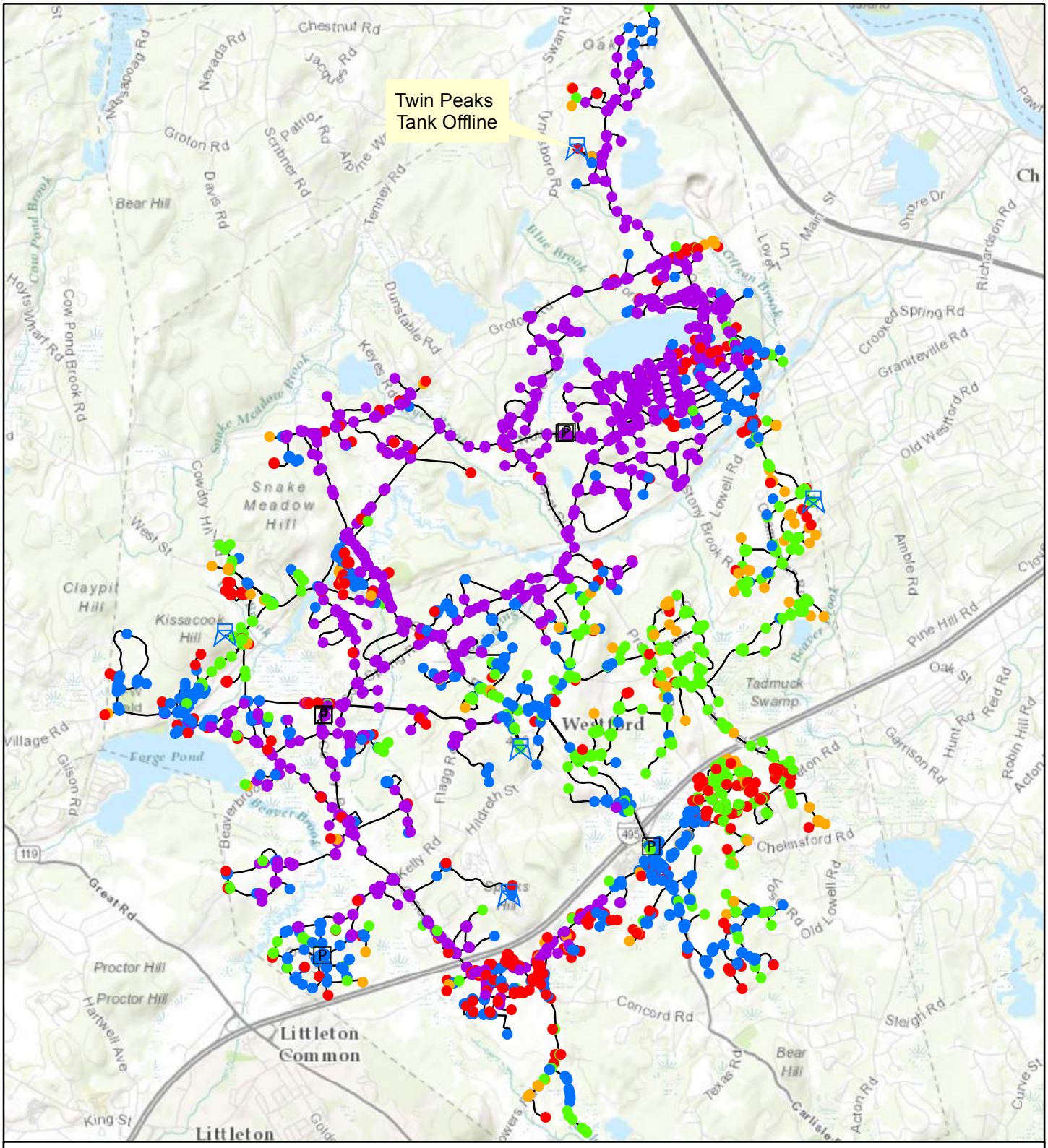
0 0.75 1.5 Miles

June 2016

Figure 4-12

Source Contribution
as Percent from Forge Village
Westford Water Department
Westford, MA

Tighe&Bond



Average Water Age, hours

- 3 - 59
- 60 - 117
- 118 - 185
- 186 - 314
- 315 - 412

P Pumps

Water Storage Tanks

0 0.75 1.5 Miles

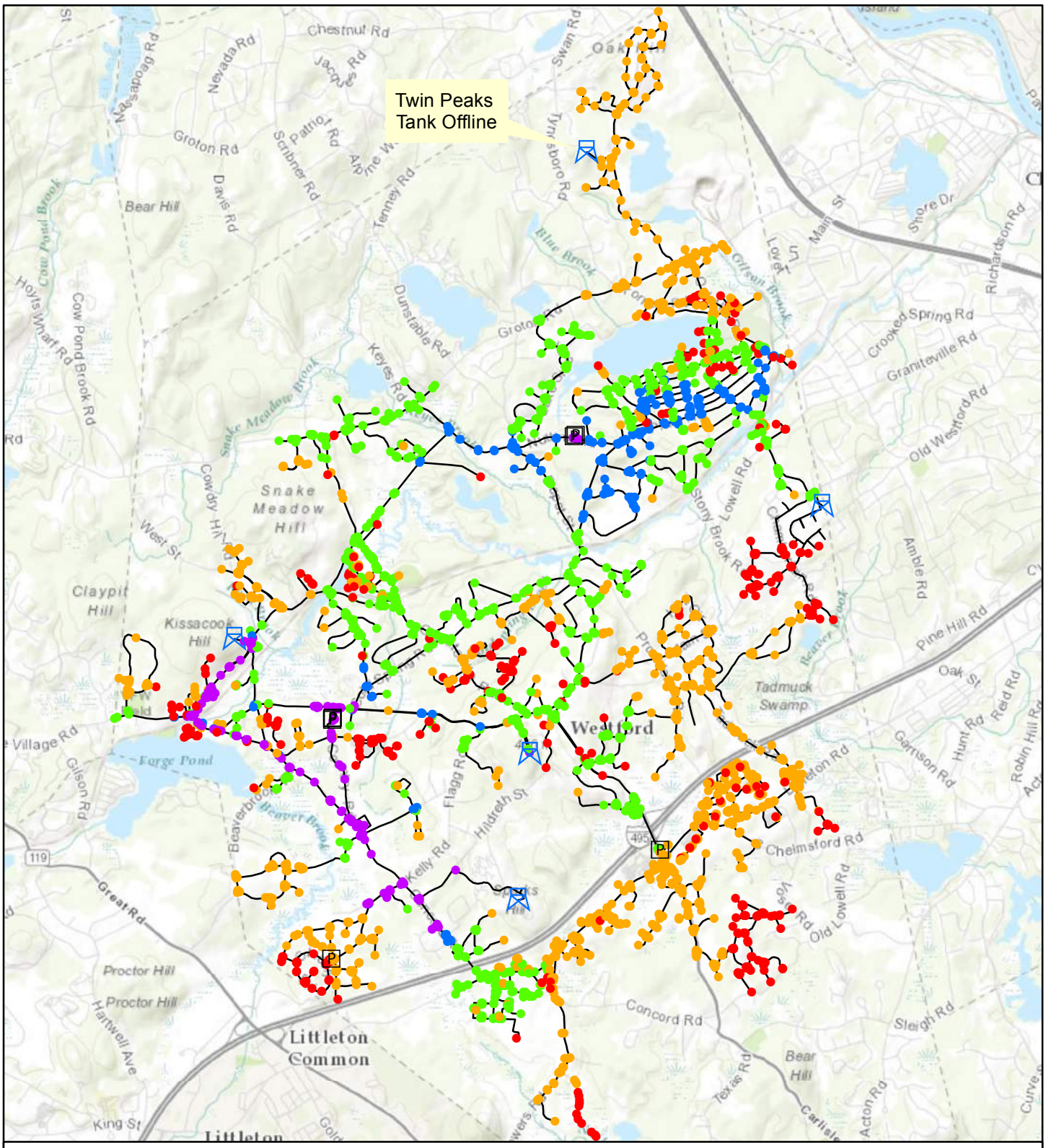
Figure 4-13

Alternative 1
Twin Peaks Tank Offline
Average Demand Scenario
Westford Water Department
Westford, MA

Tighe&Bond

Document Path: J:\W\W2160 Westford Water Dept\Model\ArcMaps\WQ Alternatives 8-2016\Westford_Alt1_Age_Map.mxd

October 2016



AFF, gpm

- <800
- 801 - 1,500
- 1,501 - 2,500
- 2,501 - 3,000
- >3,000

P Pumps

Water Storage Tanks

0 0.75 1.5 Miles

Figure 4-14

Alternative 1
Twin Peaks Tank Offline
Model Predicted Available Fire Flow
Westford Water Department
Westford, MA

Tighe&Bond

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August 2016

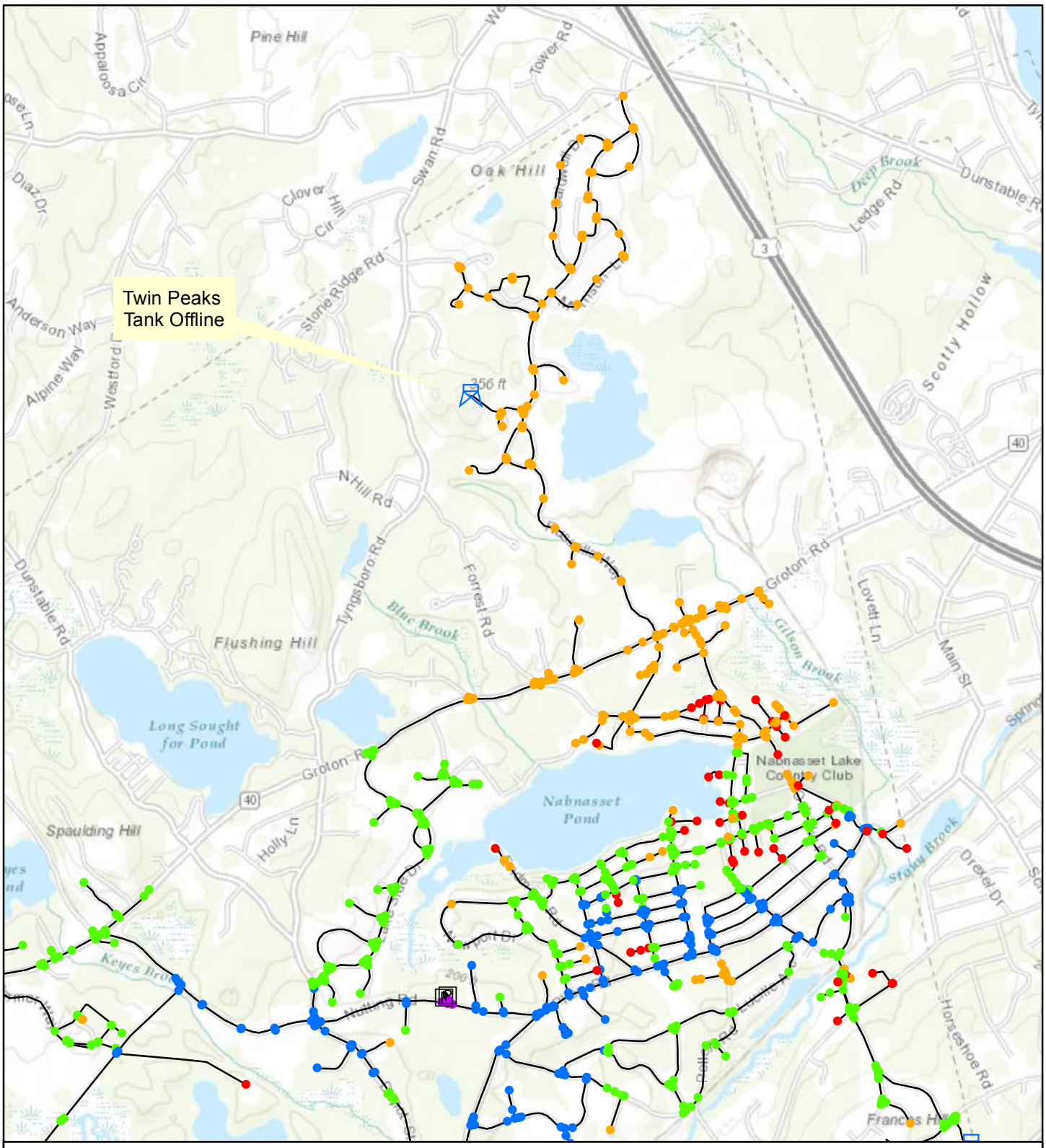


Figure 4-15

Alternative 1
Twin Peaks Tank Offline
Model Predicted Available Fire Flow
Westford Water Department
Westford, MA

Tighe&Bond

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August 2016

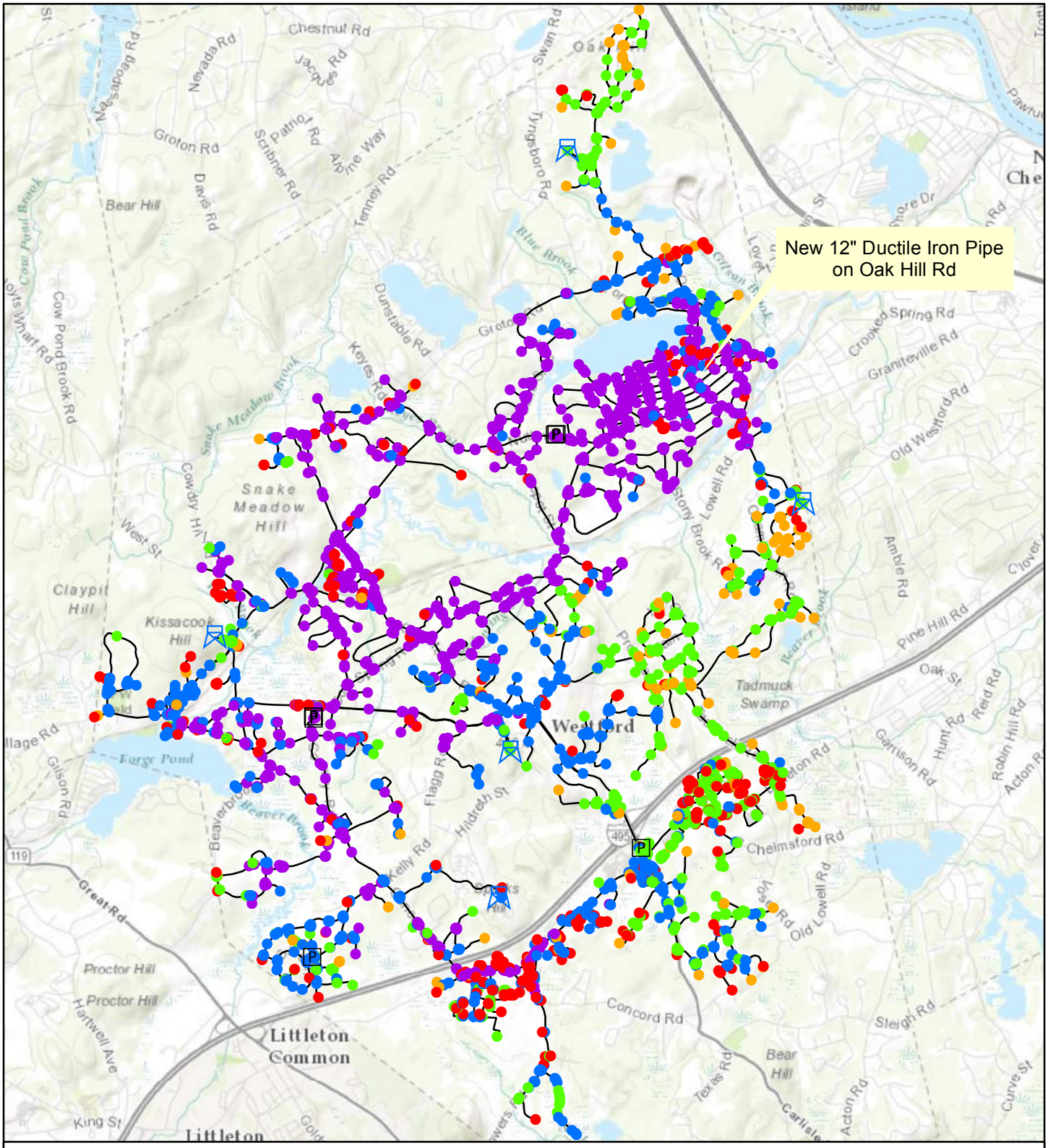
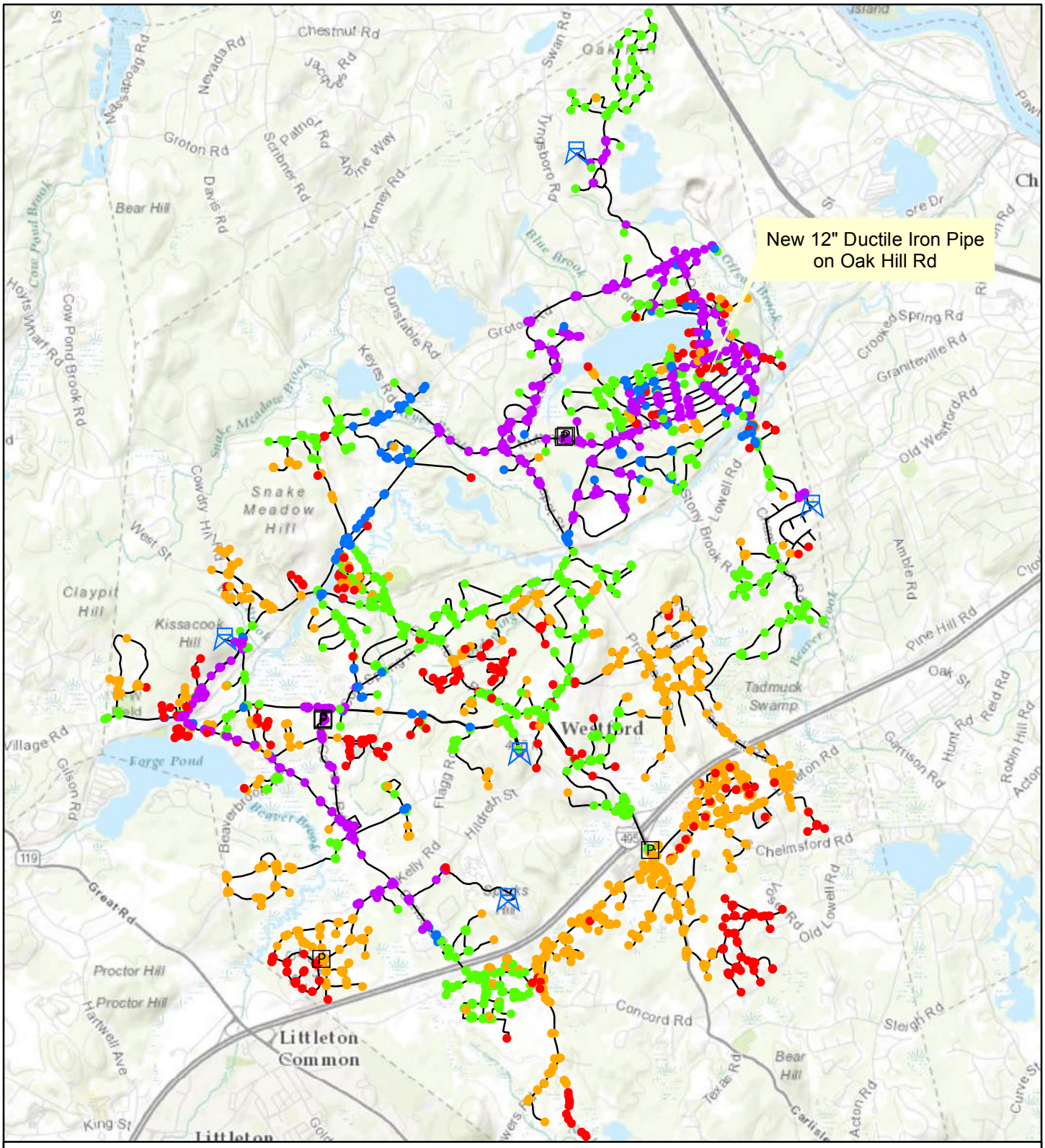


Figure 4-16
Alternative 2
Oak Hill Rd Water Main Upgrades
Model Predicted Average Water Age
Westford Water Department
Westford, MA

Tighe&Bond

Document Path: J:\W\W2160 Westford Water Dept\Model\ArcMaps\WQ Alternatives 8-2016\Westford_Alt2_Age_Map.mxd

October 2016



AFF, gpm

- <800
- 801 - 1,500
- 1,501 - 2,500
- 2,501 - 3,000
- >3,000

P Pumps

Water Storage Tanks

0 0.75 1.5 Miles

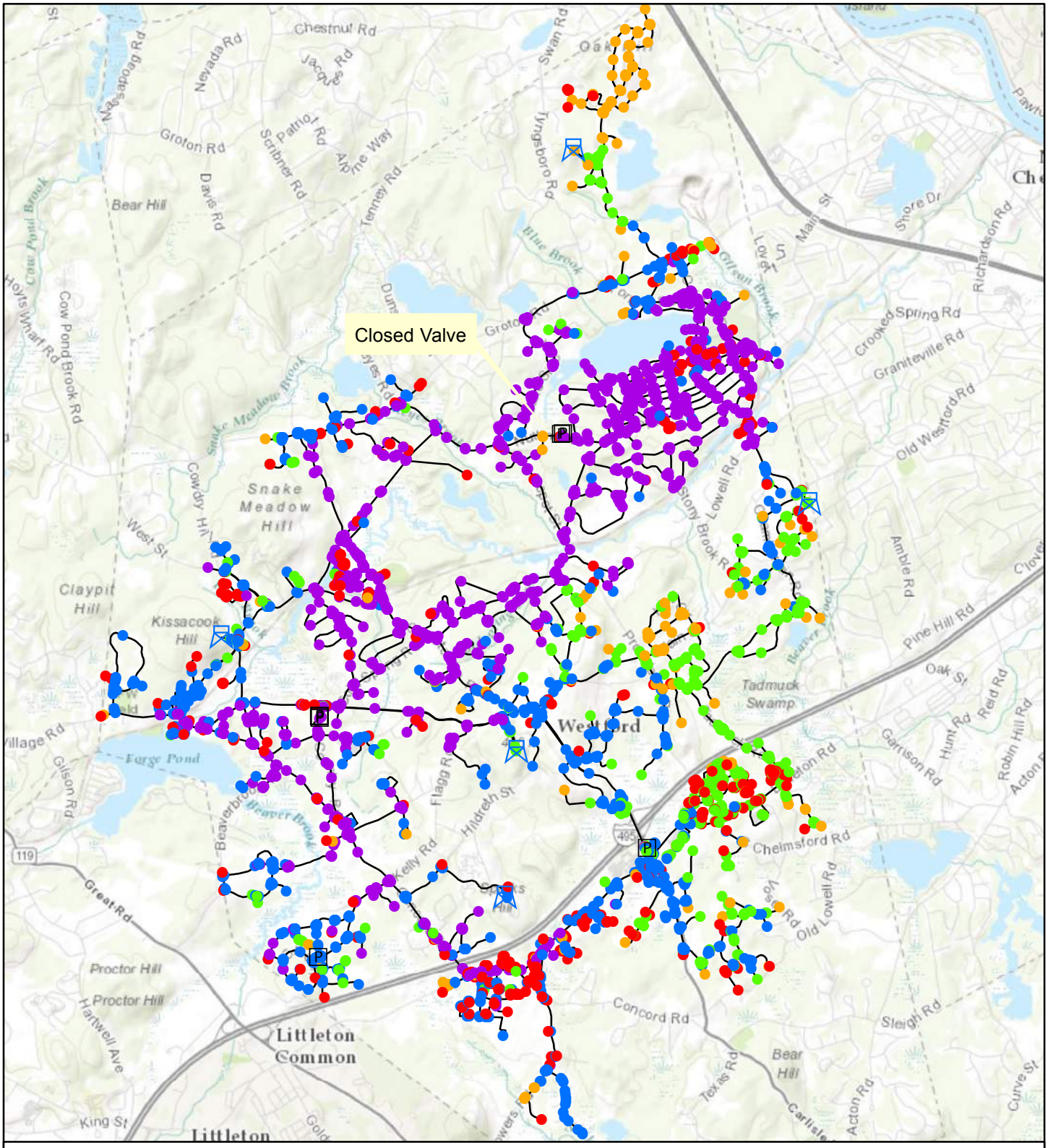
Figure 4-17

Alternative 2
New 12" Ductile Iron on Oak Hill Rd
Model Predicted Available Fire Flow
Westford Water Department
Westford, MA

Tighe&Bond

Document Path: J:\W\W2160 Westford Water Dept\Model\ArcMaps\WQ Alternatives 8-2016\Westford_AFF_Map_Alt2.mxd

August 2016



Average Water Age, hours

- 4 - 60
- 61 - 128
- 129 - 202
- 203 - 326
- 327 - 412

P Pumps

Water Storage Tanks

0 0.75 1.5 Miles

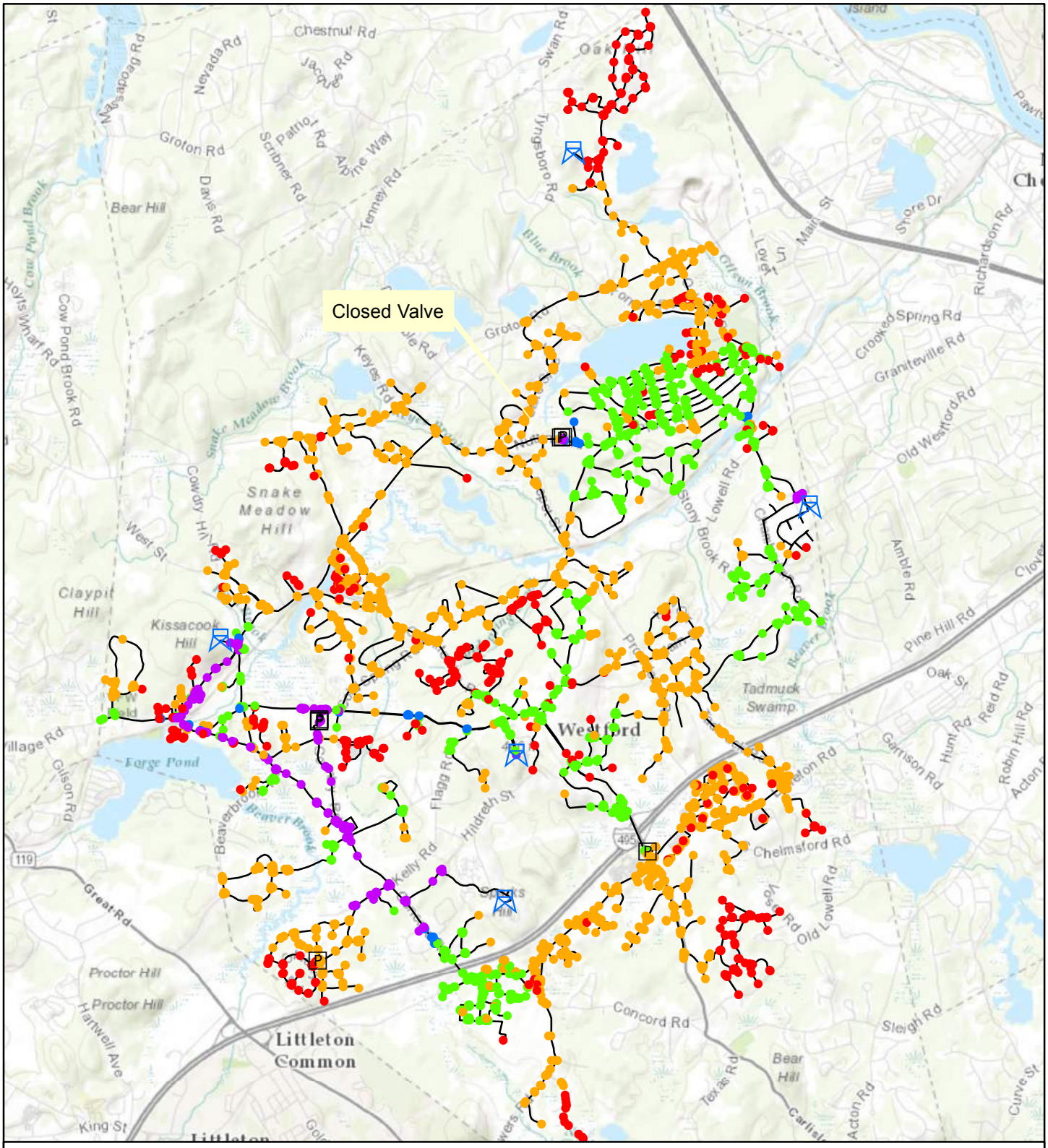
Figure 4-18

Alternative 3
Closed Valve on Nutting Rd
Preventing Western Flow From WTP
Westford, MA

Tighe&Bond

Document Path: J:\W\W2160 Westford Water Dept\Model\ArcMaps\WQ Alternatives 8-2016\Westford_Alt3_Age_Map.mxd

October 2016



AFF, gpm

- <800
- 801 - 1,500
- 1,501 - 2,500
- 2,501 - 3,000
- >3,000

P Pumps

Water Storage Tanks

0 0.75 1.5 Miles

Figure 4-19

Alternative 3
Closed Valve on Nutting Rd
Preventing Western Flow from WTP
Westford Water Department
Westford, MA

Tighe&Bond

Document Path: J:\W\W2160 Westford Water Dept\Model\ArcMaps\WQ Alternatives 8-2016\Westford_AFF_Map_Alt3.mxd

August 2016

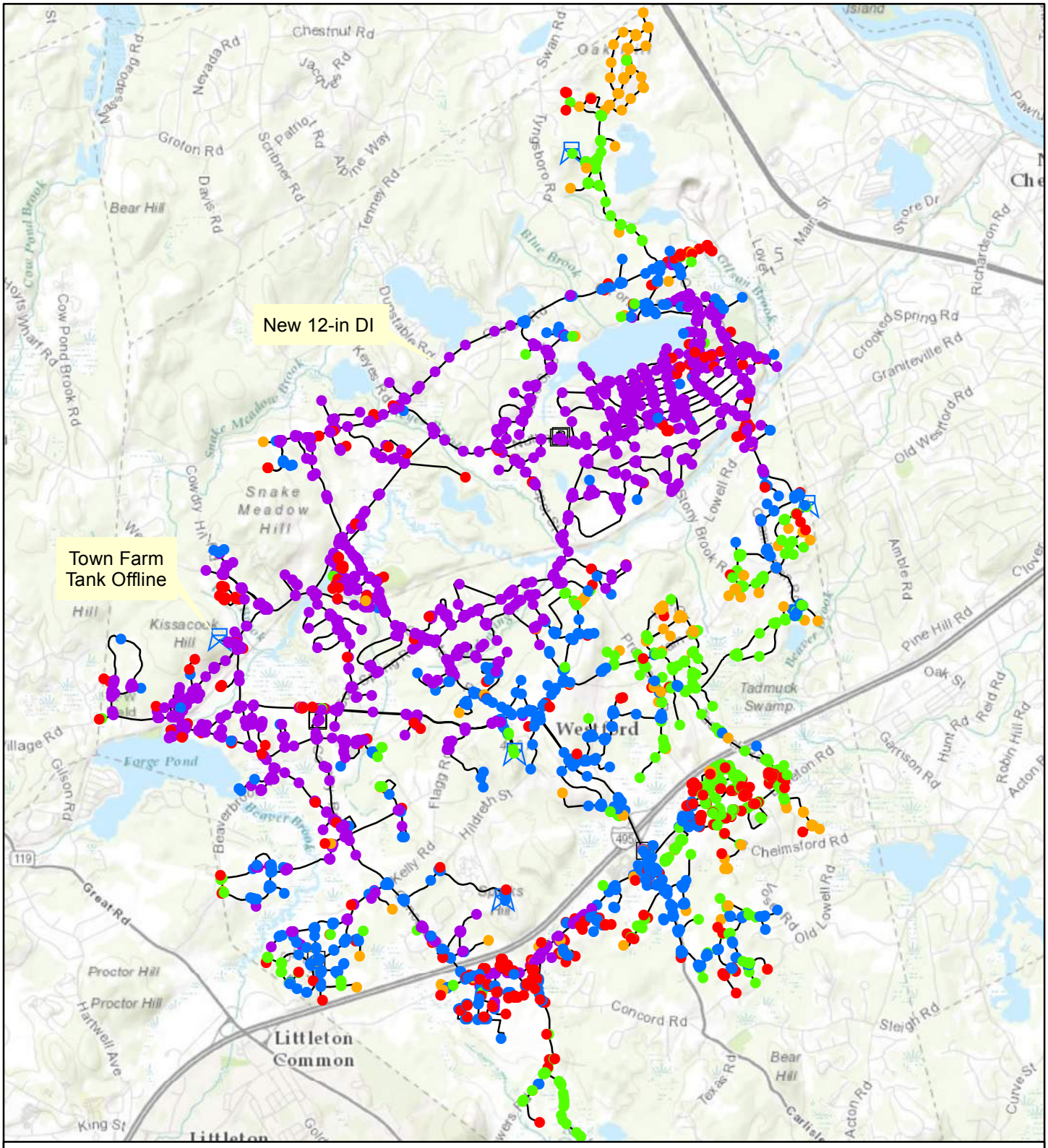


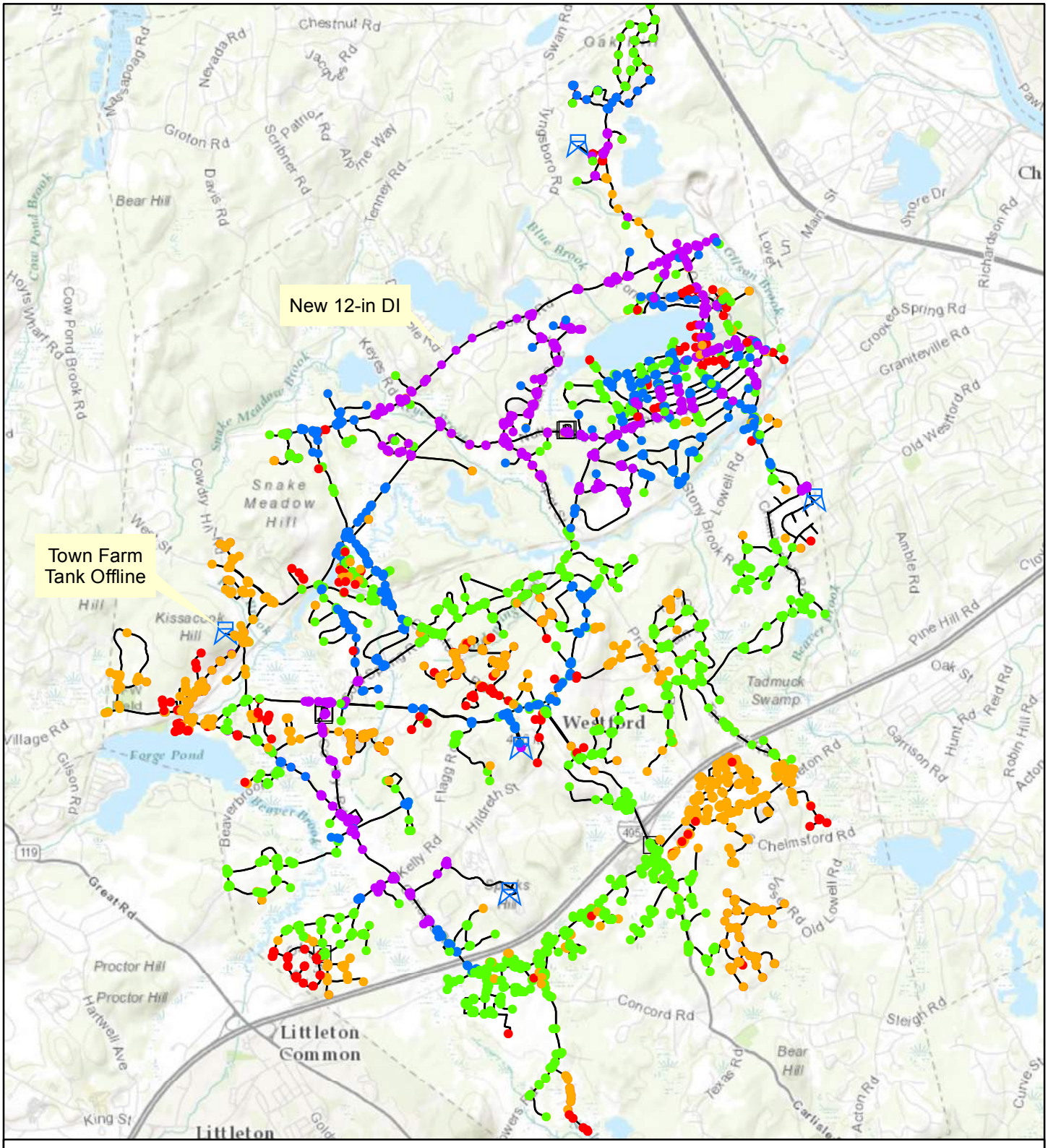
Figure 4-20

Alternative 4
New 12-in Water Main in Groton Road Town Farm Tank Offline, Model Predicted Average Water Age
Westford Water Department
Westford, MA

Tighe&Bond

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October 2016



AFF, gpm

- <500
- 501 - 1,000
- 1,001 - 2,000
- 2,001 - 3,000
- >3,000

P Pumps

Water Storage Tanks

0 0.75 1.5 Miles

Figure 4-21

Alternative 4
Predicted Available Fire Flow
New 12-in Water Main in Groton Road
Town Farm Tank Offline
Westford Water Department Westford, MA

Tighe&Bond

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August 2016

Section 5

Section 5
Water Supply Requirements

The water supply requirements for the Westford Water Department were developed in the 1997 Water Supply Master Plan Update, which have been updated in this Section. This Section presents the updated water supply capacity analysis projected through the year 2035 based on present day trends. The supply projections are compared to the Water Department's approved yields to determine the excess capacity available. This section also includes discussions about the Water Department's Water Management Act Permit requirements and achieving compliance in the future.

5.1 Historical and Current Water Demand

It is typical for the water usage to fluctuate year to year depending upon weather, the amount of construction and development in Town, and system operations. With improvements to the water system, upgraded source and customer metering, and better water management, water usage variations are less extreme.

Historical water usage is shown in Figure 5-1. The water usage increased steadily from 1982 to 1986. There was a peak in 1988 of 595 MG followed by a usage decrease to 443 MG in 1992. The usage then increased to 644 MG in 1998 and a sharp decrease to 543 MG in 1999. During the years 2000 through 2012, the water usage varies, with a general decrease in usage. In more recently years, usage has slightly increased by approximately 6 percent between 2012 and 2016.

5.1.1 Unnaccounted for Water

The Water Department's UAW has ranged from 1% to 9% of total water pumped between 1980 and 2015, as shown in Figure 5-1. The UAW data was unavailable for a few years during this time period. UAW is generally estimated as follows:

UAW = total water pumped – metered use – estimated non-meter usages

Based on 2014 usage, the total metered usage was 94.1% of the total water pumped and the estimated usage was 1.4%, resulting in unaccounted for water of 4.5%.

In 2014, the average UAW for public water suppliers in Massachusetts was 14.6%[6] and the industry standard is 10% to 15%[7]. The Commonwealth of Massachusetts recommends a goal of 10% or less UAW. Westford is within the acceptable range of the state average.

Figure 5-2 includes the historical average day demand and maximum day demand in Westford from 1980 through 2016. The average day demand has consistently been below the volume permitted by the Water Department's WMA permit.

[6] Source: Massachusetts Executive Office of Energy and Environmental Affairs, *Performance Standards for Public Water Supplies - RGPCD & UAW*, 2014.
[7] Source: Massachusetts Executive Office of Energy and Environmental Affairs and Water Resources Commission, *Water Conservation Standards*, updated June 2012.

Figure 5-1
Historical Annual Water Usage and UAW

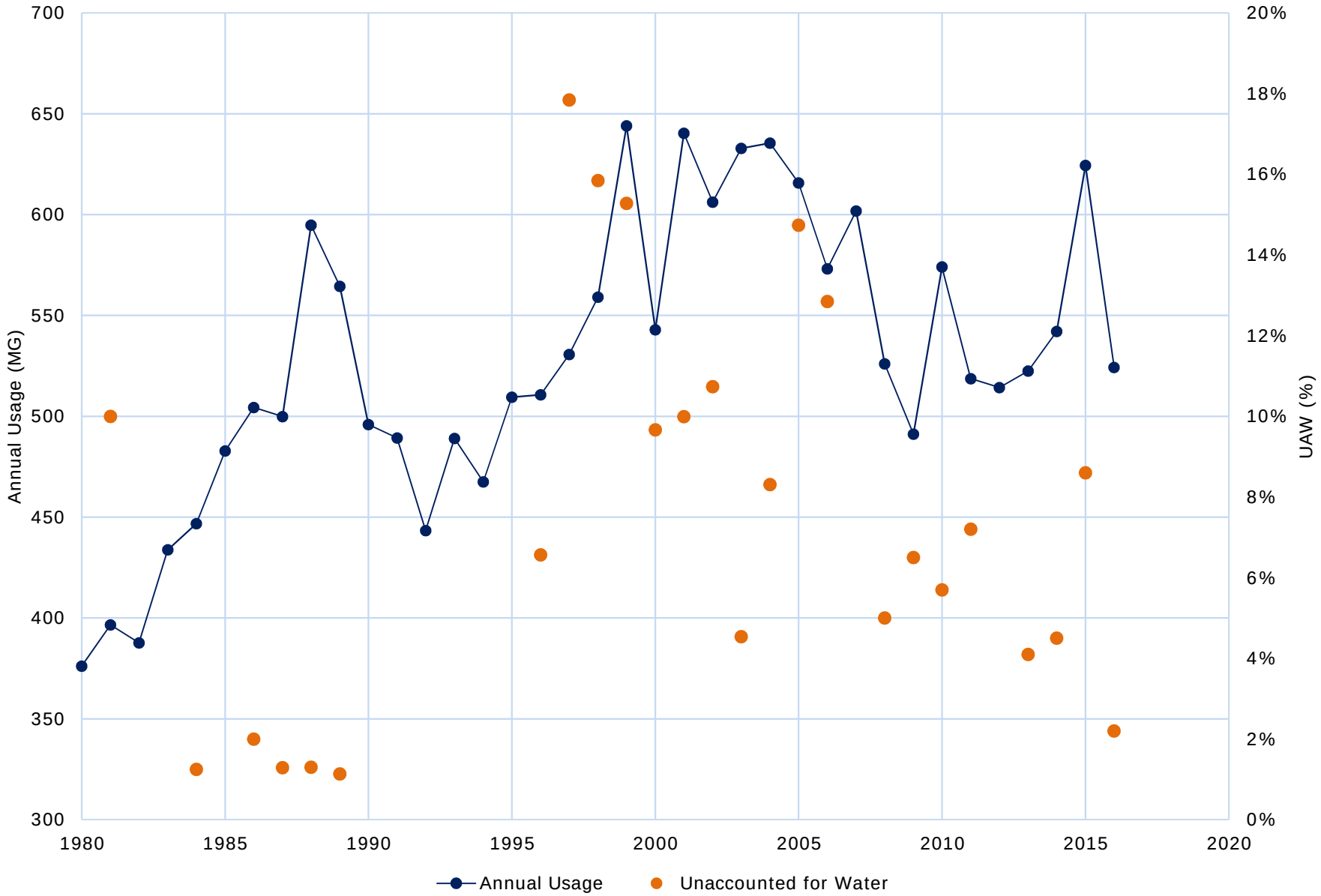
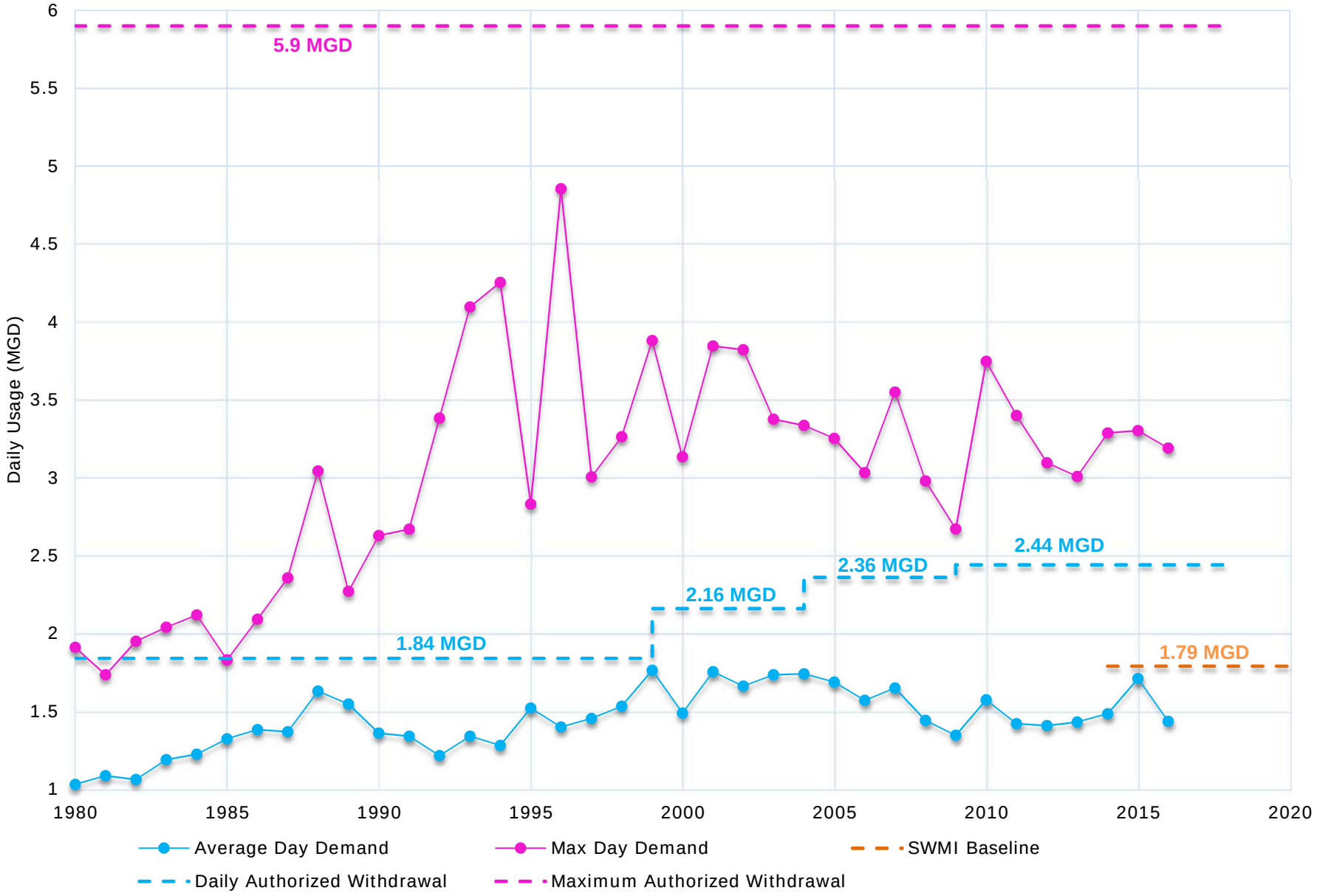


Figure 5-2
Historical ADD and MDD

Tighe&Bond



5.1.2 Residential Gallons per Capita per Day and Services

From 2000 through 2016, the Water Department's RGPCD has ranged from 59 to 74, with an average of approximately 66, as shown in Table 5-1. RGPCD data are unavailable prior to 2000 and for 2007 and 2012 the values were not included in the ASRs. The Commonwealth of Massachusetts recommends a goal of 65 gpd, so the Water Department is generally within the acceptable range of the State's recommendation.

Generally, the number of services connected to the distribution system has increased since 1980 due to the population growth and addition of developments throughout Westford. In 1980, there were 2,577 connections and in 2016 there were 5,365 connections. The number of service connections has more than doubled in the 36 years since 1980. In the last five years, connections have grown by around 3.5%.

Table 5-1
Historical RGPCD

Year	RGPCD
2000	61
2001	72
2002	66
2003	65
2004	66
2005	70
2006	65
2008	64
2009	59
2010	74
2011	68
2013	64
2014	62
2015	68
2016	60
Minimum	59
Maximum	74
Average	65.6

5.2 Projected Demands

As part of this Master Plan, both short- and long-term water use projections have been developed. Short-term projections look at the current demands on the system and the known developments in Town. Typically, this projection is used to evaluate the impact of development on the water supply capacity. Long-term projections are used for planning and phasing of water supply development projects and are typically a twenty-year period.

The 2007 Water System Master Plan Update utilized a linear regression technique that used past trends including new services, average day demand, and per service consumption to predict future average and maximum daily demands. This simplistic technique did not account for the numerous factors in Westford that affect projected demands:

- The system does not currently service the entire Town (only approximately 75% of the population). The portions of Town that are served by the water system are largely the most developed areas, so additional water demand in the currently

serviced area of Town will generally not be due to population growth and instead will be due to redevelopment and new commercial properties, as well as some employment growth.

- There has been a recent "boom" of commercial development along major routes in Town, which has already impacted the water system. At the time of this Report, there are limited known future commercial developments and the Town is almost at the 10% goal for Chapter 40B development. However, ongoing commercial and residential re-development is expected and will impact demand depending upon the water usage requirements.
- Westford has recently taken a very stringent approach to water conservation and has reduced outdoor watering to only two times per week during the summer under most conditions, and zero times per week when streamflow is too low.
- New regulations may require the Town to reduce demands through conservation, water reuse/restrictions and management (e.g., WMA and SWMI requirements).

5.2.1 Short-Term Demands

As part of preparing the "Water Management Act & Sustainable Water Management Initiative Planning Report" in late 2014, Tighe & Bond coordinated with the Water Department to develop a list of water usage for prospective developments throughout Westford. In 2014, this list assumed a total demand of 0.36 MGD per day from new and redevelopment projects would be added to the system. Since 2014, a number of developments have been completed, which totaled an 0.09 MGD in estimated average demand. In addition, more information has become available about the proposed developments with larger anticipated water use. As part of preparing this Water System Master Plan, Tighe & Bond worked with both Town and Water Department staff to update the list of planned developments. Table 5-2 includes a table showing prospective developments and anticipated water use as of the date of this report, showing short-term average day demands are around 0.16 MGD.

In addition, the Water Department is exploring expanding the system to service the approximately 80 three-bedroom houses in Vine Brook Estates located off Powers Road. Assuming an average daily demand of 65 gpcd and 2.93 as the average number of people per household, an average daily demand for this development could be approximately 15,500 gallons (0.015 MGD).

5.2.2 Long-Term Demands

Projecting the demand on Westford's water system into the 20-year future must recognize two competing trends: continuing increases in efficiency in the home and workplace and an increase in commercial and business uses and employment within the service area. Any projections must also include assumptions about the potential for new areas of Town to connect to the distribution system. How all the assumptions are worked together can provide varying degrees of conservatism in the planning projections. The projections included in this report are conservative and thus protective of existing customers. The 20-year projections consider the existing service area and the potential future service area, based on discussions with Water Department Staff.

Table 5-2
Summary of Water Usage for Prospective Developments and New Connections in Westford

Development	No. Units/SF	Bedrooms	Title 5 Flow	Title 5 GPD	Water Use[(1)] (gpd)	Notes and Assumptions
134 Littleton Road (4,300 SF retail, 4,300 SF office)	4,300 4,300		50/1000SF 75/1000SF	538	632	Assumed included in current usage
17 & 19 Lawson Rd (1 unit)	1	2	110	220	259	Assumed 2 bedrooms for apartments/condos
28/30 Old Lowell Road (1 unit)	1	2	110	220	259	Assumed 2 bedrooms for apartments/condos
317 Littleton Road (2,200 SF office)	2,200		75/1000SF	165	194	Assumed included in current usage
46 Groton Rd (2 units)	2	2	110	440	518	Assumed 2 bedrooms for apartments/condos
Abott Mill, Phase II	125	2	110	27,500	32,354	Assumed 125 units, 2 bedrooms for apartments/condos
Bruce Freeman Rail Trail					0	Rail trail/assume no/limited usage
Littleton Landing (7 units)	7	2	110	1,540	1,812	Assumed 2 bedrooms for apartments/condos
Minot's Corner reconstruction project					0	Roadway project/assume no usage
NetScout (156,495 SF office)	156,495		75/1000SF	11,737	13,809	Assumed included in current usage
O'Brien Farm (conservation restriction)					0	Conservation Restriction/no flows
Orchard Square (11,160 SF retail, 7,000 SF restaurant)	11,160 7,000		50/1000SF 35/seat	1,083	1,274	Assumed 75GPD/1,000SF (Title 5 restaurant 35 GPD/seat
Residences at Westford West (240 units - 105 1br, 111 2br, 24 3br, average of 1.66 br/unit)	282	1.66	110	51,493	52,140	The projected water use of 52,140 is based on developer's application, not on Note (2)
Spalding Estates (31 units)	31	2	110	6,820	8,024	Assumed 2 bedrooms for apartments/condos
Sugar Maple Lane Townhouses (28 units)	28	2	110	6,160	7,247	Townhouses for sale, assumed 2 bedrooms for apartments/condos
Two Robbins Road (180 units - 18 3 br, 104 2 br, 58 1 br (average of 1.77 br per unit))	180	1.77	110	35,046	38,720	The projected water use of 38,720 is based on developer's application, not on Note (2)
				TOTAL (GPD)	**157,241**	
				TOTAL (MGD)	**0.157**	
				TOTAL (MG)	**57**	

Notes:
(1) Assumed wastewater flow is 0.85% of water use, therefore Title 5 values were multiplied by 1.1765 to estimate water usage.

5.2.2.1 Existing Service Area

Population projections prepared by planning agencies including the University of Massachusetts Donahue Institute, Massachusetts Department of Transportation, and Northern Middlesex Council of Governments, were used as the starting point for projecting future water demand.

As of the date of this report, the Town of Westford has a population of approximately 22,000 residents. Since 1960, the population has grown steadily, increasing by 3,000 to 4,000 people every 10 years. Prior to 1960, the population increased by only a few hundred every ten years. The steady increase in population is indicative of Westford's evolution from a semi-rural town to a suburb. Figure 5-3 shows the Town's historical population change from 1850 through the 2010 Census, as well as population projections.

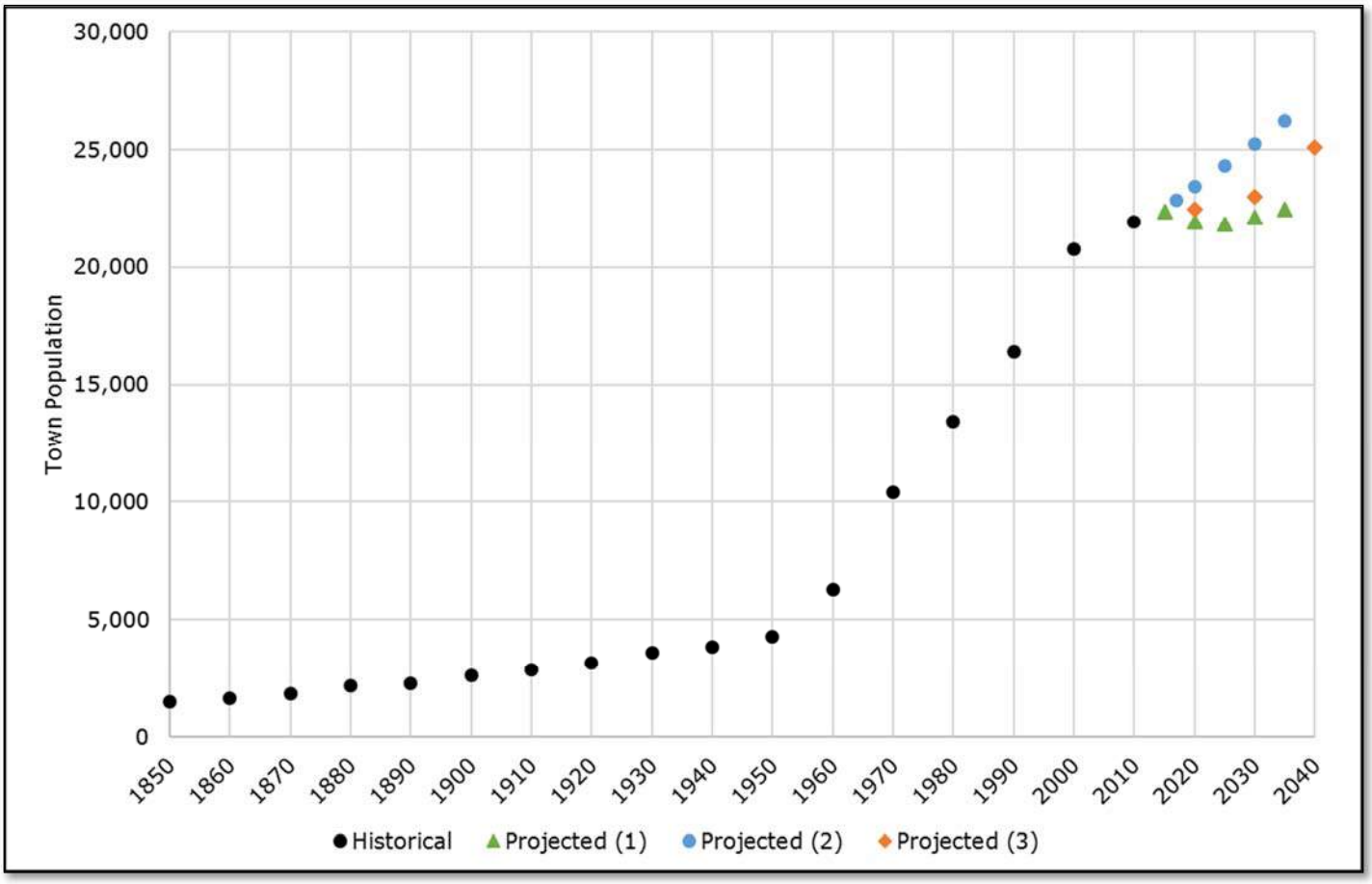


Figure 5-3 Historical and Projected Population for Town of Westford

Projections are from the following sources:

(1) University of Massachusetts Donahue Institute, Population Estimates Program. Denoted in Figure 3-3 as a green triangle.
URL: *http://pep.donahue-institute.org/*

(2) Massachusetts Department of Transportation, Massachusetts Population Projections. Denoted in Figure 3-3 as a blue circle. URL:

https://www.massdot.state.ma.us/Portals/17/docs/Demographics/MunicipalDemographics-Population.pdf

(3) Northern Middlesex Council of Governments, Greater Lowell Region Population Figures and Estimates, 2010-2040. Denoted in Figure 3-3 as an orange diamond. URL: *http://www.nmcog.org/Websites/nmcog/images/2016-2040_RTP/6_-_Chapter_4_Demographics_81015.pdf*

Looking at an average growth based on these three sources, Town-wide population is projected as shown in Table 5-3.

Table 5-3
Town-Wide Average Population Growth

Year	Average Population	Percent Growth
2010[1]	21,951	
2015	22,400	2.0
2020	22,650	1.0
2025	22,950	1.5
2030	23,500	2.2
2035	24,300	3.3

[1] Actual from 2010 U.S. Census

We utilized the population to estimate future demand within the existing service area by starting with the 2015 demand and applying percent growth every five years. This should account for growth in employment and but will not be sufficient to account for significant commercial development in the service area.

Table 5-4
Projected Demands Based on Population Growth

Year	Average Daily Demand (MGD)
2015	1.49[1]
2020	1.52
2025	1.54
2030	1.56
2035	1.59

[1] Average of 2007 through 2016 actual values

While population is growing slightly, school enrollment has been on a decline since 2003 when there was an enrollment "bubble" in the K-2 level. In January of 2016 a report that evaluated prediction of school enrollment in Kindergarten through senior year of high school prepared by a resident working with the School Building Utilization group and provided to the Westford School Committee. This report assessed concerns related to the declining enrollment in Westford Public Schools. As stated in this report, "for a number of years, the number of births recorded by Westford's Town Clerk have declined at a much higher rate than the number of Kindergarteners enrolled five years later. This results in the enrollment projections for Kindergarten being consistently underpredicted…" This report presented a methodology that reduces the error in estimating future enrollment projections, but concurs that enrollment is declining. This report found:

- The decline in K through 2 enrollments beginning in 2004 continues, and are predicted to level off at about 800 students in 2020.

- Grade 3 through 5 enrollments have been declining since 2011, and are predicted to level off at around 900 students in 2025.
- A similar rate of decline in Grades 6 through 8 will begin in 2016 to 2019.
- High school enrollments will remain near their current level, growing by about 100 students over 4 to 5 years.

Even though school enrollment is slightly decreasing, the overall population projections generally indicate that Westford's population will continue growing over the next few decades, creating a greater demand on the Town's water system.

5.2.2.2 Potential Service Area Expansion

As further described in the Capital Improvement Plan in Section 6 of this report, there are streets in Town that have been identified as potential for expansions of the service area. Table 5-5 lists these proposed extensions. Figure 5-4 shows the extent of these potential area expansions. The anticipated average daily demand from residential areas only is less than 0.109 MGD. In aggregate, the residential average daily demand along with demands from non-residential areas if developed could result in a significant increase in average daily and maximum daily demands. As system expansions are being considered, the impacts from each expansion should be individually considered and modeled.

Table 5-5 Potential Service Area Expansion

Proposed Extension	Total # of Lots	Total acres	# of Residential lots	Residential Areas (acres)	Residential ADD (GPD)[1]	# of Non-residential Parcels[2]	Non-residential Areas (acres)
L-1	77	216	70	112	13,332	7	104
L-2	29	57	29	57	5,523	0	0
L-7	63	342	47	110	8,951	16	232
L-8	120	110	118	95	22,473	2	15
M-1	139	361	130	268	24,758	9	93
M-10	46	65	41	58	7,808	5	7
M-2	26	44	26	44	4,952	0	0
M-7	18	29	18	29	3,428	0	0
M-8	46	168	38	74	7,237	8	93
M-9	58	121	54	105	10,284	4	16

[1] Average daily demand was calculated by 65 gpcd x No. of Residential Parcels x 2.93 (average number of people per household in Westford)

[2] Non-residential parcels were made up of the following land use types: Multiple Use, Field Crops, Nurseries, Vacant Land (not in residential zone), Commercial, Public Service Properties, Exempt Properties, etc.

Another driver for system expansion may be related to water quality concerns in private wells. In the northern area of Town, homeowners have reported issues with high levels of manganese, sodium arsenic, and radon.

For the purposes of estimating potential future water use, we assumed that in the 20-year planning period only approximately 25% of the residential lots will be added to the system, so a total of 0.027 MGD was included in the projections starting in 2025. Many of the non-residential areas of protected open space and therefore are not developable.

DUNSTABLE

TYNGSBOROUGH

DRACUT

LOWELL

GROTON

CHELMSFORD

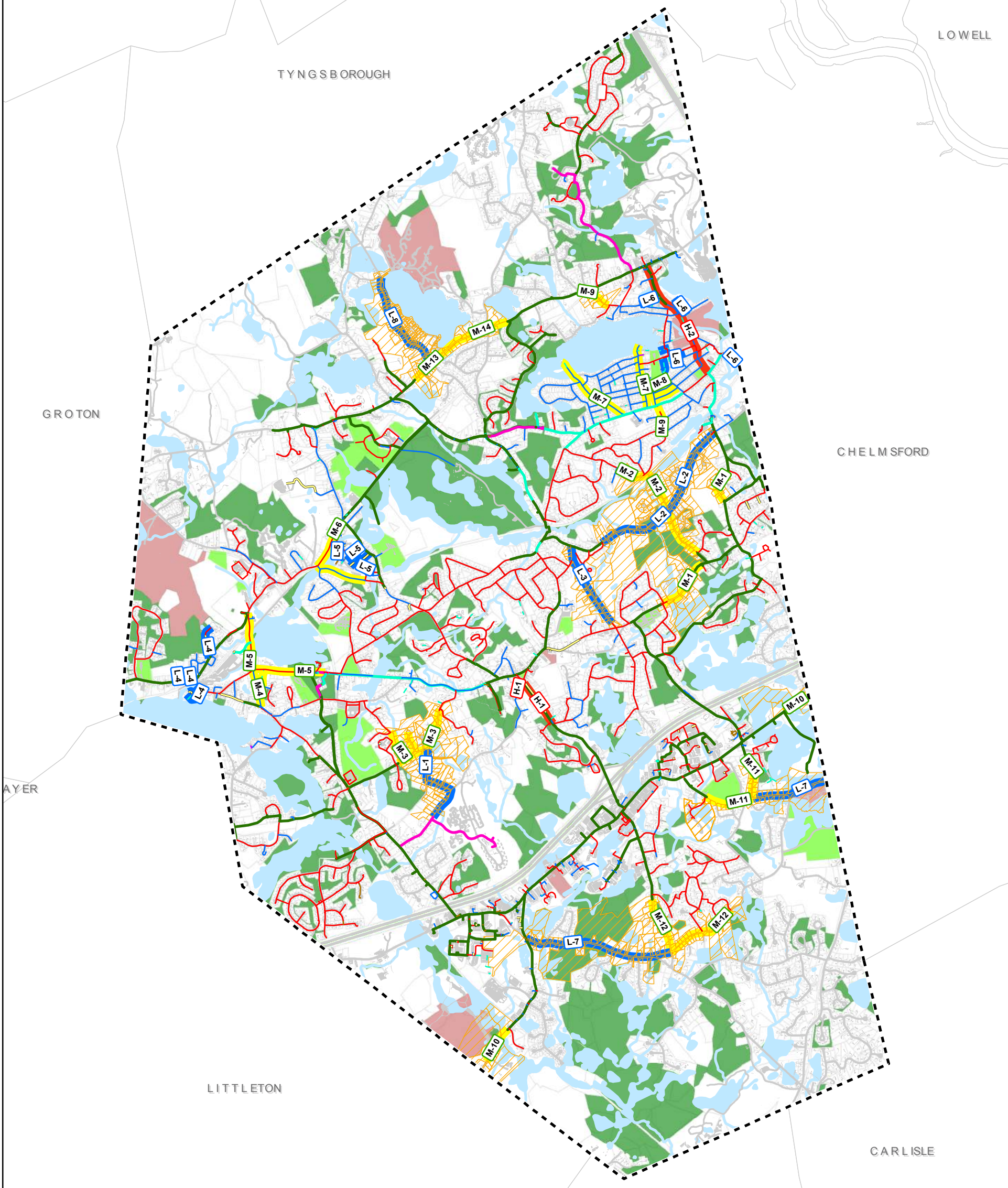
AYER

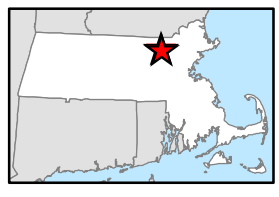
LITTLETON

CARLISLE

ACTON

BOXBOROUGH





Legend

Capital Improvement Projects

Priority

- High
- Medium
- Low
- Ponds
- Rivers and Streams
- Impervious Surface
- Town Boundary
- New Service Area Parcels

Open Space: Level of Protection

- In Perpetuity
- Limited
- None

Water Main

Diameter (inches)

- 1
- 1.5
- 2
- 4
- 6
- 8
- 9
- 10
- 12
- 16
- Unknown

1:48,000

0 2,000 4,000

Feet

N

FIGURE 5-4
POTENTIAL SERVICE AREA EXPANSION

Westford, Massachusetts

February 2018

Tighe&Bond Consulting Engineers Environmental Specialists

G:\GIS\MA\WestfordMA\avproj\WaterSystemExpansionandOS.mxd

W-4787

5.2.2.3 Impact of Open Space Preservation

Preservation of open space and conservation of Westford's natural resources are a priority. There are numerous local controls that restrict development including the Water Resource Protection Overlay District, the Floodplain Overlay District, the Conservation Overlay District, and the Open Space Rural Development section of the Zoning Bylaws.[8]

Since 2002, Westford has protected more than 600 acres of open space through land acquisitions and conservation restrictions. The Town adopted the Community Preservation Act (CPA) in 2002 as a means of raising local funds for open space protection, historic preservation, and affordable housing. Westford recently acquired two large parcels of open space, the East Boston Camps property and the Stepinski parcel, which reduce the total inventory of developable residential land.

The most recent Open Space and Recreation Plan (OSRP)[9], finalized in June 2010, provides insight into potential future land uses. Since the majority of Westford's land is zoned for residential use, it is anticipated that the majority of future new and redevelopment will be residential. The Town's zoning code will exert significant control over its land use pattern at buildout. However, Westford is currently experiencing tear-downs and, according to the OSRP, "mansionization". Many small, older homes in Westford have been demolished and replaced by larger dwellings, especially summer homes around some of the larger ponds in the northern section of Town, which are being expanded or rebuilt to the maximum extent possible.

The total amount of land zoned for commercial and industrial use is small compared to the size of the residential districts. However, in recent years Westford has attracted considerable interest in commercial and industrial development. Even though these uses are allowed in limited areas, they can exert an enormous impact on Westford's character and future growth.

As described in the OSRP, there are a number of natural areas that are unprotected from development, including undeveloped parcels along waterbodies and near drinking water supplies, the Town's remaining quarries, undeveloped hilltops, fields and farms (e.g., Parker Village, Volo Farms, Scanlon Farm, and Greenwood Farm) along scenic roads, and other forested tracts (e.g., Massachusetts Institute of Technology's 570 acres around Haystack Observatory, Nashoba Valley Ski Area's 75 acres, and 200 acres of the two sportsman clubs). As development pressure increases, the Town's remaining large unprotected open spaces and more marginalized parcels (e.g., those with steeper slopes, underlying bedrock, and less suitable soil contents) could be targeted for development

[8] Open Space Rural Development requires that a portion of each residential development site be reserved as common open space at a ratio of 10,000 square feet of upland per dwelling unit, with some variations for larger developments or those located in an industrial zone.

[9] Westford Open Space and Recreation Plan. June 2010. URL: http://www.westfordma.gov/pages/government/towndepartments/boardsandcommittees/WestfordMA_concomm/documents/Open%20Space%20Plan%202010-2015,%20Final,%20June,%202010.pdf

Westford's considerable open spaces are shown in Figure 5-5. This figure presents open space areas based on the level of protection identified in the Massachusetts Geographic Information System (MassGIS) data layers. According to MassGIS[10], the following are definitions of level of protection that apply to open space in Westford:

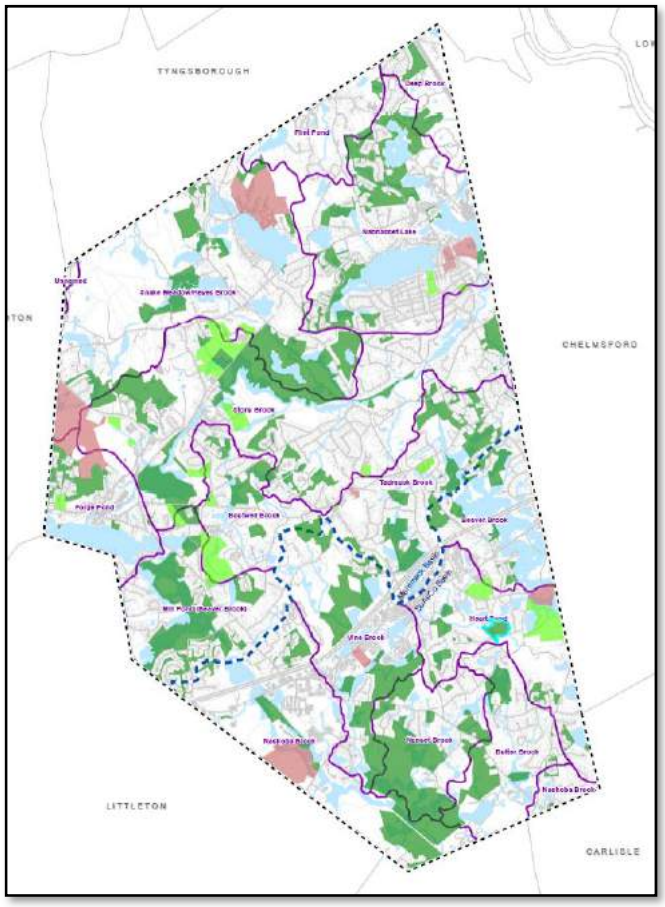


Figure 5-5 Westford's Open Space

- **In Perpetuity** (dark green areas in Figure 5-4): Legally protected in perpetuity and recorded as such in a deed or other official document. Land is considered protected in perpetuity if it is owned by the Town's conservation commission or, sometimes, by the water department; if the Town has a conservation restriction on the property in perpetuity; if it is owned by one of the state's conservation agencies (thereby covered by Article 97); if it is owned by a nonprofit land trust; or if the Town received federal or state assistance for the purchase or improvement of the property. Private land is considered protected if it has a deed restriction in perpetuity, if an Agriculture Preservation Restriction has been placed on it, or a Conservation Restriction has been placed on it.
- **Limited** (light green areas in Figure 5-4): Protected by legal mechanisms other than those above, or protected through functional or traditional use. These lands might be protected by a requirement of a majority municipal vote for any change in status. This designation also includes lands that are likely to remain open space for other reasons (e.g., cemeteries and municipal golf courses).
- **None** (red areas in Figure 5-4): Totally unprotected by any legal or functional means. This land is usually privately owned and could be sold without restriction at any time for another use (e.g., scout camps, private golf course, and private woodland).

As previously discussed in Section 5.2.2.2., the areas for potential service expansion include a number of non-residential parcels. Table 5-5 showed total of 51 non-residential parcels consisting of 560 areas are in areas that could, someday, be provided with water service by an expansion of the distribution system. However, 15 parcels consisting of 245

[10] MassGIS Data – Protected and Recreation Open Space, October 2015. URL: http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/osp.html

acres (43% of the 560 acres) are considered open space with some level of protection and therefore would not be developable in the near term.

5.2.3 Summary of Projected Demands

Based on the information provided in the previous sections, Table 5-6 and Figure 5-6 depict the overall 20-year protected demands that consider short-term planned development, population growth, economic growth, and system expansion.

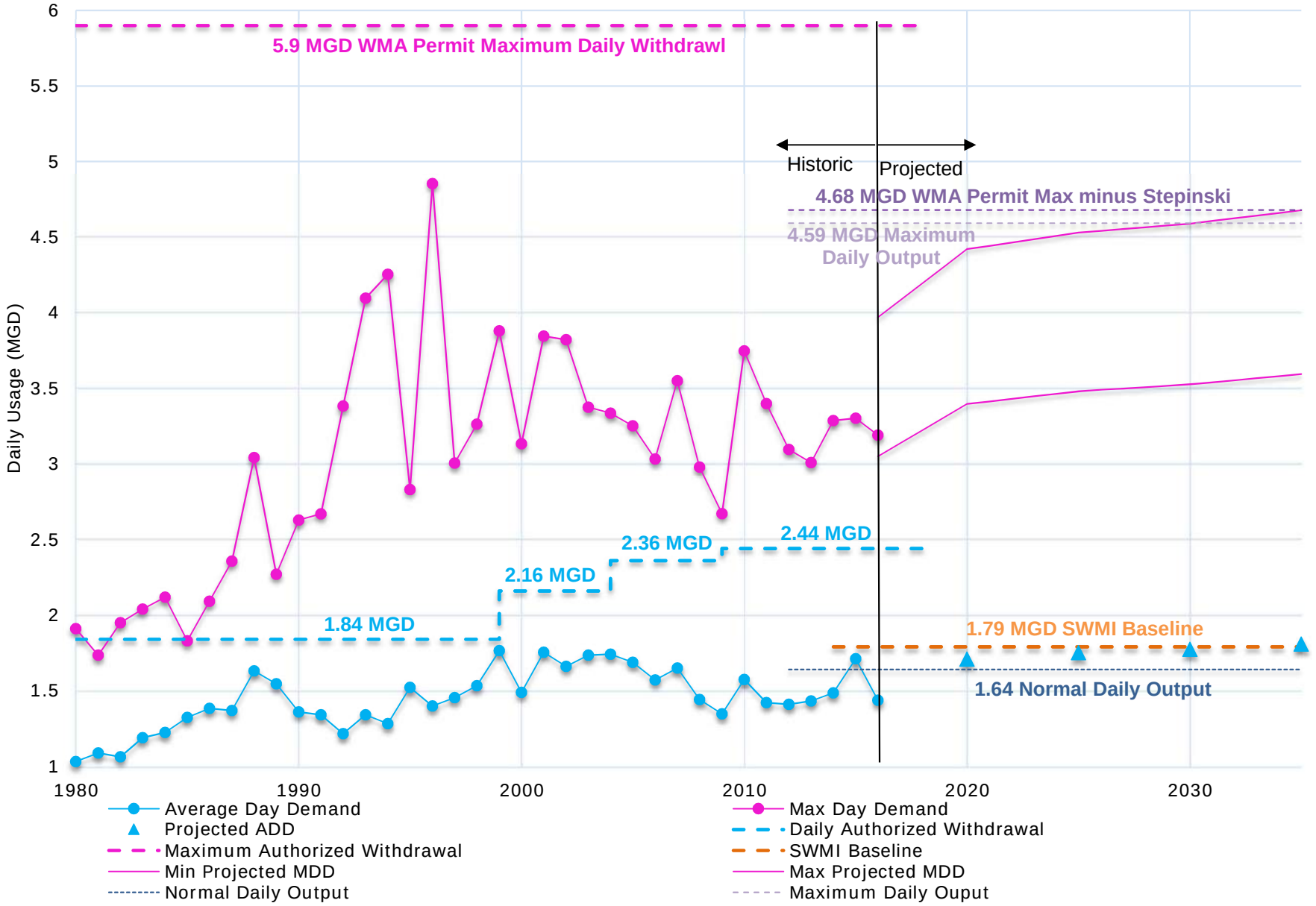
Table 5-6
Summary of Projected Demands

Year	Projected Summary of Average Daily Demand (MGD)	Projected Lower Range Maximum Daily Demand (MGD)	Projected Upper Range Maximum Daily Demand (MGD)
2015	1.49[1]	3.30[2]	
2020	1.71	3.40	4.42
2025	1.75	3.48	4.53
2030	1.77	3.53	4.59
2035	1.81	3.59	4.67

1 Average of 2006 through 2016 actual values
2 Actual 2016 value
3 Lower range MDD was estimated by applying the ratio between MDD and ADD from 1980 through 2016 (second quartile or 50% value) to the ADD
4 Upper range MDD was estimated by applying the ratio between MDD and ADD from 1980 through 2016 (90^{th} percentile value) to the ADD

Figure 5-6
Projected ADD and MDD

Tighe&Bond



5.2.4 DCR Water Needs Forecast

In October 2017, the Massachusetts Department of Conservation and Recreation (DCR) developed a draft water needs forecast for Westford's water supply system, which can be used to assist in renewing the Town's existing WMA permit. Tighe & Bond provided Section 5 of this Report, Water Supply Requirements, to DCR in advance of their preparation of the future demands.

DCR's forecast indicates estimated future water needs for the Town's service area. DCR developed a forecast for two different future water use scenarios:

- Scenario 1: Residential water use is 65 RGPCD and UAW is 10% throughout the permit period, with a buffer of an additional 5% for uncertainty in growth projections
- Scenario 2: Residential water use and UAW reflects current trends for Westford's system, with a buffer of an additional 5% for uncertainty in growth projections

The following assumptions related to current system metrics[11] and population and employment[12] were used in the development of DCR's draft forecast

- System demand = 1.51 MGD
- RGPCD = 63.44 gallons per capita per day
- UAW = 4.21%
- Service population = 16,699
- Non-residential demand = 0.30 MGD
- Town-wide base employment (2016) = 12,035

Section 5.1 of this Report, Historical and Current Water Demand, presents additional information about Westford's UAW and RGPCD.

Table 5-7
Population and Employment Projections

Year	Service Population Projections	Employment Projections
2018	16,993	12,793
2024	17,759	13,608
2029	18,125	13,678
2034	18,683	13,749

[11] Sources: Volumes reported in ASRs (2012-2016). Percent served calculated using 2016 ASR service population divided by the 2016 federal census estimate = 70% served. Service population calculated using an average of 2012-2016 federal census estimates multiplied by 70%. 2016 town-wide base employment interpolated using Massachusetts Department of Transportation (MassDOT) employment projections (July 2015).

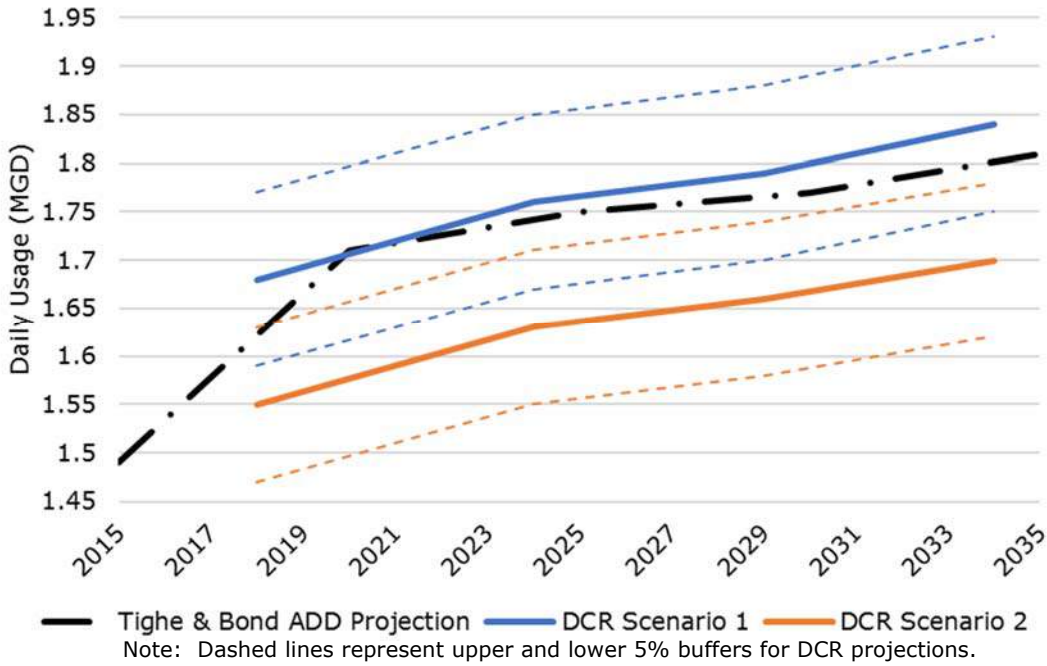
[12] Sources: Town-wide population projections used the percent increase from "Westford Water System Master Plan" by Tighe & Bond. Service population assumed to be 72% of the town population starting in 2024 to account for service area expansion. Town-wide employment projections used MassDOT employment projections (July 2015) and interpolations thereof. A demand of 5.7% was added for treatment plan losses (average from 2012-2016).

Using current water system metrics and the population and employment projections, DCR determined the Town's future water use as follows:

Table 5-8
DCR Water Needs Forecast

Year	Projection for Scenario 1 (MGD)	Projection for Scenario 2 (MGD)
2018	1.68	1.55
2024	1.76	1.63
2029	1.79	1.66
2034	1.84	1.70
5% Buffer	0.09	0.08

Figure 5-7 shows DCR's water needs forecast scenarios along with the projected ADD included in this Report. The ADD projected in this Report is within the same range as DCR's water needs forecast. From a planning perspective, DCR estimates are reasonable, however, because these projections are used to define the total authorized withdrawal for the Department in their WMA permit through the end of the next permit cycle, these estimates are considered restrictive (i.e., maximum projected daily use of 1.94 MGD vs current permit of 2.44 MGD). DCR's projections through 2034 forecast a significantly reduced total withdrawal compared to the 2.44 MGD included in the current permit and registration. A reduced total authorized withdrawal may pose problems for the Water Department and should be discussed with MassDEP during the WMA permit renewal process.



Note: Dashed lines represent upper and lower 5% buffers for DCR projections.

Figure 5-7 Water Use Projection Comparison

Section 6

Section 6
Water Capacity Analysis

The water supply requirements for the Westford Water Department were developed in the 2007 Water System Master Plan Update. This update to the Water System Master Plan includes the following water capacity analysis, which provides an assessment of the projections through the year 2035 based on present day trends. The supply projections were compared to the Departments Approved Yields to determine the excess capacity available. The Water Management Act Permit was also addressed to achieve compliance in the future.

6.1 Supply Capacity and Adequacy

To evaluate the adequacy of the existing supplies, we compared the projected demands for the water system discussed in Section 5 to the available supply. This evaluation considers the maximum daily output and the normal daily output:

1. To estimate average daily output, we assumed the Cote and Stepinski Wells are only able to achieve a combined yield of 1.17 MGD, the remainder of the sources are able to achieve the average maximum daily pump rate (MGD) recorded over the last five years of pumping data (2012-2016).

2. To estimate maximum daily output, we assumed the Cote and Stepinski Wells are only able to achieve a combined yield of 1.17 MGD, the remainder of the sources are able to achieve the maximum daily pump rate (MGD) recorded over the last five years of pumping data (2012-2016).

3. To estimate normal daily output, we assumed all wells continue to be pumped at a similar daily rate (MGD) as the average of the last five years of pumping data (2012-2016).

We also considered the upper benchmark as the scenario where all wells can achieve their approved yield and the largest source (Stepinski) is off-line, for a total maximum withdrawal of 4.68 MGD. However, Water Department staff currently operate the wells such that each well is pumped no more than 75% of the maximum daily withdrawal allowed under the WMA permit.

Table 6-1 lists the approved yield and maximum daily output and normal daily output based on data reported in Annual Statistical Reports from 2012 through 2016.

Table 6-1
Water Withdrawal Limits

Well	WMA Permit Maximum Authorized Withdrawal Volume (MGD) [1]	75% WMA Permit (MGD)	Average Maximum Daily Output (MGD) [2]	Maximum Daily Output (MGD) [3]	Normal Daily Output (MGD) [4]
Forge Village No. 1	0.34	0.225	0.224	0.248	0.116
Forge Village No. 2	0.59	0.443	0.458	0.530	0.229
Country Road No. 2	0.61	0.458	0.437	0.571	0.224
Fletcher	0.69	0.518	0.493	0.624	0.187
Howard Road	0.43[5]	0.323	0.323	0.396	0.142
Nutting Road and Satellites	0.65[6]	0.488	0.409[7]	0.572[7]	0.171
Depot Road	0.72	0.54	0.368	0.523	0.129
Cote	0.65	0.488	1.17	1.17	0.175
Stepinski	1.22	0.915			0.267
Total =	5.9	4.43	3.88	4.59	1.64
Total (w/out Stepinski) =	4.68				

1 The approved yields for Westford's water supplies are based on the Water Withdrawal Permit issued to the Westford Water Department, effective November 6, 2014 through November 30, 2018.
2 Average Maximum daily output is the average of maximum single day pumping over the last five years
3 Maximum daily output is the maximum value of all maximum single day pumping over the last five years.
4 Normal daily output is the average of the flow rates based on the total volume pumped (MG) divided by the number of days pumped over the last five years.
5 The combined rate of the five Howard Road Wells is not to exceed this daily rate.
6 The combined rate of the Nutting Road Well and Satellite Wells No. 1 and 2 is not to exceed this daily rate.
7 The maximum daily output is based on the sum of the average of maximum daily outputs for both wells using data from ASRs from 2012 through 2016. This number is conservative as it reflects a maximum for each well that may have occurred on separate days, not on the same day.

Table 6-2 shows the maximum daily output without the Stepinski well on-line versus the projected range in maximum daily demand. In the 20-year planning period, the upper bound of the projected maximum daily demand will reach the authorized withdrawal without the Stepinksi well on-line. While this is still less than the total 5.9 MGD maximum authorized withdrawal that is approved by the WMA permit, it signifies that without continued aggressive water conservation and demand management, the Water Department should be concerned about long-term capacity issues during peak demands (e.g. summer time) and long periods of drought.

Table 6-2
Capacity vs. Predicted Maximum Daily Demand

Year	WMA Maximum Authorized Withdrawal Volume w/out Stepinski (MGD)	Current Average Maximum Daily Output (MGD)	Projected MDD (MGD)	Approved Maximum Authorized Withdrawal Surplus (+) or Deficit (-) (MGD)
2015	4.68	3.882		
2020			3.40 to 4.42	+0.26 to 1.28
2025			3.48 to 4.53	+0.15 to 1.20
2030			3.53 to 4.59	+0.09 to 1.15
2035			3.59 to 4.67	+0.01 to 1.09

Table 6-3 shows the normal daily output versus the projected average daily demand that considers both short term and long-term growth.

Table 6-3
Normal Daily Output vs Predicted ADD

Year	Normal Daily Output	WMA Average Daily Withdrawal	SWMI Baseline	Projected ADD (MGD)	Approved Average Daily Withdrawal Surplus (+) or Deficit (-) (MGD)	SWMI Baseline Exceedance
2015	1.64	2.44	1.79			
2020				1.71	+ 0.73	+ 0.08
2025				1.75	+ 0.69	+ 0.04
2030				1.77	+ 0.67	+ 0.02
2035				**1.81**	+ 0.63	- 0.02

Projections do not indicate the WMA average daily withdrawal will be exceeded within the planning period, however the SWMI Baseline is projected to be exceeded by 2035. Because projections are estimates, to be conservative, it would be prudent for the Water Department to begin planning to be implementing minimization and mitigation by 2025 to address SWMI requirements.

6.1.1 Short-Term Considerations

During summer 2017, Tighe & Bond completed a review of the Application for Water System Impact Study submitted to the Westford Water Department for both the proposed Two Robbins Apartment Homes located at 2 Robbins Road and The Residences of Westford West to be developed behind the Red Hat Building at 314 Littleton Road.

Our water impact review included performing scenarios on an existing extended period simulation hydraulic model of the Water Department's distribution system that was developed by Tighe & Bond using InfoWater software.

Our review evaluated potential changes related to increased water demand including system pressure decreases and increases in head loss along the connecting water main, and predicted available fire flow at the site. Drawings obtained as part of a Peer Review for the development showed each of the proposed development areas and connection to the distribution system. The reported average day and maximum day demands for the development were converted to gallons per minute and adjusted for the existing diurnal demand pattern in the model. This will accurately account for typical water usage over a 24-hour period.

Fire flow conditions were simulated to predict the available fire flow during peak hour and maximum day demand conditions. In addition, Tighe & Bond modeled available fire flow in the immediate area surrounding the site to determine additional flow available at nearby hydrants. Available fire flow is defined as the flow available at each model node, with no node in the system dropping to below 20 psi. This simulation was run assuming the proposed fire suppression system at each development was active. As the proposed Two Robbins Apartments and the Residences of Westford West development are located next to one another, Tighe & Bond also ran the model with demands from both proposed projects impacting the system simultaneously.

Our review of the Water Department's supply capacity and simulations performed on the computer model indicate that the water distribution system has adequate infrastructure and supply to accommodate the proposed developments. The additional water demand will have minimum impact on the system pressure. Additionally, fire flow simulations predict that the fire flow requirements for the project will be met. The results of the model scenarios are as follows:

- Model simulations predict that the anticipated demands from the two developments will not have a significant impact on distribution system pressure (< 1 psi).
- The 12-inch ductile iron pipe appears to be appropriately sized to handle the anticipated demands.
- Hydrants bordering the proposed site along Littleton and Robbins Roads will have a predicted available fire flow greater than 1,000 gpm while still meeting the fire flow requirements to the developments.
- The total available fire flow for the area adjacent to the developments is between 2,000 and 2,500 gpm.
- Model simulations that assume demands from both the Two Robbins Apartments and the Residences of Westford West development show a fairly low impact on the system. With both fire flows running at a combined rate of 905 gpm, the static pressure at 2 Robbins Rd is 73 psi and at the Residences is 72.7 psi.

Based on this evaluation, the Westford Water Department has adequate capacity to supply these two proposed developments and will be able to meet the requested average day and maximum day demands. The distribution system will also be able to provide adequate pressure and meet the reported fire flow requirements of the project.

6.2 Distribution Storage

Distribution storage is used for flow equalization (peak hour demand supply), fire flow volume, and short-term emergency water supply. Between the five storage facilities discussed in Section 3.4, the water system currently has a total of approximately 4.85 million gallons of distribution storage. Once the Prospect Hill water storage tank is replaced in 2018, the system will have an additional 0.43 million gallons of storage with a new total of 5.28 million gallons.

6.2.1 Low Service Zone Usable Volume

There are four storage facilities in the Low Service Zone (LSZ) and one in the High Service Zone. The current usable storage in the LSZ is calculated to be 4.3 million gallons based on the service elevation, elevation of each tank, and overflow elevation for the LSZ of 407.6'.

Distribution storage capacity should be sized to meet both domestic and emergency demands for the high service zone. Evaluation of storage capacity includes the following considerations:

- Fire storage
- General emergency storage (water main break, pump station failure, water system supply loss)
- Total existing usable storage

Fire storage capacity must be sized to meet fire flow demands in the system while still allowing the system to meet the maximum daily demand. As such, the fire flow for the High Service Level can be estimated with the following equation:

Fire Flow Storage = Needed Fire Flow + Max Day Demand – Production Capacity

For the low service zone, the needed fire flow was based on a flow of 4,000 gpm for three (3) hours. Production capacity in this calculation assumes that the Forge Village Water Treatment Plant is offline and only Nutting Road Water Treatment Plant is providing supply.

General emergency storage capacity can be estimated a variety of ways to represent a water main break, pump failure, or a temporary loss of supply. For this analysis, the emergency storage was calculated based on a two (2) hour emergency event occurring during Peak Demand, which was calculated to be three (3) times the maximum daily demand.

Table 6-4 summarizes the results of the storage capacity analysis for the LSZ. Based on this evaluation, the capacity of storage in the LSZ is adequate for flow equalization and fire flows.

Table 6-4 Available Equalization and Emergency Storage in the Low Service Zone

Condition	2015	2025	2035
Average Day Demand (1)	1.49	1.75	1.81
Maximum Day Demand (2)	3.30	4.01	4.13
Required Fire Storage (3)	0.88	0.97	0.98
Needed Fire Flow (4)	*0.72*	*0.72*	*0.72*
MDD during Fire Flow Event (5)	*0.41*	*0.50*	*0.52*
Production Capacity (6)	*0.25*	*0.25*	*0.25*
Required Emergency Storage (7)	0.83	1.00	1.03
DISTRIBUTION STORAGE REQUIRED (8)	**1.71**	**1.97**	**2.02**
Less Existing Usable Storage			
Town Farm Tank	0.43	0.43	0.43
Frances Hill Tank	0.86	0.86	0.86
Hildreth Hills Tank	2.00	2.00	2.00
Twin Peaks Tank	1.00	1.00	1.00
TOTAL USABLE STORAGE VOLUME	**4.29**	**4.29**	**4.29**
ADDITIONAL STORAGE REQUIRED	**-2.52**	**-2.26**	**-2.21**

(1) 2015 Average Day Demand is based on actual recorded data from ASRs. For 2035 this was based on projections included in Section 5.

(2) Maximum Day Demand is average of projections included in Section 5.2.3.
(3) Required fire storage equals Needed Fire Flow plus MDD required during fire event minus production capacity of the system.

(4) 4,000 gpm for 3 hours

(5) Based on Maximum Day Demand

(6) 1400 gpm for 3 hours, assumes Forge Village WTP off-line

(7) Peak Hour Demand for 2 hours

(8) Sum of Total volume required and Production Capacity

6.2.2 High Service Zone Usable Volume

Analysis completed in the 2007 Master Plan showed that the high service zone requires approximately 650,000 gallons of total storage. The 172,000 gallon Prospect Hill Tank was recommended to be replaced with a 750,000 gallon elevated type facility at the same location to maximum the usable volume and minimize pressure fluctuation. This volume was estimated to the meet the demands of the High Service Zone through the year 2025.

Since that plan was approved, the Water Department appropriated funds to complete the design and construction of the new tank with the intent of placing the tank into service during Summer 2018. As part of preparing the design, a capacity analysis of the storage was completed.

As part of preparing the preliminary design for replacement of the Prospect Hill Tank, Tighe & Bond completed a storage capacity evaluation for the high service zone.

The existing Prospect Hill Water Storage Tank is 172,000 gallons; however, only the upper 56% of the total volume can be considered usable storage under typical operating conditions. Table 6-5 presents an analysis of the available equalization and emergency storage available for the existing tank. Available equalization storage is defined as the volume in the tank that provides at least 35 psi pressure at the high point in the high service zone under static conditions. Available emergency storage is defined as the volume in the tank below the required equalization storage and above the level that results in a minimum pressure of 20 psi throughout the water level under static conditions.

Table 6-5 Available Equalization and Emergency Storage in the High Service Zone

Overflow Elevation	558.4	FT
Minimum Elevation	468.4	FT
Tank Diameter	18	FT
Total Volume	172,000	GAL
Elevation of Highest Service	461.5	FT
Available Equalization Elevation (35 psi)	542.3	FT
Available Emergency Elevation (20 psi)	507.7	FT
Volume Available for Equalization	30,712	GAL
Volume Available for Emergency	65,880	GAL
Usable Volume	96,592	GAL

The results in Table 6-5 show that only 30,712 gallons of water is available for equalization storage so that once the water level drops below 542.3 ft in the storage tank, the services at the highest elevations will begin to experience lower than optimal water pressures. Under current operating conditions the pumps which feed the tanks only operate to maintain the water level above 545.4 ft so that under normal operating conditions system pressure is not an issue. During a fire event; however, the water level can fall rapidly and result in low pressures in much of the high service zone.

The emergency storage of 65,880 gallons is not sufficient to meet accepted fire/emergency storage standards for the service zone. Even at locations where the needed fire flow is lowest (750 gpm) based on Insurance Services Office (ISO) data, this emergency volume is insufficient to provide more than two hours of fire flow.

Mixing is also an issue at the existing tank. Because only the top several feet of the tank are utilized, the hydraulic model indicates that only 8% of the tank volume is changed with each empty/fill cycle which is not sufficient to promote sufficient mixing within the tank. Insufficient mixing can result in stratification and cause water quality concerns.

Distribution storage capacity should be sized to meet both domestic and emergency demands for the high service zone. Evaluation of storage capacity includes the following considerations:

- Fire storage
- General emergency storage (water main break, pump station failure, water system supply loss)
- Equalization storage

Fire storage capacity must be sized to meet fire flow demands in the system while still allowing the system to meet the maximum daily demand. As such, the fire flow for the High Service Level can be estimated with the following equation:

Fire Flow Storage = Needed Fire Flow + Max Day Demand – Production Capacity

For the high service zone, the needed fire flow was based on a flow of 2,500 gpm for two (2) hours. Production capacity in this calculation assumes that the Forge Village Booster Station is offline and only the Boston Road Pump Station (at 400 gpm) is providing water into the high service zone.

General Emergency Storage capacity can be estimated a variety of ways to represent a water main break, pump failure, or a temporary loss of supply. For this analysis, the emergency storage was calculated based on a two (2) hour emergency event occurring during Peak Demand which was calculated to be three (3) times the maximum daily demand.

Equalization storage is defined as the volume of water that provides for the daily demands of the system without allowing the tank to drop below the volume available for fire and emergency storage. The equalization storage should be sized large enough to maintain the tank level above the emergency volume and to provide adequate turnover of the tank. The final result is typically based on which is higher; either 25% of the maximum day demand, or 20% of the total tank volume. In this case 20% of the total tank volume (or 25% of the fire/emergency volume is larger than 25% of the maximum day demand.

When evaluating storage capacity for a tank, there are different methodologies that can be utilized to determine the storage capacity. Two different approaches were utilized for determining the storage capacity for the Prospect Hill Tank:

- Method 1 – Utilizes the greater of either the fire or general emergency storage with the assumption that these two emergencies are unlikely to occur simultaneously. Equalization storage is then calculated to be 20% of the total tank volume.

- Method 2 - Calculates the sum of the fire storage and general emergency storage. Equalization storage is then calculated to be 20% of the total tank volume.

Table 6-6 summarizes the results of the storage capacity analysis using the two different methods for the High Service Zone.

Table 6-6 High Service Zone Storage Capacity Analysis

Condition	2015	2035
Average Day Demand(1)	0.16	0.17
Maximum Day Demand(2)	0.36	0.37
Required Fire Storage(3)	0.42	0.42
Needed Fire Flow(4)	*0.45*	*0.45*
MDD During Fire Flow Event	*0.04*	*0.05*
Production Capacity(5)	*0.07*	*0.07*
Required Emergency Storage(6)	0.09	0.09
Greater of Required Fire or Emergency Storage (Method 1)	0.42	0.42
Sum of Fire plus Emergency Storage (Method 2)	0.51	0.52
Equalization Storage (Method 1)	0.11	0.11
Equalization Storage (Method 2)	0.13	0.13
Total Tank Volume (Method 1)	**0.53**	**0.53**
Total Tank Volume (Method 2)	**0.61**	**0.62**

(1) Average Day Demand is based on 10% of the average day demand in the whole distribution system. For 2015 this was based on actual recorded data from ASRs. For 2035 this was based on projections as developed in Section 5 of this report. Billing data suggests that 8% of the demand comes from the HSZ, but 10% was used to provide a more conservative number.
(2) Maximum Day Demand is 2.18 times Average Day Demand based on an average MDD/ADD Ratio calculated from 2006 through 2015 data.
(3) Required fire storage equals Needed Fire Flow plus MDD required during fire event minus production capacity of the system.
(4) Needed Fire Flow is calculated as 2500 gpm for 3 hours.
(5) Production capacity for the zone is assumed to be 400 gpm which assumes that the Forge Village Booster Pumps are out of operation.
(6) Required Emergency Storage is assumed to be 3 times the maximum day demand for 2 hours.

Method 1 results in a volume of 0.53 MG and Method 2 results in a volume of 0.62 MG for a recommended storage capacity for the proposed Prospect Hill Tank. This evaluation resulted in recommending a 600,000-gallon storage tank for the new Prospect Hill Tank. This will provide adequate fire and emergency storage within the High Service Zone.

6.3 Potential Future Sources

As the Town of Westford continues to grow, additional permanent and emergency sources of supply should be considered to support existing and future needs. These sources can be provided via interconnection to an abutting water system or by development of a source.

6.3.1 Interconnections

The Town has existing emergency interconnections with neighboring water systems in Tyngsborough and Groton. Full interconnections to abutting municipalities, including Littleton, Chelmsford, Tyngsborough, and Groton, are all theoretically feasible, however, there are limitations that impact Westford's ability to actually connect.

Groton Water System[13]: The water system has over 52.3 miles of water mains, 1,892 water services, 383 fire hydrants, and three water supply wells (Baddacook Pond Well, Whitney Pond Well #1, and Whitney Pond Well #2). Water is pumped from these sources to the Chestnut Hill Water Storage tank. This 1 million-gallon storage tank, constructed in 2005, is at an elevation of 516 feet.

Chelmsford Water System[14,15,16]: Chelmsford has three separate water districts, including the Chelmsford, North Chelmsford, and East Chelmsford Districts. Chelmsford Water District's water supply is from 19 sources from the Merrimack and Concord River basins. Chelmsford Water District's facilities provide roughly 1 billion gallons of clean drinking water each year. The North Chelmsford Water District has approximately 2,800 service connections, with just under 100 service connections in Tyngsborough. North Chelmsford Water District's water is sourced from 4 gravel packed wells located in the Bomil Well Field. East Chelmsford Water District's water supply is sourced from two wells on Canal Street, which receive greensand filtration and chemical additions to remove iron and manganese and control corrosion. These systems have various pressure zones.

Tyngsborough Water System[17]: Tyngsborough Water District purchases all of its water from the City of Lowell (water treatment facility treats and filters water from the Merrimack River), and Pennichuck Water (water treatment facility treats and filters water from the Merrimack River and Pennichuck Brook). The Water District in the process of developing a new water supply well off River Road. The Town is currently experiencing significant growth which is limiting their available capacity until the new well is completed. This may not occur until at least 2020.

Littleton Water System[18]: Littleton's water system is sourced by five gravel packed wells and a tubular wellfield. Average consumption is 1.00 MGD. The water system serves a population of approximately 8,360 residents with 2,812 residential service connections, and also has 190 commercial service connections, 45 industrial service connections, and 10 municipal or institutional service connections, for a total of 3,057

[13] Groton Water Department Annual Water Quality Report for 2015, April 2016
[14] Chelmsford Water District Annual Water Quality Report for 2015
[15] North Chelmsford Water District 2015 Annual Water Quality Report
[16] MassDEP Source Water Assessment and Protection Report for East Chelmsford Water District
[17] Tyngsborough Water District Annual Water Quality Report for 2015
[18] Littleton 2015 Annual Statistical Report

service connections. There are 78 miles of water main, 3 water storage tanks, 2 water treatment plants, 2 pump stations, and the average system operating pressure is 90 psi. Littleton currently does not have available capacity due to recent development and a large water user that recently relocated to Town.

Connecting to the **Acton Water District's** water system is not economically feasible because Westford's system is a significant distance away. Connecting to their water system would require a lengthy water main extension, which would likely be cost-prohibitive.

While there is an emergency interconnection to connect to **Tyngsborough's** water system as a permanent future source solution, Westford would be required to obtain permission from the suppliers that currently serve the Town. If Tyngsborough were to develop a water supply, and it produced excess volume, the towns can consider interconnecting.

There is a possibility to extend the 12" main on Littleton Road from Princeton Apartments to the Town line to achieve an interconnection with the **Chelmsford Water District**. There may also be a possibility to extend the 12" main on Powers Road from Equestrian Lane to the Town line to achieve an interconnection with the **Littleton** water system. Further discussion on specific capital improvements is included in the Capital Improvement plan in Section 7.

If a permanent interconnection was considered with Groton, Chelmsford Water District, or Littleton to support future demand needs, the municipalities would have to:

- Complete a hydraulic capacity analysis for both water systems, including evaluating existing and future demands simultaneously, storage demand, and hydraulics
- Identify and define regulations that would limit the transfer including the Interbasin Transfer Act, water quality and treatment issues, and withdrawal limits and SWMI requirements.
- Define and refine capital improvements including water main extensions likely required, and improvement such as a pumping stations

Once the above evaluations are complete and it would be favorable to interconnect, the towns can enter in an inter-municipal agreement to establish a permanent interconnection.

6.3.2 New Sources

Westford's wells are within the Stony Brook sub-basin of the Merrimack River watershed. There are limited opportunities to develop new sources in this same basin due to restrictions on the overall aquifer and limitations imposed by the WMA SWMI program.

6.3.2.1 Vine Brook Estates Public Water Supply

Westford had recently been considering taking ownership of the Vine Brook Estates Public Water Supply[19]. Water supply for Vine Brook Estates comes from two gravel packed wells (GP-1 and GP-2). GP-2 was designed and constructed in 2011 to replace the tubular wellfield that consisted of seven 8-inch diameter steel well casings with stainless steel

[19] Source Water Assessment Program (SWAP) Report for Vine Brook Estates.
URL: http://www.mass.gov/eea/docs/dep/water/drinking/swap/nero/2330014.pdf

screens driven to an average depth of 26 feet. The wellfield has a Zone I of 250 feet and an Interim Wellhead Protection Area (IWPA) of 2,512 feet. The well is located in an aquifer with a high vulnerability to contamination due to the absence of hydrogeologic barriers that can prevent contaminant migration. The well serving the facility has potassium hydroxide added for corrosion control. These wells provide the water supply for the approximately 80 homes in the Vine Brook neighborhood. The existing distribution system consists of mostly 4-inch and 6-inch PVC piping that has an approximate operating pressure of 40 psi. It is our understanding that the piping material that was used for the original water system was low grade and cannot withstand the higher operating pressure of the Water Department's existing distribution system on Powers Road, which has a normal operating pressure of approximately 80 psi.

The Water Department recently completed a limited test well investigation of the Vine Brook property to determine if there is a potential to develop a new source. The results indicated there are not favorable locations to continue pursuing a new well site in this location. The Water Department should continue to investigate other potential future well sites in Town including areas outside the current distribution system.

6.3.2.2 Gage Land

There is a 74.88 acre parcel of land located abutting Heart Pond (south-eastern area of Town) that is owned by the Town of Westford as Town Forest. While there is no mapped aquifer shown on publicly available mapping, Water Department staff have discussed further evaluation of this parcel to determine the potential for a new source. One of the benefits of this parcel is that it is not within an existing wellhead protection or surface water protection area, not within protected habitat areas (i.e. Area of Critical Environmental Concern, Priority, or Estimated Habitat) or near an outstanding resource water, and does not appear, based on review of publicly available mapping, to have any contaminated sites or regulated sites on the parcel or nearby.

Per 310 CMR 22.00, the public water supplier must own the entire Zone I for the well or obtain conservation restrictions/easements for land within the Zone I for areas not under their ownership. For a well that is 100,000 gallons per day or greater, the Zone I is a 400' protective radius, and for wells less than 100,000 gpd it is determined by the pumping rate. To be conservative, we have assumed a 400' radius is needed for a well on this site. Based on parcel boundaries, if the well was located generally in the middle of the land, it is likely the Department could own the entire Zone I. If the Department wished to proceed with investigation of this site, we would recommend completing a test well investigation and required paperwork with MassDEP (BRP WS17).

Section 7

Section 7
Capital Improvement Plan

With the assistance of the Westford Water Department, Tighe & Bond prepared a Capital Improvement Plan (CIP) for the Westford Water System. This section presents an overview of infrastructure needs that are anticipated over the next 20 years to maintain and improve the Town's public drinking water system.

Based on the evaluation of the water system, we identified and prioritized necessary improvements related to facility and the distribution system. These improvements become part of a ten year capital improvement plan (CIP) that will allow the Water Department to budget, fund and implement improvements in a prioritized manner. The improvements have been prioritized as high, medium and low.

- **High priority** improvements are required to meet regulatory requirements, address critical system needs, and have the most impact on correcting deficiencies.
- **Medium priority** improvements are less critical but address deficiencies or may require preliminary engineering to develop the specific scope of the project.
- **Low priority** improvements are required to address future conditions, correct less critical deficiencies and begin replacing aging infrastructure. These may be related to system expansion or increases in demands/flows.

Distribution system improvements should be coordinated with other Town projects such as road reconstruction and traffic/drainage improvements and priorities adjusted as required.

7.1 Facility and Distribution System Improvements and Opinions of Costs

Table 7-1 presents a summary of water system facility improvements grouped by project type (water treatment plants, pump stations, water storage tanks, and other improvements) with priority and preliminary opinion of feasibility level cost for each project.

Table 7-2 presents a list of the water main improvements organized by villages or areas of Town. This list shows the prioritization, extent, recommended diameter, and a preliminary opinion of feasibility level cost for design and construction of each project. Figure 7-1 shows the locations of these proposed projects.

7.2 Ten Year CIP

To implement the capital improvements in an affordable, phased program, a multi-year improvement program has been outlined in Table 7-3. The goal is to develop an affordable program that can be planned, financed and implemented. There are several issues that could significantly impact this; grouping of projects into a single project, grant funding and bonding of improvements. The bonding of improvements changes the budgeting of these projects and reduces the rate impacts by spreading the cost over time.

Table 7-1 Water System Facility Improvements

Facility	Improvement Type	Description	Priority	Total Cost
WATER TREATMENT PLANT PROJECTS				
Forge Village WTP	Process	Upgrade Ultraviolet Disinfection system	Medium	$ 600,000
Forge Village WTP	Process	Replace filter media with Greensand Plus	Medium	$ 400,000
		Subtotal Forge Village WTP		**$ 1,000,000**
Nutting Road WTP	Process	Upgrade Ultraviolet Disinfection system	Medium	$ 600,000
Nutting Road WTP	Process	Replace filter media with Greensand Plus	Medium	$ 400,000
Nutting Road WTP	Process	Install backwash sludge storage system	Low	$ 550,000
Nutting Road WTP	Exterior	Recoat clearwell roof	Low	$ 10,000
Nutting Road WTP	Exterior	Recoat exterior siding	Low	$ 60,000
Nutting Road WTP	Exterior	Replace asphalt shingle roof	Low	$ 100,000
		Subtotal Nutting Road WTP		**$ 1,720,000**
		TOTAL WATER TREATMENT PLANTS CAPITAL IMPROVEMENTS		**$ 2,720,000**
PUMP STATION PROJECTS				
Forge Village P.S. No. 1	Process	Replace vacuum sand chamber, pump system, and contro	Medium	$ 120,000
Forge Village P.S. No. 1	Site	Repair/replace 10" & 6" discharge water main	Medim	$ 90,000
Forge Village P.S. No. 1	Standby Power	Install standby generator	Medium	$ 80,000
Forge Village P.S. No. 1	Exterior	Install new doors and windows	Low	$ 20,000
Forge Village P.S. No. 1	Security/Site	Install chain link fence	Low	$ 30,000
		Subtotal Forge Village Pump Station No. 1		**$ 340,000**
Forge Village P.S. No. 2	Standby Power	Install standby generator for Station No.1 and No.2	Medium	$ 100,000
Forge Village P.S. No. 2	Interior	Replace steel grating and repaint lower level and piping	Low	$ 15,000
		Subtotal Forge Village Pump Station No. 2		**$ 115,000**
Fletcher Pump Station	Site	Install chain link fence around well	Medium	$ 4,000
Fletcher Pump Station	Exterior	Replace asphalt shingle roof and paint soffit	Medium	$ 12,000
		Subtotal Fletcher Pump Station		**$ 16,000**
Howard Road Pump Station	Standby Power	Install standby generator to replace direct drive engine	Medium	$ 80,000
Howard Road Pump Station	Process	Replace vacuum pump	Medium	$ 25,000
		Subtotal Howard Road Pump Station		**$ 105,000**
Nutting Road Pump Station	Security	Install fencing around satellite wells	Medium	$ 6,000
Nutting Road Pump Station	Security	Install new exterior lighting	Low	$ 500
Nutting Road Pump Station	Interior	Replace wood platform and stairs	Low	$ 7,500
		Subtotal Nutting Road Pump Station		**$ 14,000**
Depot Road Pump Station	Exterior	Replace roof with membrane system	Medium	$ 10,000
		Subtotal Depot Road Pump Station		**$ 10,000**
Cote Pump Station	Security	Install access bar gate	Low	$ 3,000
Cote Pump Station	Standby Power	Install portable generator with a manual transfer switch	Medium	$ 60,000
		Subtotal Cote Pump Station		**$ 63,000**
		TOTAL PUMP STATIONS CAPITAL IMPROVEMENTS		**$ 663,000**

Facility	Improvement Type	Description	Priority	Total Cost
WATER STORAGE TANK PROJECTS				
Town Farm Road Tank	Exterior	Powerwash and recoat exterior	High	$ 240,000
Town Farm Road Tank	Exterior	Clean the roof and repair caulking at seams	High	$ 5,000
Town Farm Road Tank	Exterior	Install flexible sealant at foundation	High	$ 4,000
Town Farm Road Tank	Exterior	Install flapper valve on overflow pipe	High	$ 3,000
Town Farm Road Tank	Interior	Clean, sandblast and recoat interior	High	$ 260,000
Town Farm Road Tank	Interior	Install mixing system	High	$ 40,000
Town Farm Road Tank	Safety	Replace existing manway with OSHA-compliant manway	High	$ 8,000
Town Farm Road Tank	Site	Improve access road and tank site, install fencing	High	$ 120,000
Town Farm Road Tank	Site	Install chain link fence around tank	High	$ 25,000
		Subtotal Town Farm Storage Tank		**$ 705,000**
Francis Hill Tank	Exterior	Powerwash and recoat exterior	Medium	$ 425,000
Francis Hill Tank	Exterior	Install flexible sealant at foundation	Low	$ 5,000
Francis Hill Tank	Exterior	Install flapper valve and air gap on overflow pipe	Medium	$ 10,000
Francis Hill Tank	Interior	Clean and remove sediment from interior	Medium	$ 15,000
Francis Hill Tank	Interior	Install mixing system	Medium	$ 40,000
Francis Hill Tank	Structural	Install new roof vent and safety rails	Medium	$ 15,000
Francis Hill Tank	Security	Install locking ladder gate and locks on roof access hatch	Low	$ 3,000
Francis Hill Tank	Safety	Install cover on fall protection	Low	$ 2,000
Francis Hill Tank	Site/Security	Install chain link fence around tank	Medium	$ 25,000
Francis Hill Tank	Site	Access road and drainage improvements	Low	$ 75,000
Francis Hill Tank	Site	Relocate electrical equipment to above ground structure	Medium	$ 20,000
		Subtotal Francis Storage Tank		**$ 635,000**
Hildreth Hills Tank	Interior	Install mixing system	Medium	$ 60,000
Hildreth Hills Tank	Interior	Clean and remove sediment from interior	Medium	$ 10,000
Hildreth Hills Tank	Exterior	Overcoat exterior with two-coat breathable acrylic coating	Low	$ 150,000
		Subtotal Hildreth Hills Storage Tank		**$ 220,000**
		TOTAL STORAGE TANKS CAPITAL IMPROVEMENTS		**$ 1,560,000**
OTHER FACILITY / IMPROVEMENT PROJECTS				
Vine Brook Estates	Interconnection	Replace water system	High	$ 1,820,000
		Subtotal Vine Brook Estates		**$ 1,820,000**
New Water Supply	Test wells	Test well investigation and pump test	Medium	$ 75,000
New Water Supply	New Source	Construct new source	Low	$ 2,000,000
		Subtotal New Source		**$ 2,075,000**
Water Department Garage	Exterior	Replace roof	Low	$ 60,000
Water Department Garage	Security	Install video security system	Low	$ 10,000
		Subtotal Water Department Garage		**$ 70,000**
SCADA System	Process	SCADA System Upgrades	Medium	$ 40,000
Fixed Meter Reading	System	Fixed meter reading system	High	$ 200,000
		Subtotal SCADA and Metering		**$ 40,000**
		TOTAL MISCELLANEOUS CAPITAL IMPROVEMENTS		**$ 4,005,000**
		TOTAL FACILITY CAPITAL IMPROVEMENTS		**$ 8,948,000**

Table 7-2 Water Distribution System Improvements

Priority	Type of Project	Project Location	Map Number	From	To	Size (inches)	Length (feet)	Design	Construction
TOWN CENTER PROJECTS									
High	Replacement	**Boston Road**	H-1	Lincoln Street	Crown Road	12	2,000		$ 600,000
		Hildreth Street	H-1	Lincoln Street	Paegant Way	8	700		$ 210,000
						Subtotal Project	**2,700**	**$ 70,000**	**$ 810,000**
Medium	New Extension	**Main Street**	M-1	Kirsi Circle	Sinbad Lane	12	1,800		$ 540,000
Medium	New Extension	**Chamberlain Road**	M-1	Hunt Road	Swanson Lane	12	1,500		$ 450,000
						Subtotal Project	**3,300**	**$ 80,000**	**$ 990,000**
Medium	New Extension	**Stony Brook Road**	M-2	Swedes Crossing	Polley Lane	12	3,800		$ 1,140,000
			M-2	Blue Ridge Road	Dean Drive	8	1,100		$ 330,000
						Subtotal Project	**4,900**	**$ 120,000**	**$ 1,470,000**
Medium	New Extension	**Flagg Road**	M-3	Alcorn Crossing	Robinson Road	12	1,700		$ 510,000
		Robinson Road	M-3	Flagg Road	Hutchins Way	12	1,400		$ 420,000
		Hartford Road	M-3	Heritage Way	Robinson Road	8	1,200		$ 360,000
		Starr Circle	M-3	Robinson Road	End	8	1,000		$ 300,000
						Subtotal Project	**5,300**	**$ 130,000**	**$ 1,590,000**
Low	New Extension	**Flagg Road**	L-1	Robinson Road	Hildreth Street	12	2,400		$ 720,000
		Hildreth Street	L-1	Flagg Road	Monandnock Drive	16	1,300		$ 455,000
						Subtotal Project	**3,700**	**$ 100,000**	**$ 1,175,000**
Low	New Extension	**Lowell Road**	L-2	Strawberry Lane	Stony Brook Road	12	3,000		$ 900,000
			L-2	Stony Brook Road	Chamberlain Road	12	3,500		$ 1,050,000
						Subtotal Project	**6,500**	**$ 160,000**	**$ 1,950,000**
Low	New Extension	**Providence Road**	L-3	Main Street	Lowell Road	12	**3,500**	**$ 90,000**	**$ 1,050,000**
						TOTAL TOWN CENTER PROJECTS	**29,900**	**$ 750,000**	**$ 9,035,000**
FORGE VILLAGE PROJECTS									
Medium	Replacement	**Abbot Street**	M-4	Forge Village Road	Concord Road	12	1,500		$ 450,000
		Mulberry Lane	M-4	Forge Village Road	Crescent Street	6	700		$ 210,000
						Subtotal Project	**2,200**	**$ 60,000**	**$ 660,000**
Medium	Replacement	**Forge Village Road**	M-5	Treatment Plant	Town Farm Road	12	**3,000**		$ 900,000
		Town Farm Road	M-5	Forge Village Road	East Prescott Street	12	**2,300**		$ 690,000
						Subtotal Project	**5,300**	**$ 130,000**	**$ 1,590,000**
Low	Replacement	**Orchard Street**	L-4	East Prescott Street	End	6	400		$ 120,000
		Bradford St., Pond St., & Canal Street	L-4	Pleasant Street	Pleasant Street	8	1,400		$ 420,000
		Hill Street	L-4	West Prescott Street	End	6	600		$ 180,000
		Coolidge Street	L-4	West Prescott Street	End	6	400		$ 120,000
						Subtotal Project	**2,800**	**$ 70,000**	**$ 840,000**
						TOTAL FORGE VILLAGE PROJECTS	**10,300**	**$ 260,000**	**3,090,000**

Priority	Type of Project	Project Location	Map Number	From	To	Size (inches)	Length (feet)	Design	Construction
GRANITEVILLE PROJECTS									
Medium	Replacement	**North Main Street**	M-6	River Street	Bridge Street	12	2,100		$ 630,000
		Bridge Street	M-6	Pine Ridge Road	End of 8"	8	1,800		$ 540,000
						Subtotal Project	**3,900**	**$ 100,000**	**$ 1,170,000**
Low	Replacement	**Broadway**	L-5	Cross Street	House No. 3	8	1,300		$ 390,000
		Church Street	L-5	Broadway	School Lane	6	500		$ 150,000
		First St., Second St., Third St., Fourth St.	L-5	Broadway	End	6	2,200		$ 660,000
						Subtotal Project	**4,000**	**$ 100,000**	**$ 1,200,000**
						TOTAL GRANITEVILLE PROJECTS	**7,900**	**$ 200,000**	**$ 2,370,000**
NABNASSET PROJECTS									
High	New Extension/Replacment	**Oak Hill Road**	H-2	Plain Road	Groton Road	12	**3,200**	**$ 80,000**	**$ 960,000**
Medium	AC Pipe Replacement	**Elm Road**	M-7	Plain Road	End	8	2,500		$ 750,000
		Endmoor Road	M-7	Plain Road	End	8	3,000		$ 900,000
						Subtotal Project	**5,500**	**$ 140,000**	**$ 1,650,000**
Medium	AC Pipe Replacement	**Woodbine Terrace, York Ave., Wilshire Ave., Torrington Lane**	M-8	Plain Road	Williams Avenue	8	**3,300**	**$ 80,000**	**$ 990,000**
Medium	New Extension	**Polley Road**	M-9	Plain Road	Lucille Avenue	8	1,100		$ 330,000
		Forrest Road	M-9	Groton Road	Lawson Road	8	1,300		$ 390,000
						Subtotal Project	**2,400**	**$ 60,000**	**$ 720,000**
Low	1.5"/2" Pipe Replacement	**Wilson Lane, Trails End Road, Camp Road, Knoll Road**	L-6	Edwards Avenue	End	6	1,200		$ 360,000
		Jonas Road	L-6	Brookside Road	End	6	500		$ 150,000
		Emerson Road	L-6	JoJo Lane	End	6	800		$ 240,000
		Forrest Road	L-6	Gassett Road	Oak Hill Road	6	900		$ 270,000
						Subtotal Project	**3,400**	**$ 90,000**	**$ 1,020,000**
						TOTAL NABNASSET PROJECTS	**17,800**	**$ 450,000**	**$ 5,340,000**
PARKER VILLAGE PROJECTS									
Medium	Interconnection	**Littleton Road**	M-10	Princeton Apartments	Chelmsford Town Line	12	1,100		$ 330,000
		Powers Road	M-10	Equestrian Lane	Littleton Town Line	12	2,000		$ 600,000
						Subtotal Project	**3,100**	**$ 80,000**	**$ 930,000**
Medium	New Extension	**South Chelmsford Road**	M-11	Southgate Road	Tadmuck Road	12	2,000		$ 600,000
		Tadmuck Road	M-11	South Chelmsford Road	End of 12"	12	1,400		$ 420,000
						Subtotal Project	**3,400**	**$ 90,000**	**$ 1,020,000**
Medium	New Extension	**Carlisle Road**	M-12	End of Main	Old Lowell Road	12	2,200		$ 660,000
		Old Lowell Road	M-12	Carlisle Road	Jennie Richards Road (east end)	12	3,000		$ 900,000
						Subtotal Project	**5,200**	**$ 130,000**	**$ 1,560,000**

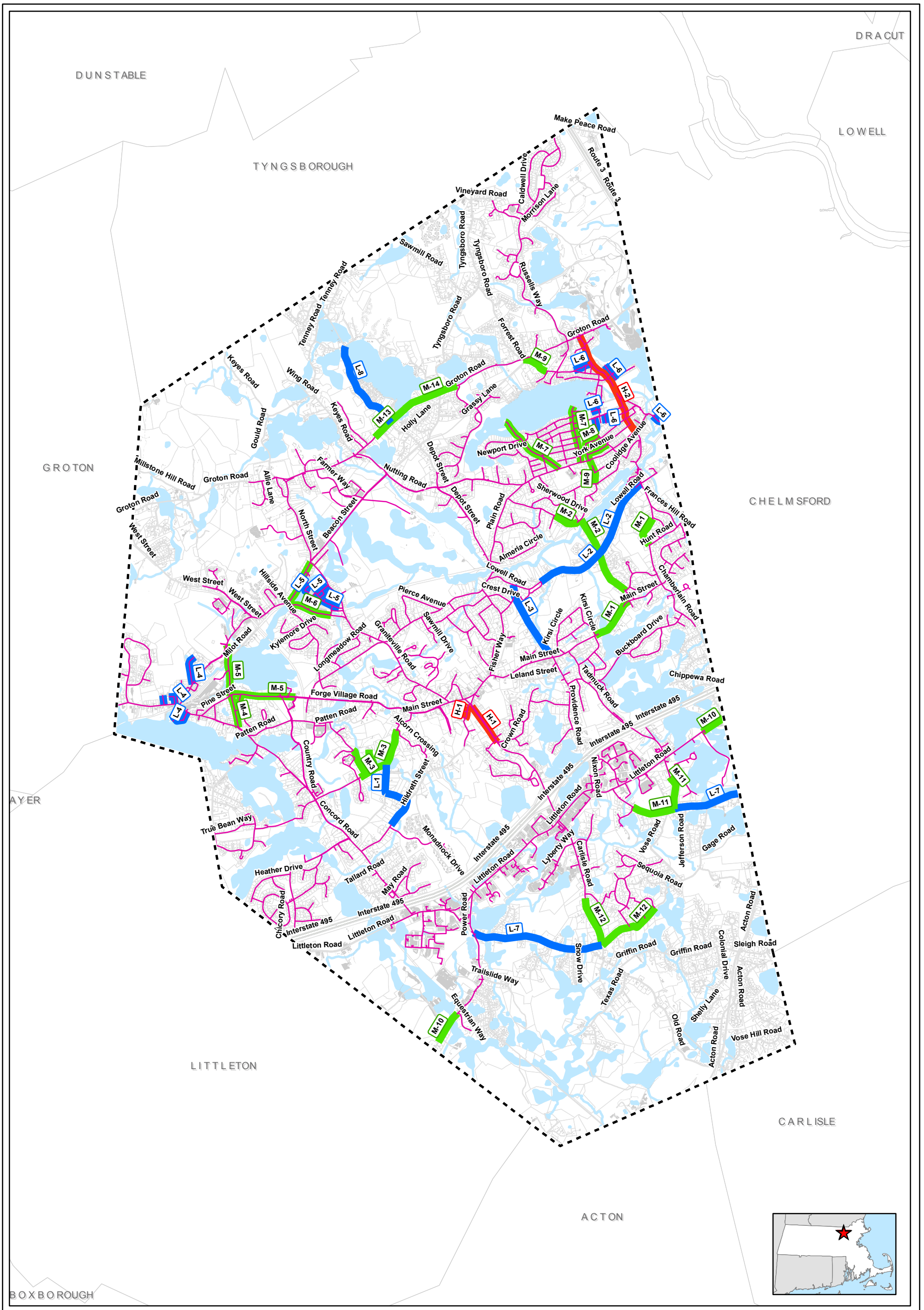
Priority	Type of Project	Project Location	Map Number	From	To	Size (inches)	Length (feet)	Design	Construction
Low	New Extension	**South Chelmsford Road**	L-7	Tadmuck Road	Chelmsford Town Line	12	**3,000**	**$ 80,000**	**$ 900,000**
Low	New Extension	**Concord Road**	L-7	Powers Road	Carlisle Road	12	**5,700**	**$ 140,000**	**$ 1,710,000**
							20,400	**$ 520,000**	**$ 6,120,000**
LONG SOUGHT FOR POND PROJECTS									
Medium	New Extension	**Groton Road**	M-13	End of 12"	DCR Parking Lot	12	**2,000**	**$ 50,000**	**$ 600,000**
		Groton Road	M-14	DCR Parking Lot	Lakeside Terrace	12	**2,500**	**$ 60,000**	**$ 750,000**
Low	New Extension	**Dunstable Road**	L-8	Groton Road	Wymans Beach Road	12	**4,000**	**$ 100,000**	**$ 1,200,000**
							6,000	**$ 210,000**	**$ 1,800,000**
							92,300	**$ 2,390,000**	**$ 27,755,000**

Table 7-3 10 Year Capital Improvement Plan

Description	Priority	Fiscal Year	Project Amount	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024	FY2025	FY2026	FY2027	FY2028
Distribution System Improvements													
Boston Road/Hildreth Street (Design)	High	**2020**	**$90,000**		$90,000								
Boston Road/Hildreth Street (Construction)	Medium	**2022**	**$1,500,000**				$1,500,000						
Main Street/Chamberlian Road	Medium	**2026**	**$990,000**								$990,000		
Stony Brook Road	Medium	**2023**	**$1,470,000**					$1,470,000					
Flagg Road/Robinson Road	Medium	**2025**	**$1,590,000**							$1,590,000			
Flagg Road/Hildreth Street	Medium	**2027**	**$1,175,000**									$1,175,000	
Abbot Street/Mulberry Lane	Medium	**2020**	**$660,000**		$660,000								
Forge Village Road/Town Farm Road	Medium	**2024**	**$1,590,000**						$1,590,000				
North Main Street/Bridge Street (Design)	Medium	**2020**	**$86,000**		$86,000								
North Main Street/Bridge Street (Construction)	Medium	**2023**	**$975,000**					$975,000					
Nabnasset System Improvements (Design)	High	**2019**	**$130,000**	$130,000									
Nabnasset System Improvements (Construction)	Medium	**2021**	**$1,560,000**			$1,560,000							
Elm Road/Endmoor Road	Medium	**2024**	**$1,650,000**						$1,650,000				
Woodbine Terrace/Yorkshire Ave.	Medium	**2026**	**$990,000**								$990,000		
Groton Road	Medium	**2025**	**$1,350,000**							$1,350,000			
Groton Road (DCR Property to Dunstable Rd)	High	**2019**	**$500,000**	$500,000									
TOTAL WATER MAIN PROJECTS			**$16,306,000**	**$630,000**	**$836,000**	**$1,560,000**	**$1,500,000**	**$2,445,000**	**$3,240,000**	**$2,940,000**	**$1,980,000**	**$1,175,000**	**$1,650,000**
Facility Improvements													
Forge Village Water Treatment Plant													
Upgrade Ultraviolet Disinfection system	Medium	**2021**	**$600,000**			$600,000							
Replace filter media with Greensand Plus	Medium	**2019**	**$400,000**	$400,000									
Nutting Road Water Treatment Plant													
Upgrade Ultraviolet Disinfection system	Medium	**2023**	**$600,000**					$600,000					
Replace filter media with Greensand Plus	Medium	**2021**	**$460,000**			$460,000							
Backwash sludge storage system (Design)	Low	**2022**	**$60,000**				$60,000						
Backwash sludge storage system (Construction)	Low	**2024**	**$500,000**						$500,000				
Recoat clearwell roof	Low	**2023**	**$10,000**					$10,000					
Recoat exterior siding	Low	**2023**	**$60,000**					$60,000					
Asphalt roof replacement	Low	**2028**	**$100,000**										$100,000
Pump Station Projects													
Forge Village Pump Station No.1 Upgrades	Medium/Low	**2022**	**$340,000**				$340,000						
Forge Village Pump Station No.2 Upgrades	Medium/Low	**2022**	**$115,000**				$115,000						
Fletcher Pump Station Upgrades	Medium	**2020**	**$16,200**		$16,200								
Howard Road Pump Station Upgrades	Medium	**2023**	**$105,000**					$105,000					
Nutting Road Pump Station Upgrades	Medium/Low	**2020**	**$14,000**		$14,000								
Depot Road Pump Station Upgrades	Medium	**2020**	**$10,000**		$10,000								
Cote Pump Station Upgrades	Medium/Low	**2020**	**$63,000**		$63,000								

Description	Priority	Fiscal Year	Project Amount	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024	FY2025	FY2026	FY2027	FY2028
Water Storage Tank Projects													
Town Farm Tank Improvements	High	**2020**	**$705,000**		$705,000								
Francis Hill Tank Improvements	Medium	**2022**	**$635,000**				$635,000						
Hildreth Hills Tank Improvements	Medium/Low	**2023**	**$220,000**					$220,000					
Miscellaneous Projects													
Vine Brook Water System	High	**2019**	**$1,820,000**	$1,820,000									
New Water Supply Source	Medium/Low	**2028**	**$2,075,000**								$75,000		$2,000,000
Water Department Garage Improvements	High	**2019**	**$70,000**	$70,000									
SCADA System Upgrade	High	**2020**	**$40,000**		$40,000								
Fixed Meter Reading	High	**2020**	**$200,000**		$200,000								
TOTAL FACILITY PROJECTS			**$9,218,200**	**$2,290,000**	**$1,048,200**	**$1,060,000**	**$1,150,000**	**$995,000**	**$500,000**	**$0**	**$75,000**	**$0**	**$2,100,000**

TOTAL CAPITAL PROJECTS			**$25,524,200**	**$2,920,000**	**$1,884,200**	**$2,620,000**	**$2,650,000**	**$3,440,000**	**$3,740,000**	**$2,940,000**	**$2,055,000**	**$1,175,000**	**$3,750,000**



Legend

- Ponds
- Rivers and Streams
- Impervious Surface
- Water Main

Capital Improvement Projects

Priority

- High
- Low
- Medium

1:48,000

0 2,000 4,000

Feet

N

FIGURE 7-1
MAP OF WATER DISTRIBUTION SYSTEM IMPROVEMENTS

Westford, Massachusetts

February 2018

[redacted]

Section 8

Section 8
Conclusions and Recommendations

In the coming years, the Water Department will be faced with numerous challenges to operate and maintain their supply and distribution system. To address these challenges, this Water System Master Plan evaluated water quantity, water quality, and operation and maintenance needs to present a strategic and sustainable plan to guide the Water Department over the next twenty years and meet the goals of providing safe, high quality, adequate water supply and uninterrupted service at a reasonable pressure and reasonable cost, protecting public health, meeting fire protection needs, and addressing Federal and State regulatory requirements.

Facility and Distribution System Improvements: Improvements to water system facilities and the distribution system were identified and prioritized in Section 7. These improvements were presented in a ten year capital improvement plan (CIP) that considered affordability, financing, and logical phasing. Annual capital expenditures range from around $1.8 Million to $3,75 Million with an average of $2.7 Million annually. Actual implementation of the CIP depends on if and how projects are grouped, source of funding(e.g. grant funding, bonding, or even for particular facilities Community Preservation Act (CPA) funds), and schedule of improvements.

Water Quality: As previously described in the water quality and regulatory assessment in Section 2, the Water Department's system is currently meeting all applicable heath standards regulated by the Commonwealth of Massachusetts and by the federal government. There are no current regulations that would require the Water Department to modify operations. The Department should continue to watch for EPA to issue a draft revised Lead and Copper Rule, potentially in 2018. In addition, Westford should remain aware that emerging contaminants could pose a threat the water supply, however, research is in the early stages and generally, regulatory requirements are not anticipated in the near future. Massachusetts is underway with developing a drinking water action level for PFAS. Based on recent information, release of an action level similar to Connecticut's approach of 70 ppt for five PFAS compounds is expected to be released very shortly.

Water Quantity: One of the challenges the Water Department will be faced with is meeting both short-term and long-term water use projections. Short-term projections look at the current demands on the system and the known developments in Town. Typically, this projection is used to evaluate the impact of development on the water supply capacity. Long-term projections are used for planning and phasing of water supply development projects cover a twenty-year period. In Westford, there are numerous factors that affect projected demands:

- The system does not currently service the entire Town (only approximately 75% of the population). The portions of Town that are served by the water system are largely the most developed areas, so additional water demand in the currently serviced area of Town will not likely be due to population growth and instead will due to redevelopment, new commercial properties, and some employment growth.
- There has been a recent "boom" of commercial development along major routes in Town, which has already impacted the water system. At the time of this Plan, the

known future commercial developments are anticipated to add approximately 0.16 MGD to the average daily demand.

- There are significant unknowns related to new and redevelopment projects, both commercial and residential. Ongoing commercial redevelopment within the current service area is expected and will impact demand depending upon the water usage requirements.
- The Department has been aggressive with water conservation practices.
- New regulations may require the Water Department to further reduce demands through enhanced conservation, water reuse/restrictions and management (e.g., WMA and SWMI requirements).

The overall 20-year protected demands that consider short-term planned development, population growth, economic growth, and system expansion are included in Table 8-1. Both the average daily and maximum daily projected demands are not expected to exceed the WMA permit limits for withdrawal in the planning period, however, the average maximum daily demand may be challenging for the Water Department's system to meet by the end of the 20-year planning period. Unknowns associated with potential new and redevelopment within the existing service area, system expansion, and impacts due to climate change will require the Water Department continue to monitor operations and demands carefully and continue to implement aggressive water conservation and demand management techniques.

Table 8-1
Summary of Projected Demands

Year	Projected Summary of Average Daily Demand (MGD)	Projected Lower Range Maximum Daily Demand (MGD)	Projected Upper Range Maximum Daily Demand (MGD)
2015	1.49 [1]	3.30 [2]	
2020	1.71	3.40	4.42
2025	1.75	3.48	4.53
2030	1.77	3.53	4.59
2035	1.81	3.59	4.67

1 Average of 2006 through 2016 actual values
2 Actual 2016 value
3 Lower range MDD was estimated by applying the ratio between MDD and ADD from 1980 through 2016 (second quartile or 50% value) to the ADD
Upper range MDD was estimated by applying the ratio between MDD and ADD from 1980 through 2016 (90^{th} percentile value) to the ADD

Never Stop Looking for Opportunities to Address the Water Management Act Sustainable Water Management Initiative Requirements: Future demands are anticipated to exceed the SWMI baseline of 1.79 MGD by 2035, and may exceed the SWMI baseline sooner depending on variabilities in average day demand, new and redevelopment projects, and environmental factors. The Department should coordinate with Highway and Engineering staff to implement stormwater management measures where practical within the drinking water areas to infiltrate stormwater runoff and recharge groundwater to obtain credit under the SWMI program. The Department should also follow the other SWMI related recommendations included in Appendix B.

Carefully Consider and Plan Rate Increases: As the Water Department progresses with the Capital Improvement Plan presented in Section 7 of this report, along with addressing unplanned needs, such as new regulatory requirements or a needed water main extension to protect public health, they should continue to routinely evaluate its rate structure and rates. The Water Department evaluates their rate structure periodically and should continue to be proactive in this respect. It may be prudent for the Water Department to comprehensively revisit the rates to confirm the source of funding (rates vs. debt), the structure including base charge and steps, revenue stability, etc. supports not only operations but future capital projects.

Continue to Serve the Community: As private wells experience water quality issues due to manganese, sodium chloride, arsenic, and radon, plan water main extensions to meet the Department's goals of providing a sustainable, high-quality drinking water source for residents, businesses, and industry.

Maximize Existing Sources: As the Department moves forward, maximizing existing sources by keeping wells maintained through routine inspections and cleanings (frequency depends on well production, use, and water quality), and, as needed, redeveloping.

If necessary in the future, redundant wells could be installed if the Department becomes concerned about production, if rehabilitation is unsuccessful.

Another option to maximize existing sources includes utilizing available production, demand, and water quality data to identify if there are ways to time withdrawals across multiple sources to allow wells to rest or overall optimize operations across the entire system. This exercise is promoted through MassDEP's SWMI initiative and starts with a data collection and "desktop optimization" effort that considers demands and historical production and existing system constraints including, but not limited to, infrastructure, pressure, water quality, operations, costs, regulatory matters, and societal needs. The next step would be to develop an Excel based tool to track and assess sources production over time. This spreadsheet would combine information that is already being gathered by the Department, the SCADA system, and regional climate and hydrological data sources into one data set. From this data, past trends can be analyzed and compared to current operations data and a supply versus demand assessment can be completed.

Continue to Consider New Sources: Although the projections show that the Department should be able to meet the demands assuming water conservation and demand management continues to be aggressive, development of a new source should continue to be pursued. Another source is important to provide redundancy in the system. A source on the southern side of Westford would be in a separate aquifer from the other sources and able to serve a new part of the system. However, there are limited opportunities in this area of Town. From a SWMI perspective, adding a well in a less stressed basin can be more challenging as it will require minimization and mitigation efforts and a more stringent WMA permit and will require collaboration with MassDEP to discuss the permit requirements and SWMI impacts of developing this source.

Coordination with Other Ongoing Local Planning: The Department should coordinate with ongoing planning and monitoring projects, including the Open Space and Recreation Plan update to confirm any lands planned for water supply protection are included, and should keep abreast of the results of the Healthy Lakes and Ponds Program.

Complete a Build Out Analysis for Service Area: To improve the Department's ability to plan for the 20-year period and beyond, we recommend the Department consider collaborating with the Town Director of Land Use Management / Town Planner to complete a comprehensive build out for the existing and potential future service area that considers zoning, subdivision rules, and natural and permitting limitations (e.g. wetlands, etc.)

Appendix A

Water Distribution System Map

Town of Westford Water System

LEGEND

- Public Water Supplies
- Hydrants
- Gates
- Private Wells
- Treatment Plant
- Tank
- Pump Station
- Parcel
- Town Boundary
- High Service Pressure Zone Boundary

Water Main

Material

- ASBESTOS CEMENT
- CAST IRON
- COPPER
- DUCTILE IRON
- PVC
- STEEL
- UNKNOWN

Hydrography

- Open Water
- Rivers, Streams

0 2,000 4,000

Feet

Tighe&Bond

Engineers | Environmental Specialists

TOWN OF WESTFORD INCORPORATED SEPT. 23, 1729

DUNSTABLE

DUNSTABLE

LOWELL

TYNGSBOROUGH

GROTON

CHELMSFORD

LITTLETON

ACTON

CARLISLE

Twin Peaks Storage Tank 1 MG Overflow elev. 407.6'

Nutting Road Water Treatment Plant 1,400 gpm

Nutting Road Pumping Station 500 gpm 0.72 MGD

Depot Road Well & Pumping Station 500 gpm 0.72 MGD

Cote Wellfield & Pump Station 450 gpm 0.65 MGD

Highway Garage Booster Station

Stepinski Wellfield & Pump Station 850 gpm 1.22 MGD

Francis Hill Storage Tank 1.25 MG Overflow elev. 407.6'

Town Farm Storage Tank 0.43 MG Overflow elev. 407.6'

Forge Village Pump Stations 1 & 2 PS1 236 gpm PS2 410 gpm

Forge Village Water Treatment Plant 2,100 gpm

Country Road Well & Pump Station 425 gpm 0.61 MGD

Fletcher Well & Pumping Station 480 gpm 0.69 MGD

Howard Road Well & Pumping Station 300 gpm 0.43 MGD

Hitchin Post Booster Station

Prospect Hill Storage Tank 0.172 MG Overflow elev. 558.4'

Hildreth Hills Booster Station

Hildreth Hills Storage Tank 2 MG Overflow elev. 407.6'

Boston Road Booster Station 700 gpm

Greystone Pond

Long Sought-for Pond

Flushing Pond

Nabnasset Lake

Keyes Pond

Burges Pond

Forge Pond

Beaver Brook

Reed Brook

Stony Brook

Tadmuck Brook

Nonset Brook

Nashoba Brook

Sumter Brook

Interstate 495

Littleton Road

Route 3

Town of Westford
Water System

LEGEND

- Public Water Supplies
- Hydrants
- Gates
- Private Wells
- Treatment Plant
- Tank
- Pump Station
- Parcel
- Town Boundary
- High Service Pressure Zone Boundary

Water Main
Diameter (inches)
- 1
- 1.5
- 2
- 4
- 6
- 8
- 10
- 12
- 16
- Unknown

Hydrography
- Open Water
- Rivers, Streams

0 2,000 4,000
Feet

Tighe&Bond
Engineers | Environmental Specialists

Twin Peaks Storage Tank 1 MG Overflow elev. 407.6'
Nutting Road Water Treatment Plant 1,400 gpm
Nutting Road Pumping Station 500 gpm 0.72 MGD
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Hildreth Hills Storage Tank 2 MG Overflow elev. 407.6'
Boston Road Booster Station 700 gpm

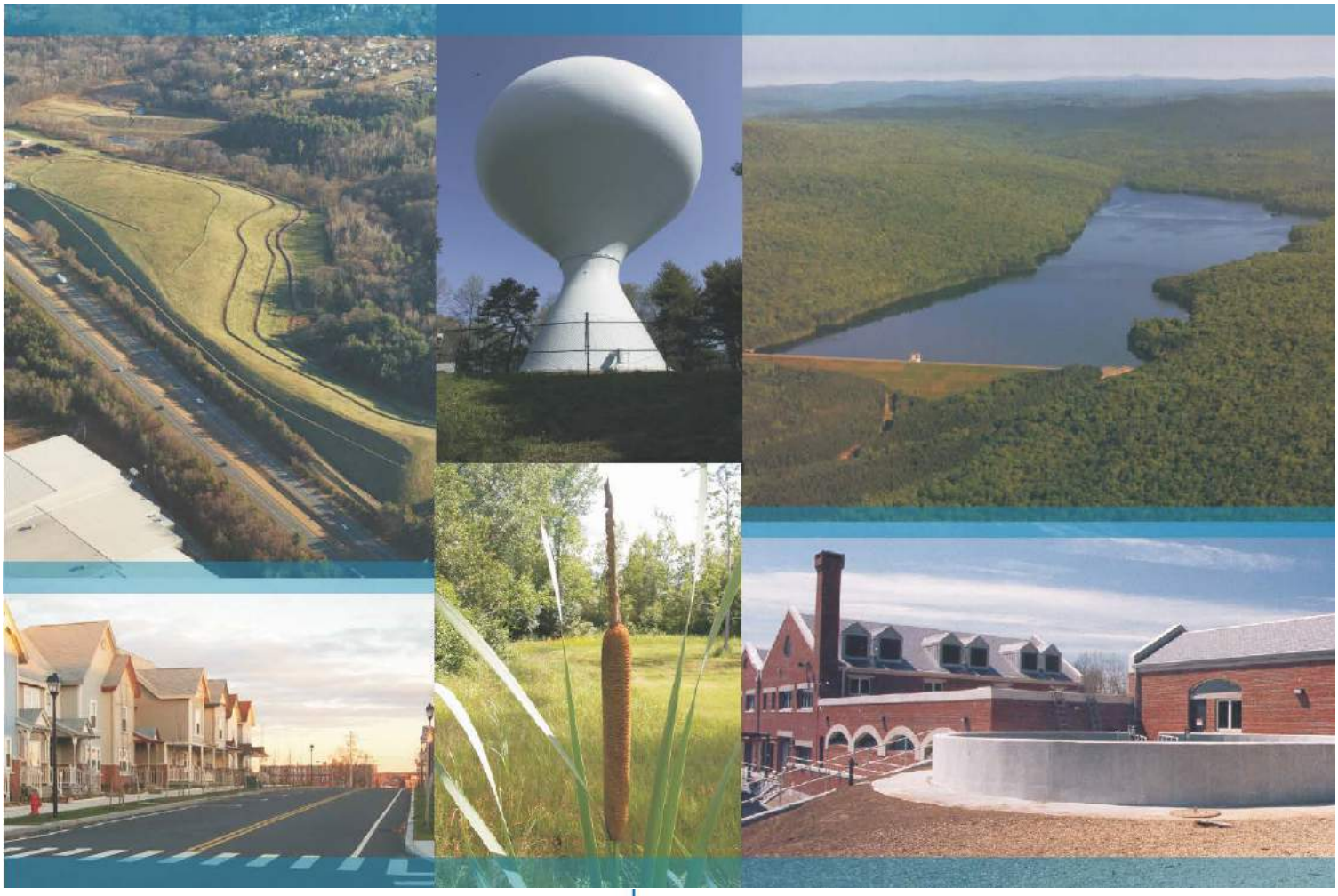
Greystone Pond
Long Sought-for Pond
Flushing Pond
Nabnasset Lake
Keyes Pond
Burges Pond
Forge Pond
Stony Brook
Tadmuck Brook
Reed Brook
Beaver Brook
Nonset Brook
Nashoba Brook
Sumter Brook

DUNSTABLE
TYNGSBOROUGH
LOWELL
GROTON
CHELMSFORD
LITTLETON
ACTON
CARLISLE

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Appendix B

Water Management Act & Sustainable Water Management Initiative Planning Report, January 2015



Tighe&Bond

Town of Westford, Massachusetts

Water Management Act & Sustainable Water Management Initiative Planning Report

Prepared For:

Westford Water Department
Westford, Massachusetts

January 2015

32-2071
January 28, 2015

Mr. Stephen Cronin, Superintendent
Town of Westford
Water Department
60 Forge Village Road
Westford, MA 01886

Re: **Sustainable Water Management Initiative Planning**
Final Report

Dear Mr. Cronin:

Tighe & Bond is pleased to present the enclosed final report developed to assist the Westford Water Department with preparing for the impacts of the Commonwealth's Water Management Act (WMA) revised regulations and the Sustainable Water Management Initiative (SWMI) framework on your WMA permit renewal process. The Water Department's permit renewal is expected to occur in 2018. As you are aware, these recent regulatory changes will significantly impact the permit renewal process and require a greater level of planning and increased implementation effort not only during the renewal process but throughout the permit term. Because the SWMI framework includes water, wastewater, and stormwater, permit planning and implementation will most likely involve other Town Departments.

This report includes an overview of Westford's current water, wastewater, and stormwater conditions, updates to historical water use and projected anticipated water use through the 20 year permit period, an evaluation of the anticipated WMA permit tier and requirements, and a summary of the actions the Water Department must take for the WMA permit renewal.

The Massachusetts Department of Environmental Protection has calculated the Water Department's baseline to be **1.79 MGD**. Our estimates indicate that the average day demand in year 2038 could exceed 2.0 MGD, which would require an offset of approximately 0.26 MGD. A large portion (0.20 MGD) of this offset is already covered by current operations including discharge of wastewater to groundwater via septic systems and small treatment plants. The Water Department will need to strategize how to offset the remaining demand through stormwater recharge, enhanced conservation efforts, and evaluating operational improvements to shift pumping locations or timing, as feasible.

This report also includes our evaluation of the potential impact associated with extending the water distribution system to service 100% of the Town's population. We estimate that the water demand under this scenario may exceed 2.67 MGD, therefore requiring an offset of approximately 0.88 MGD over baseline. The additional offset under this scenario will require substantially more planning and implementation efforts.

Thank you for the opportunity to provide assistance in planning for the WMA and SWMI framework. We have enjoyed working with you and your staff on this project and we look forward to assisting the Water Department with future water system planning and implementation.

If you have any questions or need any additional information, please contact me or Tracy Adamski.

Very truly yours,

TIGHE & BOND, INC.



Thomas J. Mahanna, P.E.
Vice President

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Section 1 Introduction

Section 2 Overview of Westford's Current Water Supply, Wastewater, and Stormwater Conditions

2.1 Water Supply....2-1
2.2 Wastewater....2-3
2.3 Stormwater....2-3

Section 3 Anticipated WMA Permit Tier Designation

3.1 Westford's System Baseline....3-2
3.2 Groundwater Withdrawal Category and Biological Category....3-2
3.3 Coldwater Fisheries Resource in Westford....3-3
3.4 Requested Water Volume....3-3

Section 4 Anticipated WMA Permit Requirements

4.1 Minimization of Impacts....4-1
4.1.1 Desktop Optimization....4-2
4.1.2 Water Releases and Returns....4-4
4.1.3 Additional Conservation Measures....4-5

Section 5 Mitigation & Offsets to Withdrawals

5.1 Direct Mitigation....5-1
5.1.1 Wastewater Adjustments....5-1
5.1.2 Stormwater Recharge....5-2
5.2 Indirect Mitigation....5-2

Section 6 Summary

6.1 Overview of Permit Requirement Impacts on Westford....6-1

List of Tables

Table 1 Westford Water Department Supply Sources
Table 2 Annual Production
Table 3 Tier Designation
Table 4 Westford Baseline
Table 5 Subbasin Characterization Summary
Table 6 Town of Westford Population 1980 to 2040
Table 7 Westford Water Department Water Usage from 1980 to 2040
Table 8 Baseline and Withdrawal Demands
Table 9 August Net Groundwater Depletion by Subbasin
Table 10 Summary of Desktop Optimization by Subbasin
Table 11 Alternative Sources: Interconnections
Table 12 Summary of Westford's Dams
Table 13 Example Conservation Measures
Table 14 Potential Wastewater Returns
Table 15 Indirect Mitigation Credits

Attachments

Attachment A – Figures
Figure 1 Town of Westford Public Water Supply
Figure 2 Groundwater Withdrawal Categories
Figure 3 Biological Categories
Attachment B – Summary of Water Usage for Prospective Developments in Westford
Attachment C – Water Supply Projection

Section 1
Introduction

The Westford Water Department is proactively assessing the ramifications of the regulatory changes to the Commonwealth's Water Management Act (WMA) permitting process. The Massachusetts Department of Environmental Protection (MassDEP) revised the WMA regulations (310 CMR 36.00) in November 2014 to implement its Sustainable Water Management Initiative (SWMI) framework, which significantly changes the WMA permitting process for new permits as well as permit renewals. SWMI sets a baseline for water suppliers based on the average of 2003 to 2005 reported water withdrawals, and then requires mitigation for withdrawals above that baseline in the next 20-year permit period. This mitigation is required even if the public water supplier's proposed withdrawal is within its previously permitted water withdrawal rate. The permit cycle for the Merrimack River Basin, where Westford's groundwater withdrawals are located, is scheduled for 2018.

This report summarizes relevant characteristics of the Town of Westford's water system and its service area. It also includes discussion of the permitting considerations and requirements under the WMA regulations which were promulgated in November 2014. These regulations incorporate the SWMI Framework and MassDEP's "Water Management Act Permit Guidance Document" dated November 7, 2014 ("Guidance Document"). This discussion includes measures for minimizing impacts of withdrawals under SWMI, and identifies potential mitigation and offset actions for credits against requested withdrawals.

After reviewing the Water Department's 2003 to 2005 withdrawal data, we estimate that Westford's baseline will be approximately 1.80 million gallons per day (MGD). The baseline is set by adding 5% to the 2003 to 2005 average daily withdrawal of 1.72 MGD. Westford's baseline as determined by MassDEP is 1.79 MGD. Based on previous water demand projections, 2038 average day demands are estimated to be 2.05 MGD. Using this data, Westford's ask in their new WMA permit would be as much as 0.26 MGD above baseline. Furthermore, the subbasins from which Westford is withdrawing water are mapped as Category 5 (highest impact) for both Groundwater Level (GWL) and Biological Category (BC).

Based on these preliminary estimates, we expect that the Water Department would be permitted under Tier 2, which is for water suppliers requesting an additional withdrawal above baseline but that does not result in a change to the GWL or BC. The presence of the Reed Brook coldwater fishery will also be factored into the permitting process.

Section 2 Overview of Westford's Current Water Supply, Wastewater, and Stormwater Conditions

The Town of Westford is located within two major river basins: the Merrimack River and the Sudbury-Assabet-Concord (SuAsCo) River watersheds. The watershed divide crosses generally east/west across the town, with the northern portion of the town in the Merrimack River Watershed, and the southern portion of the town in the SuAsCo River Watershed. All of Westford's water supply wells are located in the Merrimack River watershed.

The SWMI Framework uses drainage areas that were delineated by the U.S. Geological Survey. SWMI uses Hydrologic Unit Code (HUC) 12 (HUC-12), also known as the "subwatershed" or "sub-basin" scale, which is typically 10-40,000 acres (15-62 square miles). A number of sub-basins overlay the Town of Westford, however, the public water supply points are within only four of the basins. Figure 1 shows the divide between the Merrimack and the SuAsCo watersheds and the delineation of subbasins and Westford's public water supply points.

Reed Brook is the single Coldwater Fishery Resource (CFR) located within the town. Reed Brook is located in Subbasin 13049 of the Merrimack Basin and is upstream of the Water Department's water supply sources in that subbasin.

2.1 Water Supply

The Town of Westford's public water supply is provided by nine gravel-packed groundwater wells located in the Merrimack River Watershed, extending across the central area of town. All of the Water Department's wells are treated at one of two greensand filtration plants: the Forge Village Water Treatment Plant and the Nutting Road Water Treatment Plant.

Westford's Authorized Capacity under the WMA

Table 1 summarizes pertinent information regarding the authorized capacity of the Water Department's supply sources. The water system has a registered capacity of 1.18 MGD. Their current WMA permit, which expires on November 30, 2018, includes a permitted capacity of 1.26 MGD. Therefore, the total authorized capacity for the Westford Water Department through November 2018 is 2.44 MGD.

TABLE 1
Westford Water Department Supply Sources

Source	MassDEP ID	Subbasin	WMA Permit Limit Maximum Day (MGD)	WMA Permit + Registration Annual Average (MGD)
Nutting Road Well and satellite wells	3330000-02G, -17G, -18G	13044	0.65	
Depot Road Well	3330000-03G	13048	0.72	
Forge Village Well Field	3330000-01G, -09G, -10G, -11G, -12G	13049		1.26 (Permit)
Forge Village Well No. 2	3330000-05G	13049		
Stepinski Well	3330000-20G	13049	1.22	1.18 (Registration)
Cote Well	3330000-07G	13049	0.65	
Howard Road Well Field	3330000-06G, -13G, -14G, -15G, -16G	13054	0.43	
Fletcher Well	3330000-08G	13054	0.69	
Country Road Well No. 2	3330000-04g	13054	0.61	
			Total	**2.44**

Recent Annual Withdrawals

Table 2 provides a summary of the average annual withdrawal (data presented in million gallons or "MG") from each supply over the past three years based on data provided in the MassDEP Annual Statistical Reports.

TABLE 2
Annual Production

	Average Annual Production (MG)		
Source	**2011**	**2012**	**2013**
Nutting Road Well and satellite wells	39.81	42.31	66.17
Depot Road Well	30.86	0.10	28.56
Forge Village Well Field	38.89	42.03	43.62
Forge Village Road Well No. 2	88.26	67.98	77.64
Howard Road Well Field	48.82	41.18	54.96
Cote Well	63.66	101.88	67.80
Fletcher Well	36.58	55.75	69.58
Stepinski Well	86.91	99.16	58.50
Country Road Well No. 2	90.77	74.35	68.78
Total	**524.56**	**524.74**	**535.61**

Based on water usage records provided by the Water Department, we estimated that approximately 76% of the water demand is consumed by customers in the Merrimack River Watershed and approximately 24% is consumed by customers in the SuAsCo Watershed.

Demand Management and Conservation Activities

The Water Department has been implementing demand management and conservation activities for a number of years. These measures include the following:

- Conservation education in a semiannual newsletter
- Water saver device hand outs
- Rain barrel community programs (sold at reduced rates)
- Water Department Open House – activities include water conservation education
- Grade 4 groundwater presentation
- Mandatory outdoor water use restrictions (above voluntary restrictions) in 2012, 2013, and 2014

The newsletter and rain barrel sales program began in 2004. In addition, the Town conducts monthly water meter readings and is in the process of upgrading to a remote meter reading system. A comprehensive water audit is conducted approximately every five years. Westford's General Bylaws and the Water Department's Rules and Regulations clarify water use along with the associated costs of consumption. They also define the Water Department's enforcement authority and penalties that can be assessed for water theft.

2.2 Wastewater

The majority of sanitary wastewater in Westford is treated by on-site disposal systems (i.e. septic systems). The Town maintains a small public sewer system located in the town center that collects wastewater from municipal properties, including the Abbot School, Millennium School, Town Hall, Police Station, Fire Station, Roudenbush Community Center and the J.V. Fletcher Library. Wastewater collected at these buildings is treated at a package treatment plant located at the Abbot School. Treated effluent is discharged to a subsurface disposal system. The only other public sewer system in town services the Nashoba Valley Technical High School on Littleton Road. Wastewater from this school is sent to the Lowell Regional Wastewater Utility Wastewater Treatment Facility via a sewer connection through the Town of Chelmsford.

The Town has no municipally owned or operated sanitary sewer system to serve residential or commercial properties. Some private developments, mostly along Littleton Road are served by private package wastewater treatment plants with groundwater disposal.

2.3 Stormwater

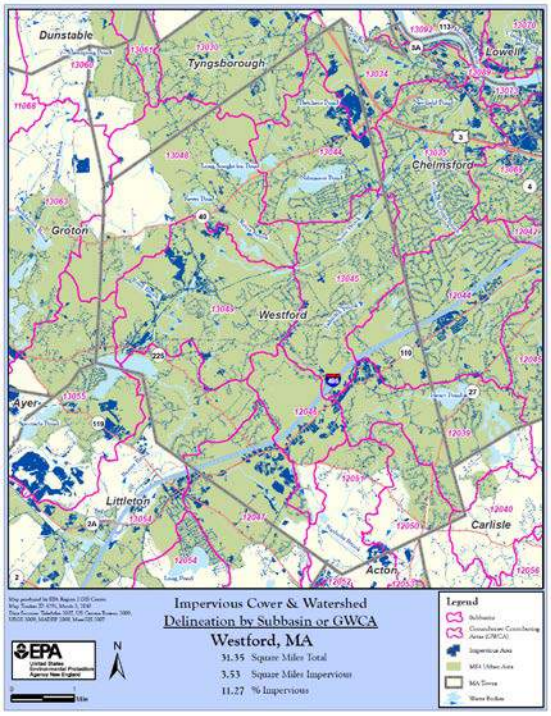
Summary of Town's Stormwater Management Program

The Town of Westford is regulated under the Environmental Protection Agency's National Pollutant Discharge Elimination System (NPDES) Phase II small municipal separate storm sewer system (MS4) general permit and performs numerous stormwater management activities. The following highlight local stormwater efforts completed to date:

- Public education and outreach including an informational mailing to residents and annual implementation of the "Living Lab" program that introduces stormwater into the 5th grade curriculum.
- Mapping of stormwater infrastructure, including the location of drainage structures, outfalls, receiving waters and connectivity.
- Adoption and enforcement of bylaws to address illicit discharges, construction site runoff and post-development stormwater issues.
- Review of proposed projects and Best Management Practices by the Conservation Commission, Engineering Department and Planning Board as necessary to enforce stormwater bylaws and regulations.
- Perform maintenance and good housekeeping practices for municipal operations, including street sweeping and catch basins cleaning. All streets are swept twice per year. All catch basins are cleaned at least once per year. Catch basins located on hills are generally cleaned twice per year.

Impervious Coverage

Based on information obtained from EPA Region 1, the Town of Westford encompasses approximately 33 square miles, of which 3.5 square miles (11%) is impervious. Of the impervious areas, approximately two square miles (6% of the town area) is considered to be directly connected to waterbodies in the community.



Stormwater Regulations

Westford's regulations were reviewed for stormwater control requirements that could be considered as mitigation measures for groundwater withdrawals, particularly recharge requirements. Westford's regulations include the following requirements:

- The general bylaws include Chapter 147: Stormwater Management that applies to construction disturbances greater than or equal to one acre of land. The Planning Board is designated the Stormwater Authority in charge of enforcing the bylaw.

- The zoning bylaws establish a Water Resource Protection Overlay District to protect aquifers and recharge areas serving an existing or potential public water supply from contamination. Areas within the Water Resource Protection District (WRPD) I are controlled by the standards in 310 CMR 22.00 for Zone I of a public water supply well. Uses within WRPD II and WRPD III delineated areas are restricted and may require a Special Permit from the Planning Board. New or redevelopment projects with WRPD II which will render more than 15% of the lot area or 2,500 square feet impervious are required to recharge stormwater using onsite stormwater BMPs.

- Major commercial and retail projects requiring a special permit are required to meet performance standards, including a requirement to meet the MassDEP Stormwater Management Standards.

- Planning Board Subdivision Rules and Regulations, which are referenced in the Zoning Bylaw, including Site Plan Review requirements, includes the requirement that:

  "to the maximum extent feasible, stormwater shall be recharged rather than piped to surface waters. Over critical aquifer recharge areas, this may require the use of open drainage systems along streets in a subdivision. Applicants are encouraged to implement current stormwater management guidelines as established by the Department of Environmental Protection."

- The Subdivision Rules and Regulations also require that:

  "any sites that are over 1 acre in disturbed area or for other reasons are required to submit a NPDES Stormwater permit under the EPA shall be required to submit to the Town Engineer a copy of the original submission, approved permit, all plans, calculations and other relevant information used to indicate compliance."

Section 3
Anticipated WMA Permit Tier Designation

Compliance with the WMA under the SWMI Framework depends on several factors:

- The System Baseline withdrawal volume (reference point against which a request will be considered either an "existing" or an "increasing" withdrawal);
- Separate Major Basin Baselines if an applicant has sources in more than one major basin (i.e. Merrimack vs. SuAsCo; not applicable to Westford);
- The Groundwater Withdrawal Category (GWC) of the Sub-basin(s) where the applicant's sources are located, and Net Groundwater Depletion (NGD) of such Sub-basin(s);
- The Biological Category (BC) of the Sub-basin(s) where the applicant's sources are located;
- Whether their sources share a sub-basin with a Coldwater Fish Resource (CFR) stream;
- Which sources have Registrations and which have Permits (Westford has a combined permit and a registration that applies to all sources)
- The requested water volume.

The GWC and BC of the Sub-basins in which a community's sources are located, in conjunction with Baseline and the requested volume, determine what tier designation a community will receive. The tiers in turn specifies what is required during permitting. Table 3 presents a summary of three tiers.

TABLE 3
Tier Designation

Tier	Withdrawal Request
1	No additional water above baseline
2	Additional water above baseline will not result in a change in Groundwater Withdrawal Category or Biological Category
3	Additional water above baseline will result in a change in Groundwater Withdrawal Category or Biological Category

3.1 Westford's System Baseline

The baseline demand for a system is determined by the greater of the 2003 to 2005 annual average demand or the 2005 actual demand, plus a growth factor of 5%. Furthermore, the baseline cannot be lower than the system's existing registered volume or higher than the total authorized volume for 2005. Table 4 illustrates the baseline demand calculation for the Water Department.

TABLE 4
Westford Baseline

Item	Quantity (MGD)
Registered Volume	1.18
Total Authorized Volume	2.44
2003 Demand	1.73
2004 Demand	1.74
2005 Demand	1.69
2003 – 2005 Avg. Demand(1)	1.72
2003-2005 Avg. Demand + 5%	1.80
Proposed Baseline	**1.80**

This baseline number is slightly different from the MassDEP identified baseline for Westford which is 1.79 MGD. This discrepancy is due to a difference in the values used by MassDEP to calculate the baseline and the reported withdrawals on the Department's Annual Statistical Report (ASR). Review of MassDEP's baseline calculator shows they use a withdrawal volume of 1.63 MGD for 2005. However, the Department's ASR reported 1.69 MGD for 2005's withdrawal. This discrepancy could be due to a typographical error by MassDEP or could be related to an error on the ASR. During the permit renewal cycle, the Department should verify the calculations and coordinate with DEP to ensure the baseline is correct. For planning purposes, the MassDEP baseline figure of **1.79 MGD** must be used.

3.2 Groundwater Withdrawal Category and Biological Category

The Groundwater Withdrawal Category (GWC) of each subbasin in the Commonwealth was determined by MassDEP based upon the estimated percent alteration of the subbasins "unaffected" August median flow. The "unaffected" flow was determined utilizing the Sustainable Yield Estimator (SYE) at the pour point (exit) of the subbasin and includes the flow from any upstream subbasins. Withdrawals were based on 2000 to 2004 annual average withdrawals for all WMA permitted wells and estimated private well withdrawals in the subbasin and upstream subbasins. Annual average withdrawals were adjusted by a peaking factor of 115.5% to determine August monthly withdrawals. The percent alteration of August flow was determined by dividing the August withdrawals by the August unaffected flow, which presumes a 1:1 relationship between withdrawals and streamflow impacts. The Biological Category (BC) is based on estimated impervious cover, channel slope, percent wetland in the buffer zone of the river, and the percent of August streamflow that is pumped as groundwater. Categories range from 1 (lease impacted) to 5 (most impacted). Figure 2 in Attachment A shows the GWC and Figure 3 in Attachment A shows the BC.

Net Groundwater Depletion (NGD) is a measure of the influence of <u>all</u> groundwater withdrawals and discharges on streamflow. NGD is the estimated unimpacted streamflow, less groundwater withdrawals, plus returns to groundwater from septic systems and groundwater discharges for the month of August. Data from the years 2000 to 2004 are used to identify existing conditions. The equation for this calculation is:

100 – (Aug Unaffected Flow – 2000 to 2004 GW Withdrawals + 2000 to 2004 WW returns) / (Aug Unaffected Flow) x 100

Table 5 summarizes the GWC, BC, and NGD for subbasins in Westford that contain the municipal water supply sources.

TABLE 5
Subbasin Characterization Summary

Subbasin ID	Water Supplies	Net Groundwater Depletion	Groundwater Withdrawal Category	Biological Category
13044	Nutting Rd	17.8%	5	5
13048	Depot Rd	33.6%	5	5
13049	Forge Village Wellfield & Well No.2 Cote Well Stepinski Well	90.5%	5	5
13054	Country Road No.2 Howard Road Fletcher Well	88.6%	5	5

3.3 Coldwater Fisheries Resource in Westford

Reed Brook is the only identified Coldwater Fishery Resource (CFR) located in the Town of Westford. Reed Brook is located in Subbasin 13049 of the Merrimack River Basin and is upstream of the Water Department's four groundwater sources in that subbasin. Figure 1 shows the location of Reed Brook.

The Water Department will be required to conduct a desktop optimization with a focus on specifically reducing impacts to Reed Brook. As part of renewing their WMA permit, the Water Department will need to consult with the Division of Fisheries and Wildlife and other appropriate agencies to address the impacts to the CFR as part of mitigation planning. Because the CFR is upstream of the Water Department's wells, it is unlikely that any mitigation activities could improve the resource. Therefore, we don't anticipate that the Division of Fisheries and Wildlife will require any mitigation measures in this subbasin.

3.4 Requested Water Volume

According to a build-out analysis prepared by Northern Middlesex Council of Governments (NMCOG) in 2000, the projected water demand at full build-out of the Town of Westford is 2.41 million gallons per day. Other water use projections listed in a previous Master Plan completed for the Water Department estimate that by 2030 the Water Department's average day demand will be 2.0 MGD.

Tighe & Bond completed a water supply projection analysis utilizing available population data and information provided by the Town on potential future development. The historic population data for Westford was gathered from the U.S. Census Bureau, and the projected population from 2015 through 2030 was determined from the University of Massachusetts (UMass) Donahue Institute Population Estimates Program. To include the end of the anticipated 20 year WMA permit term (2038), we extended the population

projection through 2040. To be consistent with the UMass Donahue population growth prediction, we estimated the 2035 and 2040 population using the average projected growth rate from 2020 to 2030. The population was then multiplied by 75% to represent the population of Westford that is connected to the water system. This information is presented in Table 6.

TABLE 6
Town of Westford Population
1980 to 2040

Year	Population	Approximate Population Served by Water Supply
1980	13,434	10,076
1990	16,392	12,294
2000	20,754	15,566
2010	21,951	16,463
2015	21,942	16,457
2020	22,249	16,687
2025	22,975	17,231
2030	24,029	18,022
2035	24,178	18,133
2040	24,328	18,246

The water demand resulting from proposed developments was calculated using Title 5 wastewater flows for each proposed development provided by the Town. It was assumed that the wastewater flow is 85% of water use, so the resulting water demand was determined by multiplying the wastewater flow by 1.1765. Using this method, we estimated that proposed developments will have an estimated water use of approximately 202,000 gallons per day, or 0.202 MGD. Attachment B includes the proposed developments and their associated water use.

Water use projections takes into account the projected population, as shown in Table 6, and proposed developments to determine the water demand for every five years, starting in 2015. It was determined that the projected average day water demand for the Water Department in 2040 will be 2.052 MGD. The assumptions and methods that were used to determine this is located in Attachment C.

Although the water distribution system currently serves a portion of Town, there is potential for future expansion of the system to serve additional areas or provide water to the entire community. To quantify the potential volume needed to serve 100% of the population, we utilized the full future population projections and the historical average use of 0.037 million gallons per person. We estimate that the projected average day water demand for the Water Department in 2040, assuming 100% of the population is connected to the system, will be 2.669 MGD. A summary of the projected water usage for the current portion of Town served and all of Town served is located in Table 7.

TABLE 7
Westford Water Department
Water Usage from 1980 to 2040

Year	Water Usage Assuming Service Area Is Unchanged (MGD)	Water Usage Assuming Service Extended to 100% of Population (MGD)
1980	1.031	1.031
1990	1.359	1.359
2000	1.488	1.488
2010	1.573	1.573
2015	1.871*	2.427*
2020	1.894*	2.458*
2025	1.949*	2.532*
2030	2.030*	2.639*
2035	2.041*	2.654*
2040	2.052*	2.669*

**Projected*

At the time of WMA permit renewal, DCR will develop a water demand projection for the Water Department to use as final numbers for the renewal process. However, based on our estimates described above, we anticipate the Water Department will ask for a water withdrawal above the baseline of 1.79 MGD. Table 8 lists the projected withdrawal amounts along with the amounts for the anticipated ask and the amount requiring offsets and/or mitigation. The Anticipated ask over baseline could range from approximately 0.25 MGD to 0.88 MGD.

TABLE 8
Baseline and Withdrawal Demands

Description	Volume Assuming Percent of Population Served Is Unchanged (MGD)	Volume Assuming 100% of Population Served (MGD)
Total Authorized Volume	2.44	2.44
Town Projection (20 year)	2.05	2.05
MassDEP Baseline	**1.79**	**1.79**
Anticipated Ask	**2.05**	**2.67**
Amount Requiring Offset / Mitigation	**0.26**	**0.88**

Because all of the Water Department's sources are within subbasins that are already Groundwater Category 5 and Biological Category 5, the anticipated additional withdrawal request would not increase the GWC or BC of the withdrawal basins. **Based on these preliminary estimates, we expect that the Water Department will be permitted under Tier 2, which is for water suppliers requesting an additional withdrawal above baseline but that does not result in a change to GWL or BC.** The presence of the Reed Brook Coldwater Fishery Resource will also be factored into the permitting process. The following section provides additional information on anticipated permit requirements.

Section 4
Anticipated WMA Permit Requirements

Permit requirements for public water suppliers are presented in the SWMI Framework (Table 4-1 of the document). Requirements are based on subbasin flow level and withdrawal requested Tier. The Water Department's WMA permit is anticipated to be a Tier 2/GWC 5 review with a quality natural resource in the subbasin. The will require that the Water Department comply with applicable provisions of WMA Standard Permit Conditions No.1 through 8 as listed below:

1. Source Protection
2. Firm yield for surface water supplies
3. Wetlands and vernal pool monitoring (if applicable)
4. Residential use less than 65 gallons/capita/day
5. Unaccounted for water less than 10%
6. Seasonal limits on nonessential outdoor water use
7. Water conservation measures
8. Offset Feasibility Study

Note that it is expected that the minimization and mitigation measures developed through the SWMI process will be incorporated into Standard Conditions Nos.6 through 8. Additional SWMI requirements that the Water Department will be expected to meet include:

- For the three groundwater withdrawal points in subbasins with ≥25% August NGD, the Water Department must minimize impacts of their existing withdrawals on streamflow to the greatest extent feasible considering cost, level of improvement achievable and ability to implement.
- For the one subbasin with a Coldwater Fisheries Resource, the Water Department must undergo CFR optimization planning in conjunction with evaluation of minimization efforts
- Water Department must implement mitigation measures commensurate with withdrawal above baseline (estimated to be 0.26 MGD)
- Water Department must demonstrate that there is no feasible alternative source that is less environmentally harmful. Less environmentally harmful is defined as a source that is in a GWC 1, 2, or 3 subbasin and doesn't cause that subbasin to change GWC.

Potential minimization and mitigation alternatives that may apply to Westford are discussed in the next section. The feasibility of implementing these actions have not been fully investigated. The discussion provides a basis for assessing the potential impact of the SWMI process on the Water Department permit application.

4.1 Minimization of Impacts

Public water suppliers with groundwater sources in subbasins with an August net groundwater depletion of 25% or more are required to develop and implement a plan to minimize impacts. Based on the calculated August Net Groundwater Depletion, a minimization plan is required for withdrawals from Subbasin Nos. 13048, 13049, and 13054 as shown on Table 9.

TABLE 9
August Net Groundwater Depletion by Subbasin[1]

Subbasin	Unaffected August Streamflow (MGD)	Groundwater Withdrawals (MGD)	Wastewater Returns (MGD)	August Net Groundwater Depletion (%)
13044	0.366	0.269	0.204	17.8
13048	0.637	0.378	0.164	**33.6**
13049	3.748	4.115	0.724	**90.5**
13054	1.661	1.821	0.349	**88.6**

[1]Data from MassDEP's WMA Permitting Tool

4.1.1 Desktop Optimization

The desktop optimization analysis requires a Public Water Supplier to evaluate their existing sources, or any available alternative sources including interconnections, for options to reduce environmental impacts while still meeting water demand. This assessment includes:

1. Modifying well withdrawal operations, including timing of withdrawals from various sources
2. Using potential alternative sources where availability exists

In addition to environmental concerns, existing system constraints should be considered. These may include: infrastructure, pressure, water quality, operations, costs, regulatory matters, and societal needs.

The following list of questions were evaluated to help Westford assess which sources/subbasins might be less impacted during pumping in the low flow periods (summer/fall) and which sources/subbasins may cause a greater impact. Note that sub-basin 13044 does not require a desktop evaluation.

Question	Evaluation
1. Is there a CFR present?	Yes, in one sub-basin. See Table 10.
2. What is the Mass Water Indicators (MWI) August affected streamflow in cubic feet per second per square mile (cfsm)? *MWI affected flow is (unaffected streamflow – groundwater withdrawals + all returns)/drainage area*	Withdrawals in subbasins with a higher cfsm are preferred, so withdrawals from 13044 and 13048 are preferred.
3. Does the increase over baseline cause a change in BC or GWC?	Because all sub-basins are BC 5 and GWC 5, there is no change in category for any of the sub-basins.
4. What is the groundwater withdrawal percentage? *(withdrawals/unaffected streamflow)*	Withdrawals in subbasins with lower percentages are preferred, therefore withdrawals in subbasins 13044 and 13048 are preferred.
5. Is there an available surface water supply with a release plan approved by the Department?	Westford is not supplied by surface water sources and therefore this is not applicable. Opportunities for releases

Question	Evaluation
	from impoundments are further discussed in Section 3.1.2 of this memorandum.
6. Are other sensitive resources present such as vernal pools?	Certified and potential vernal pools are located throughout Westford including within all water supply sub-basins. However, it is unknown if withdrawals impact these resources. Locations of vernal pools are presented in Figure 1.

TABLE 10
Summary of Desktop Optimization by Subbasin

Subbasin	CFR present	August affected streamflow (cfsm)	Will increase over baseline change the BC or GWC?	Groundwater withdrawal %	Surface water supply release	Other sensitive receptors (e.g., Vernal Pool)
13044	No	0.088	No	73.5	No	Vernal Pools
13048	No	0.068	No	59.3	No	Vernal Pools
13049	Yes	0.013	No	109.8	No	Vernal Pools
13054	No	0.014	No	109.7	No	Vernal Pools

As possible, shifting increased withdrawals to the Nutting Road Well and satellite wells (Subbasin 13044) or to the Depot Road Well (Subbasin 13048) or allowing wells within the other two sub-basins to rest during the low-flow period (e.g., July, August, September based on streamflow) would benefit the subbasins under the SWMI program. However, the feasibility of these actions will need further investigation.

If the Water Department were to develop additional sources for redundancy or supplemental sources, they should consider opportunities to locate wells further from the stream. Location and benefit would require individual, site specific study for any new source. The Water Department should review the 2004 Water Assets Study completed for the Town of Westford by the Massachusetts Executive Office of Environmental Affairs to assist in locating additional sources of supply.

Interconnections

The Water Department currently maintains emergency interconnections with Chelmsford, North Chelmsford, Littleton Tyngsborough and Groton. These connections are all considered emergency connections, and would require significant upgrades to use as more than an emergency resource. Also, as noted below, the neighboring communities do not have significant additional capacity to sell water to the Town of Westford. None of the communities are served by the MWRA system. Chelmsford has just under 1 MGD available based on 2012 usage. However, their demand in previous years is closer to their SWMI baseline. Tyngsborough is a consecutive supplier and purchases all of its water supply from multiple sources. In order to purchase water from Tyngsborough, Westford and the Tyngsborough Water District would need to negotiate agreements with their suppliers to provide the additional demand. Infrastructure upgrades may also be required within Tyngsborough's water system as they operate on a lower hydraulic grade line than the Westford water system.

TABLE 11
Alternative Sources: Interconnections

Water Supplier	Source Basin	SWMI Baseline (MGD)	2012 Water Usage (MGD)
Chelmsford Water District	Concord & Merrimack	3.53	2.55
Groton Water Department	Merrimack	0.45	0.44
Littleton Water Department	Merrimack	1.11	1.1
North Chelmsford Water District	Merrimack	0.94	0.69
Tyngsborough Water District	Purchased from: City of Lowell, Dracut Water Supply District and Pennichuck Water	NA	NA

Source: MassDEP's WMA Permitting Tool

4.1.2 Water Releases and Returns

The minimization analysis includes an evaluation of existing impoundments and the potential for releases from these impoundments that could return water to the subbasin or basin to improve flows. The dams and surface water impoundments in the Town of Westford were identified for assessment for potential releases to augment stream flows during low flow periods. A screening analysis was conducted to evaluate the potential for surface water releases to mitigate water withdrawals. Factors that were considered included impoundment use, location with respect to the water withdrawal, ownership, status of proposed dam removals, and current management of releases. The analysis needed to confirm availability of water for potential releases, including modeling of potential release scenarios was not performed.

There are eight dams identified by the Department of Conservation and Recreation within the Town of Westford. All or located within the Merrimack River Basin. Four of the identified dams are owned by the Town. A summary of the dams, including ownership and location is included in Table 12. Two dams are located upstream of Water Department's water supply wells.

Based on location, age, ownership, and type of impoundment, it does not appear there are feasible opportunities to release surface water to offset groundwater withdrawals within the Town.

TABLE 12
Summary of Westford's Dams

Dam Name	Owner	Subbasin	Proximity to Water Supply	Feasibility
Fletcher Pond Dam	Private	13044	Downstream of withdrawals	Not controlled by Westford
Flushing Pond Dam	Westford	13044	Downstream of withdrawals	Downstream of withdrawals, limited impact on water supplies
Nabnasset Pond Dam	Westford	13044	Downstream of withdrawals	Downstream of withdrawals, limited impact on water supplies
Commodore Food Company Dam	Private	13045	Downstream of withdrawals	Not controlled by Westford
Westford Depot Dam	Westford	13045	Downstream of withdrawals	Downstream of withdrawals, limited impact on water supplies
Long-Sought-for Pond Dam	DCR	13048	Downstream of withdrawals	Not controlled by Westford
Murray Printing Company Dam	Private	13049	Upstream of withdrawals at terminus of Fletcher Pond	Not controlled by Westford
Stony Brook Dam at Graniteville	Westford	13049	On Stony Brook above Stepinski Well	Limited impoundment area

Groundwater returns can include stormwater recharge, infiltration/inflow (I/I) improvements, and other wastewater discharges that could result in improvements to the quantity and timing of streamflow. Preference for returns is given in the following order: to the same subbasin, same major basin and another major basin.

Westford has limited opportunity to receive credit for I/I as the wastewater collection system covers a small area and is relatively new. As all wastewater is returned to groundwater via septic system and groundwater discharge systems, no other credit for wastewater returns are easily obtained. One option would be to construct public sewers within the Concord Watershed and dispose of treated wastewater through a groundwater discharge system in the Merrimack Watershed. This method however would go against the tenant of "keeping water local", and would result in a significant expense for limited environmental benefit.

4.1.3 Additional Conservation Measures

Additional conservation measures to be considered include additional indoor and outdoor conservation measures that go beyond standard WMA permit conditions. Based on the 2013 Annual Statistical Report, the Water Department's residential per capita consumption is 64 gallons per day. Therefore the Water Department can take credit for limiting watering

to no more than 2 days per week (1 day per week when the 7-day low-flow trigger occurs). Examples of additional conservation measures are provided in Table 13.

TABLE 13
Example Conservation Measures

Conservation Measure
Additional Measures to Reduce Demand
• Implement a rebate program for residential customers for high efficiency WaterSense-labeled products (toilets, lavatory faucets, showerheads, and irrigation controllers) and Energy Star-labeled clothes washers
• Offer incentives for those seeking municipal approvals to install high-efficiency WaterSense-labeled products and Energy Star-labeled appliances in new construction and renovations. Document numbers of products installed in annual report.
• Evaluate rate structure every two years and increase rates for the highest rate block.
• Implement a seasonal rate structure that sets higher rates from May 1 to September.
• Increase billing frequency to at least quarterly. (Westford currently conducts monthly readings.)
• On water bills, provide customers with water consumption information in gallons and show consumption history.
Additional Measures to Reduce Water Losses
• Conduct comprehensive water audit of water system every five years *(Westford currently implements this effort)*
• Develop and implement a meter-replacement program to ensure that all nonresidential water use is properly accounted for *(Westford currently does this).*
• Establish penalties and fines for stealing water *(Westford's code includes this).*
• Install an automated, remote leak detection system.
• Install automated, remote meter-reading system *(Westford is currently upgrading meters).*
Additional Measures to Reduce Nonessential Outdoor Watering
• Include some or all of the following provisions in an outdoor water-use bylaw or ordinance to ensure proper installation and efficient operation of automatic sprinkler systems:
• Require registration of automatic irrigation systems
• Minimize installation of high water-use landscape areas
• Restrict land clearing and lawn size in new developments
• Requires a minimum 6-inch depth of topsoil on all cleared areas to help retain moisture
• Prohibits topsoil stripping
• Provide incentives to improve efficiency of automatic irrigation systems.
• Install Water-Sense-labeled weather-based controllers on municipal properties with automatic irrigation systems
• Target highest water users with monthly mailing about their use from May 1 through September 30. Provide information comparing their use with most efficient customers.
• Extend seasonal limits on nonessential outdoor water use to private well users.
• Provide incentives for customers to infiltrate rainwater; infiltrate rainwater on municipal properties
• Provide incentives for customers to enhance soil health; enhance soil health on municipal properties.

Section 5
Mitigation & Offsets to Withdrawals

The WMA regulations require all Tier 2 and Tier 3 permittees to mitigate any increases in withdrawals above baseline, commensurate with impact. The volume of impact is the amount of water withdrawal requested above the established baseline minus wastewater returns. Impact is further qualified by whether an increase in withdrawal causes a change in the subbasin GWC or BC. Activities that occurred after 2005 qualify as direct or indirect mitigation that continue to provide environmental benefit may be considered as part of an initial mitigation plan pending MassDEP review and approval.

A mitigation plan must be developed that includes direct and indirect efforts to offset the increase in withdrawals above the baseline. The mitigation volume = (Requested rate over baseline) – (Savings through enhanced demand management) – (all applicable wastewater adjustments).

5.1 Direct Mitigation

5.1.1 Wastewater Adjustments

Wastewater returns were not incorporated into the data used to develop the GWC or BC for the subbasins. Therefore, the WMA regulations allow for wastewater returns to be factored into the required mitigation calculation. As noted in Section 1.2, wastewater in Westford is treated and disposed of through on-site systems with subsurface discharges. The majority of the development in town is located within the Merrimack River Basin, the same river basin that the groundwater withdrawals are from. Based on water supply records georeferenced to identify the Watershed Basin, approximately 76% of water demand is located within the Merrimack River Basin and 24% of water demand is located within the Concord River Basin. According to the Guidance Document, the Water Department can take 100% credit for wastewater disposal (85% of water demand) within the Merrimack River Basin, and 50% credit for wastewater recharge in the Concord Basin. Assuming that the ask for an increase over baseline will be 0.26 MGD, Table 14 presents the potential amount of that increase that will be offset by direct mitigation through wastewater returns.

TABLE 14
Potential Wastewater Returns

Water Usage (MGD)		Total Wastewater Flow (MGD) (85% of water demand)	Locational Adjustment Factor	Total Flow Offset Volume (MGD)
Merrimack Basin	0.20	0.17	100%	0.17
Concord Basin	0.06	0.05	50%	0.03
		Total Wastewater Returns (MGD)		**0.20**

The total wastewater flow to offset the increase in withdrawals above baseline is estimated to be 0.20 MGD. Assuming the Department does not extend the water distribution significantly, the total 20 year increase above baseline that requires an offset, is estimated to be no more than 0.26 MGD, and therefore the Water Department will have almost met required offset quantity by counting wastewater. However, if the Department were to expand the distribution system to serve more are or all of Westford, additional measures will be needed to offset the potential volume of 0.88 MGD above baseline. Note that, in the case of extension of the water distribution system, the wastewater return adjustment will have to be recalculated using information about wastewater disposal within the entire water service area.

While Subbasins Nos. 13044, 13049 and 13054 receive surface water discharges from NPDES-permitted discharges, only wells in "significantly" surcharged subbasins are eligible for credit. One of the factors for a subbasin to be considered "significantly" surcharged is that the surcharge must by more than 1.0 MGD. The surface water returns for the three subbasins are 0.652 MGD (13044), 0.293 MGD (13049) and 0.293 MGD (13054). Therefore, there is no surcharge credit available for the Water Department.

5.1.2 Stormwater Recharge

Direct mitigation credit can be obtained when areas that drain to the municipal stormwater system are disconnected and allowed to infiltrate into the soils and recharge the aquifer. Stormwater recharge projects (Best Management Practices) that have been installed since 2005 can be accounted for as part of mitigation and minimization under the WMA Permit process.

Municipal projects include the rain gardens installed at the Millennium Elementary School and the Day School. Mitigation credits could be determined by determining the size of these BMPs or the infiltration calculations. Credit cannot be taken for the stormwater management systems implemented at previously undeveloped sites, such as the water treatment facilities.

Private redevelopment projects that occurred in wetlands jurisdiction areas or are subject to the Town's stormwater bylaw may also have recharge projects that should be inventoried and accounted for as part of the WMA permit renewal.

In addition, as part of their Stormwater Management Program (see Section 1.3), the Town will be required by EPA to evaluate town-wide opportunities to implement stormwater recharge BMPs. As this effort progresses, this effort should be coordinated with the SWMI process. Priority should be given to recharge projects in the Merrimack River Watershed and the Town should take credit for recharge implemented.

5.2 Indirect Mitigation

Indirect mitigation activities are activities undertaken to offset the impacts of a withdrawal. Indirect mitigation activities are generally not amenable to volumetric calculation; MassDEP will utilize a qualitative credit system for the benefits of a particular action. The credit system reflects the effectiveness of a particular action in augmenting base flow (e.g., by promoting stormwater recharge during storms), improving habitat conditions, improving watershed protection, or providing other benefits that could offset the impacts of a withdrawal.

Credits are assigned as follows:

1. The activity will not benefit the improvement category = 0 credits
2. The activity will have a partial benefit to the improvement category = 5 credits
3. The activity will benefit the improvement category = 10 credits

Examples of indirect mitigation activities include:

- Habitat improvement (e.g. remove dam, replace culvert to meet stream crossing standards, streambank or stream channel restoration, fish ladder installation, establish aquatic habitat restoration fund, other habitat or stream buffer area restoration).

- Stormwater (e.g. recharge requirements in stormwater bylaw, stormwater utility including increased recharge provisions, MS4 permit compliance including increased recharge).

- Habitat protection (e.g. acquire property)

- Demand controls (e.g. private well bylaw)

Note that MassDEP will review all indirect mitigation projects on a case by case basis during the agency consultation process under the WMA permit renewal.

Credits will be converted to an indirect mitigation amount. For Tier 2 permittees like the Westford Water Department, every ten credits will provide up to 0.1 MGD in volume. Table 15 lists the credit system for indirect mitigation.

TABLE 15
Indirect Mitigation Credits

Total Credits	Indirect Mitigation Amount (MGD)
Up to 10	>0 to 0.1
Up to 20	>0.1 to 0.2
Up to 30	>0.2 to 0.3
Up to 40	>0.3 to 0.4
Up to 50	>0.4 to 0.5
...	...
Up to 100	>0.9 to 1

Over 100 total credits are evaluated on a case by case basis.

Section 6
Summary

To meet the new Water Management Act regulations and the SWMI framework, the Westford Water Department will have to complete extensive planning efforts as part of the permit renewal process. The goal of the summary and evaluation completed in this report was to provide the Department with and understanding of Westford's individual permit and planning requirements.

The water system baseline calculated by MassDEP is 1.79 MGD. Based on previous water demand projections and our estimates, the 2038 average day demand may be as high as 2.05 MGD. Based on these estimates, it is likely the Water Department will request an additional 0.26 MGD above baseline. Because the subbasins from which the Water Department withdraws water are considered Category 5 (highest impact) for both Groundwater Level and Biological Category, the increased withdrawal above the baseline will not increase the categories.

6.1 Overview of Permit Requirement Impacts on Westford

Based on our evaluation, we expect that the Westford Water Department will be designated a Tier 2 permittee. The Water Department will therefore be required to:

- Meet the eight Standard Permit Conditions of the WMA process (e.g. source protection, rgpcd less than 65, unaccounted for water less than 10%, seasonal limits, etc) and to minimize impacts of existing withdrawals and implement mitigation measures.

- Develop a written minimization plan that explores how to modify withdrawal operations such as changing timing of withdrawals or shifting operations between wells as needed seasonally, use alternative sources such as interconnections, release water from impoundments, return water the ground via wastewater or stormwater discharges, and implement additional water conservation measures.

Based on Tighe & Bond's review described in Section 3, there may be opportunities to modify operations and the Water Department should further explore these details. Recharge of groundwater through wastewater returns is already underway, as most of the Town is served by onsite wastewater disposal systems or small package treatment systems with groundwater discharge. The Department can take credit for these wastewater returns.

There may be opportunities to recharge groundwater through installation of stormwater best management practices. As the Town of Westford moves forward with comprehensive stormwater management planning and meeting requirements of EPA's municipal storm sewer system permit, the Water Department should coordinate with other municipal staff to track projects and estimate credit under the SWMI framework.

The Water Department should coordinate with other Town staff to evaluate the additional water conservation measures (see Table 13) the Town would consider to reduce demand, reduce water losses, and reduce nonessential outdoor watering

Releasing water from impoundments is unlikely to be feasible given the location, age, ownership, and type of impounds.

Utilizing interconnections should be evaluated as a last resort due to the infrastructure upgrade needs, requirements for intermunicipal agreements, cost, and in some cases, limited availability of water from the other communities.

In summary, the impact of the new WMA permitting requirements on the Westford water supply withdrawals include:

- Developing a mitigation plan that includes direct and indirect efforts to offset the increase in withdrawals above the baseline. Mitigation volume = (Requested rate over baseline) – (Savings through enhanced demand management) – (all applicable wastewater adjustments). For the Westford Water Department, the mitigation volume = 0.26 MGD over baseline – 0.20 MGD wastewater adjustment, or 0.06 MGD. The mitigation volume of 0.06 MGD can be offset by completing enhanced demand management, recharging stormwater runoff, or completing indirect mitigation activities as further described in Section 5.

- Consulting Division of Fisheries and Wildlife regarding further protection of the Coldwater Fisheries Resources as part of the mitigation planning. Because the CFR is located upstream of the Department's wells, we believe there is little mitigation that can be completed to directly reduce impacts to this resource. However, because of the presence of the resource in the same subbasin as a well, the Water Department must undergo consultation.

ATTACHMENT A

Figures

Dunstable
Tyngsborough
Lowell
Groton
Chelmsford
Littleton
Carlisle
Acton
13034
13030
13048
13044
MERRIMACK WATERSHED
13045
Reed Brook
(Cold Water Fishery)
13049
13055
12044
13054
12046
12039
CONCORD WATERSHED
12047
12050
12051

Legend

- Town Boundaries
- Groundwater Discharge
- Dams
- NHESP Potential Vernal Pools
- NHESP Certified Vernal Pools
- Community Public Water Supply - Surface Water
- Community Public Water Supply - Groundwater
- Non-Community Non-Transient Public Water Supply
- Non-Community Transient Public Water Supply
- Cold Water Fishery
- Stream/Intermittent Stream
- Major Watershed Boundary
- SWMI Watershed Boundaries
- Waterbody

Tighe&Bond
Consulting Engineers
Environmental Specialists

1. Based on MassGIS Color Orthophotography (2013)

N

1:42,000

0 2,000 4,000 Feet

FIGURE 1
Town of Westford
Public Water Supply

Westford, Massachusetts

December 2014

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X-XXXX

Dunstable
Tyngsborough
Lowell
Groton
Chelmsford
Littleton
Carlisle
Acton
13034
13030
13048
13044
13045
13049
MERRIMACK WATERSHED
13055
12044
13054
12046
12039
CONCORD WATERSHED
12047
12050
12051

Legend

- Town Boundaries
- Community Public Water Supply - Surface Water
- Community Public Water Supply - Groundwater
- Non-Community Non-Transient Public Water Supply
- Non-Community Transient Public Water Supply
- Stream/Intermittent Stream
- Major Watershed Boundary
- Waterbody
- Subbasin Boundary

Groundwater Withdrawal Categories

- Category 2
- Category 3
- Category 5

N

1:42,000

0 2,000 4,000 Feet

Tighe&Bond
Consulting Engineers
Environmental Specialists

1. Based on MassGIS Color Orthophotography (2013)

FIGURE 2
Town of Westford
Public Water Supply

Groundwater Withdrawal Categories
Westford, Massachusetts

December 2014

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W-2071

Dunstable

Tyngsborough

Lowell

Groton

Chelmsford

Littleton

Carlisle

Acton

MERRIMACK WATERSHED

CONCORD WATERSHED

133
300

130
217

117
238

61
189

53
172

42
168

43
160

37
134

131
245

83
135

70
127

105
187

49
161

82
148

Legend

- Town Boundaries
- Community Public Water Supply - Surface Water
- Community Public Water Supply - Groundwater
- Non-Community Non-Transient Public Water Supply
- Non-Community Transient Public Water Supply
- Stream/Intermittent Stream
- Major Watershed Boundary
- Waterbody
- Subbasin Boundary

Biological Categories

- Category 4
- Category 5

Tighe&Bond
Consulting Engineers
Environmental Specialists

1. Based on MassGIS Color Orthophotography (2013)

1:42,000

0 2,000 4,000 Feet

N

FIGURE 3
Town of Westford
Public Water Supply

Biological Categories
Westford, Massachusetts

December 2014

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W-2071

ATTACHMENT B

Summary of Water Usage for Prospective Developments in Westford

ATTACHMENT B
Summary of Water Usage for Prospective Developments in Westford

Development	No. Units/SF	Bedrooms	Title 5 Flow	Title 5 GPD	Water Use[(1)]	Notes and Assumptions
134 Littleton Road (4,300 SF retail, 4,300 SF office)	4,300 4,300		50/1000SF 75/1000SF	538	632	Assumed included in current usage
17 & 19 Lawson Rd (1 unit)	1	2	110	220	259	Assumed 2 bedrooms for apartments/condos
28/30 Old Lowell Road (1 unit)	1	2	110	220	259	Assumed 2 bedrooms for apartments/condos
296 Littleton Rd - Workers' Credit Union	10,000		75/1000SF	750	882	Assumed 10,000 SF
317 Littleton Road (2,200 SF office)	2,200		75/1000SF	165	194	Assumed included in current usage
3-7 Farmers Way (36 units)	36	2	110	7,920	9,318	Assumed 2 bedrooms for apartments/condos
4 Lan Drive (30,000 SF commercial)	30,000		75/1000SF	2,250	2,647	Assumed 100 GPD/1,000 SF (Title 5 warehouse listed as per person)
400 Littleton Road - Kimballs (Bumper Cars, Zipline)					0	Assumed included in current usage
46 Groton Rd (2 units)	2	2	110	440	518	Assumed 2 bedrooms for apartments/condos
5 Lyberty Way (15,000 SF additions)	15,000		75/1000SF	1,125	1,324	Assumed included in current usage
8 Brookside Road (14 units)	14	2	110	3,080	3,624	Assumed 2 bedrooms for apartments/condos
Abott Mill, Phase II	125	2	110	27,500	32,354	Assumed 125 units, 2 bedrooms for apartments/condos
Alcorn Crossing/Flagg Rd (1 unit)	1	2	110	220	259	Assumed 2 bedrooms for apartments/condos
Boch Honda (48,571 SF retail)	48,571				0	Water usage assumed to be incorporated into current use
Bridges at Westford (48 assisted living units)	48		150	7,200	8,471	Assumed 2 beds in each unit
Bruce Freeman Rail Trail					0	Rail trail/assume no/limited usage
Cornerstone Square (47,525 SF office, 173,086 SF retail, 17,800 SF restaurant)	47,525 173,086 17,800				0	Water usage assumed to be incorporated into current use
Cottages in the Woods (20 units)	20	2	110	4,400	5,177	Assumed 2 bedrooms for apartments/condos
Littleton Landing (7 units)	7	2	110	1,540	1,812	Assumed 2 bedrooms for apartments/condos
Minot's Corner reconstruction project					0	Roadway project/assume no usage
Nashoba Valley Tech High School (turf fields)					0	Athletic fields/assumed no increase in usage
NetScout (156,495 SF office)	156,495		75/1000SF	11,737	13,809	Assumed included in current usage
O'Brien Farm (conservation restriction)					0	Conservation Restriction/no flows
Orchard Square (11,160 SF retail, 7,000 SF restaurant)	11,160 7,000		50/1000SF 35/seat	1,083	1,274	Assumed 75GPD/1,000SF (Title 5 restaurant 35 GPD/seat
Orchard Square (18,160 SF retail)	18,160		50/1000SF	908	1,068	Assumed included in current usage
Pricilla Lane (4 units)	4	2	110	880	1,035	Assumed 2 bedrooms for apartments/condos
Princeton Westford Apartment Homes (200 units)	200	2	110	44,000	51,766	Assumed 2 bedrooms for apartments/condos
Red Hat, Inc. (172,812 SF office)	172,812				0	Water usage assumed to be incorporated into current use
Spalding Estates (32 units)	32	2	110	7,040	8,283	Assumed 2 bedrooms for apartments/condos
Tadmuck Meadows II (37 units)	37	2	110	8,140	9,577	Assumed 2 bedrooms for apartments/condos
Westford Technology Park West - The Gutierrez Company (525,000 SF office)	525,000		75/1000SF	39,375	46,325	Assumed included in current usage
Workers Credit Union	10,000		75/1000SF	750	882	Assumed 10,000 SF
			TOTAL (GPD)		**201,747**	
			TOTAL (MGD)		**0.202**	
			TOTAL (MG)		**74**	

Notes:
(1) Assumed wastewater flow is 0.85% of water use, therefore Title V values were multiplied by 1.1765 to estimate water usage.

ATTACHMENT C

Water Supply Projection

ATTACHMENT C
Water Supply Projection

YEAR	POPULATION [1,2,3,4]	TOTAL MG [5,6]	TOTAL MGD [7]	USAGE/POP [8]	ADD	MDD	MDD/ADD	Projected MDD (min) [9]	Projected MDD (max) [10]
1980	10,076	376.180	1.031	0.037	1.031	1.910	1.9		
1981		396.594	1.087		1.087	1.734	1.6		
1982		387.633	1.062		1.062	1.950	1.8		
1983		433.847	1.189		1.189	2.040	1.7		
1984		446.734	1.224		1.224	2.119	1.7		
1985		482.868	1.323		1.323	1.830	1.4		
1986		504.394	1.382		1.382	2.091	1.5		
1987		499.841	1.369		1.369	2.357	1.7		
1988		594.835	1.630		1.630	3.042	1.9		
1989		564.458	1.546		1.546	2.270	1.5		
1990	12,294	495.920	1.359	0.040	1.359	2.629	1.9		
1991		489.248	1.340		1.340	2.670	2.0		
1992		443.349	1.215		1.215	3.383	2.0		
1993		489.081	1.340		1.340	4.096	3.1		
1994		467.491	1.281		1.281	4.254	3.3		
1995		509.526	1.396		1.521	2.830	1.9		
1996		510.642	1.399		1.399	4.854	3.5		
1997		530.618	1.454		1.454	3.005	2.1		
1998		559.106	1.532		1.532	3.263	2.1		
1999		644.000	1.764		1.764	3.880	2.2		
2000	15,566	542.953	1.488	0.035	1.488	3.133	2.1		
2001		640.347	1.754		1.754	3.845	2.2		
2002		606.183	1.661		1.661	3.821	2.3		
2003		632.850	1.734		1.734	3.375	1.9		
2004		635.434	1.741		1.741	3.336	1.9		
2005		615.707	1.687		1.687	3.252	1.9		
2006		573.113	1.570		1.570	3.032	1.9		
2007		601.770	1.649		1.649	3.550	2.2		
2008		526.033	1.441		1.441	2.979	2.1		
2009		491.137	1.346		1.346	2.671	1.985		
2010	16,463	574.110	1.573	0.035	1.573	3.747	2.382		
2011		518.674	1.421		1.421	3.573	2.514		
2012		514.294	1.409		1.409	3.265	2.317		
2013		522.465	1.431		1.431	3.038	2.122		
2015	**16,457**	**682.891**	**1.871**	**0.037**	**1.871**			**3.714**	**4.704**
2020	**16,687**	**691.410**	**1.894**	**0.037**	**1.894**			**3.760**	**4.763**
2025	**17,231**	**711.556**	**1.949**	**0.037**	**1.949**			**3.870**	**4.902**
2030	**18,022**	**740.805**	**2.030**	**0.037**	**2.030**			**4.029**	**5.103**
2035	**18,133**	**744.921**	**2.041**	**0.037**	**2.041**			**4.051**	**5.132**
2040	**18,246**	**749.102**	**2.052**	**0.037**	**2.052**			**4.074**	**5.160**

Notes:

(1) Historic population data: US Census Bureau, Westford, MA

(2) 2015 - 2030 Projected population data: UMass Donahue Institute Population Estimates Program, Westford, MA

(3) 2035 - 2040 Projected population data:

(4) Population multiplied by 75% to represent the population connected to the system

(5) Historic Total MG: Annual Statistical Reports, Westford, MA

(6) Projected Total MG: (Projected population) x (Usage/Population factor) + (New Development Water Use)

(7) Total MGD: (Total MG) / 365

(8) Projected Usage Per Person factor: Average of historic usage per person

(9) Minimum Projected MDD: (Average Day Demand) x (Minimum MDD/ADD in Past 5 Years, 1.985)

(10) Maximum Projected MDD: (Average Day Demand) x (Maximum MDD/ADD in Past 5 Years, 2.514)

Appendix C

Facility Evaluation Reports

Facility: Booster #2 (Boston Road PS) **Evaluation Date:** 3/9/16
Address: 80 Boston Road **Evaluation Time:** 10:45 AM

Install Year: *Number of Wells Served*:

Number of Pumps and Sizes:
This pump station is not run to full capacity

Description:

VFD installed as part of an energy saving program

Overall Condition:	Like New		Good		Fair		Poor		

Additional Condition Comments:

Observed Issues (corrosion, chemical spills, water leaks, water damage, cracked/broken seals, cracked concrete, potential sources of contamination, erosion or pitting):

Trash has accumulated behind the building

Operational Parameters:
Fills the low service area to high service area
PRV can be used to return to the low service area, but it is not used

Operational Issues:
There is an existing control issue – the Forge Village PS turns on and off before Booster #2 turns on

Typical Maintenance (pump station and wells):
PRV is serviced every year

Date Last Maintained:
Building was painted in the summer of 2015
Generator is exercised regularly (as of date and time of inspection, generator had 438.1 hours)

Facility: Booster #2 (Boston Road PS) **Evaluation Date:** 3/9/16
Address: 80 Boston Road **Evaluation Time:** 10:45 AM

Additional Pumps (Present Need):

Future Need:

Needed Capital Improvements:

Remove trash from premises

Security and Access (any issues?):

Backup Power (any issues?):

Emergency Response (fail safes, equipment in place, means of alerting operators):

Additional Comments (issues, concerns, things to improve):

Facility: Cote **Evaluation Date:** 3/9/16
Address: Beacon Street **Evaluation Time:** 1:20 PM

Install Year: *Number of Wells Served*:

Number of Pumps and Sizes:

50 gpm winter

Description:

Overall Condition:	Like New		Good		Fair		Poor		

Additional Condition Comments:

Observed Issues (corrosion, chemical spills, water leaks, water damage, cracked/broken seals, cracked concrete, potential sources of contamination, erosion or pitting):

There is no access gate at the end of the access road

Operational Parameters:

Initially, perchlorate was used to treat the water. When the Nutting Road WTP was built, perchlorate was no longer used. UV was also used for a while, but is now offline.

Operational Issues:

Typical Maintenance (pump station and wells):

Date Last Maintained:

Cleaned the perchlorate tank with a vac truck week of 2/29/16

Facility: Cote **Evaluation Date:** 3/9/16
Address: Beacon Street **Evaluation Time:** 1:20 PM

Additional Pumps (Present Need):

Future Need:

Needed Capital Improvements:

Install access gate

Security and Access (any issues?):

Chain link fence with barbed wire

Backup Power (any issues?):

Engine

Can hook up a portable generator outside of the building

Emergency Response (fail safes, equipment in place, means of alerting operators):

Additional Comments (issues, concerns, things to improve):

Facility: Country Road 2 **Evaluation Date:** 3/9/16
Address: 15 Country Road **Evaluation Time:** 9:30 AM

Install Year: *Number of Wells Served*:

Number of Pumps and Sizes:
1 pump, 30 HP motor

275 gpm Summer
150 gpm Winter

Description:
Country Road 2 replaced Country Road 1
Pumps to Forge Village WTP
PS building is prefabricated, poured foundation

Overall Condition:	Like New	X	Good		Fair		Poor		

Additional Condition Comments:

Observed Issues (corrosion, chemical spills, water leaks, water damage, cracked/broken seals, cracked concrete, potential sources of contamination, erosion or pitting):

Operational Parameters:

Operational Issues:
Issues with shaft couplings – replaced 2 years ago, will check on them during April cleaning
Plugs up quickly

Typical Maintenance (pump station and wells):
Conventional cleaning (pump and surge) every 1.5 to 2 years

Date Last Maintained:
Next scheduled cleaning in April

Facility:	Country Road 2	**Evaluation Date:**	3/9/16
Address:	15 Country Road	**Evaluation Time:**	9:30 AM

Additional Pumps (Present Need):

Future Need:

Needed Capital Improvements:

Reseal concrete pump base joint at floor

Security and Access (any issues?):

Fence with barbed wire

Paved access road in good condition

No issues with security or vandalism

Backup Power (any issues?):

1 standby Katolight engine

Emergency Response (fail safes, equipment in place, means of alerting operators):

Power fail, intruder alarm, draw down, pump fail

Additional Comments (issues, concerns, things to improve):

Country Road 1 – PS was demolished, well was filled. MassDEP process was completed to officially abandon the well. The Water Department still owns the property.

Facility: Depot Road **Evaluation Date:** 3/9/16
Address: Depot Street **Evaluation Time:** 11:00 AM

Install Year: *Number of Wells Served*:

Number of Pumps and Sizes:

175 gpm winter
300-350 summer

Description:

Pumps to Nutting Road WTP

Overall Condition:	Like New		Good		Fair		Poor		

Additional Condition Comments:

Observed Issues (corrosion, chemical spills, water leaks, water damage, cracked/broken seals, cracked concrete, potential sources of contamination, erosion or pitting):

The blue panels likely contain asbestos

Nearby trees are leaning over the buliding

Operational Parameters:

Well has a good volume

Operational Issues:

High iron concentrations

Permanent bypass for chloride reasons, which will allow this pump station to be back online

Typical Maintenance (pump station and wells):

Date Last Maintained:

1 to 2 years ago

Facility: Depot Road **Evaluation Date:** 3/9/16
Address: Depot Street **Evaluation Time:** 11:00 AM

Additional Pumps (Present Need):

Future Need:

Needed Capital Improvements:

The Town will be installing a propane generator by the end of 2016

Fix the leaking roof

Trim trees that threaten the building

Security and Access (any issues?):

Backup Power (any issues?):

Emergency Response (fail safes, equipment in place, means of alerting operators):

Additional Comments (issues, concerns, things to improve):

Recent electrical upgrades

The nearby water levels raise significantly, but the pump station has not flooded

Facility: Fletcher **Evaluation Date:** 3/9/16
Address: Concord Road **Evaluation Time:** 9:50 AM

Install Year: Late 1990s *Number of Wells Served*:

Number of Pumps and Sizes:

1 submersible pump

150 gpm winter
300 – 325 gpm summer

Description:

Water sent to Forge Village WTP

Overall Condition:	Like New		Good		Fair		Poor		

Additional Condition Comments:

Observed Issues (corrosion, chemical spills, water leaks, water damage, cracked/broken seals, cracked concrete, potential sources of contamination, erosion or pitting):

Catwalk between tanks has a broken section of flooring

Well paint is corroding/chipping

Vent caps rusty

Operational Parameters:

Operational Issues:

Iron/manganese water quality issues

Typical Maintenance (pump station and wells):

Generator is exercised every two weeks

Load tested every year

Date Last Maintained:

Facility:	Fletcher	**Evaluation Date:**	3/9/16
Address:	Concord Road	**Evaluation Time:**	9:50 AM

Additional Pumps (Present Need):

Future Need:

Needed Capital Improvements:

Need to decommission the unused tanks

The generator exhaust pipe outside of the building needs to be covered to avoid water entering the open-air pipe

Security and Access (any issues?):

Chain link fence with barbed wire

No security issues, but vandalism on the transformer box (not fenced in)

Backup Power (any issues?):

Emergency Response (fail safes, equipment in place, means of alerting operators):

Additional Comments (issues, concerns, things to improve):

Chemical treatment in place at the PS is not in use anymore because the water is now sent to the Forge Village WTP.

The building is now used only for water main piping and the generator.

The well is not fenced in, but MassDEP is aware and finds this acceptable. During the last inspection, MassDEP determined that the monitoring wells should be marked more clearly so they do not get damaged by a plow or other vehicle.

Facility: Forge Village 1 **Evaluation Date:** 3/9/16
Address: 65 Forge Village Road **Evaluation Time:** 8:30 AM

Install Year: *Number of Wells Served*:

Number of Pumps and Sizes:

1 Armstrong 4300 vertical in-line, 75 HP motor 90 – 120 gpm when running

1 vacuum pump

Description:

Tubular wellfield – permit allows only 5 in operation at one time

Water sent to Forge Village WTP

Overall Condition:	Like New		Good	X	Fair		Poor		

Additional Condition Comments:

Building is structurally sound, but the doors and windows are old

Observed Issues (corrosion, chemical spills, water leaks, water damage, cracked/broken seals, cracked concrete, potential sources of contamination, erosion or pitting):

Tank corroded

Operational Parameters:

Operational Issues:

Lack of control – the vacuum pump shuts down the pump at higher flows

Unknown which wells are active and being pumped

PS loses power routinely – only one generator for both Forge Village 1 and 2 – issue during power loss

Redundant water mains leaving PS (10” and 6”)

No standalone controls – fed from Forge Village 2 PS, there are only start/stop controls incoming, and flow and intrusion alarms outgoing

No pressure monitors

Typical Maintenance (pump station and wells):

Rubber membrane installed on roof recently

Date Last Maintained:

Nothing has been maintained in recent years

Facility:	Forge Village 1	**Evaluation Date:**	3/9/16
Address:	65 Forge Village Road	**Evaluation Time:**	8:30 AM

Additional Pumps (Present Need):

Future Need:

Needed Capital Improvements:

Replace corroded tank
Install generator
Rehabilitate one of the redundant water mains and abandon the other
Install standalone controls and a pressure monitor
Install new doors and windows

Security and Access (any issues?):

No fence or other security measure
Access road is in poor condition, but would be a large and expensive project to upgrade
Vandalism on roof

Backup Power (any issues?):

1 Marathon Electric engine, 75 HP
No backup generator

Emergency Response (fail safes, equipment in place, means of alerting operators):

Intrusion alarm
Pump fail alarm
No pressure feedback

Additional Comments (issues, concerns, things to improve):

There is a buried conduit or cable between Forge Village PS 1 and 2

Facility: Forge Village 2 **Evaluation Date:** 3/9/16
Address: 65 Forge Village Road **Evaluation Time:** 9:00 AM

Install Year: *Number of Wells Served*:

Number of Pumps and Sizes:
1 vertical shaft pump

Winter 220-230 gpm
Summer 350-375 gpm

Description:
Belowground discharge
Water sent to Forge Village WTP
Best producing wells for Forge Village WTP

Overall Condition:	Like New		Good		Fair		Poor		

Additional Condition Comments:

Observed Issues (corrosion, chemical spills, water leaks, water damage, cracked/broken seals, cracked concrete, potential sources of contamination, erosion or pitting):
Packing is leaking
Corrosion on pipes and floor
"Basement" of PS is wet and rusting; steel support beams are severely corroded

Operational Parameters:

Operational Issues:
PS loses power routinely – only one generator for both Forge Village 1 and 2 – issue during power loss

Typical Maintenance (pump station and wells):
Cleaned routinely

Date Last Maintained:
Chemical treatment approximately 3 years ago
Conventional treatment approximately 2 years ago

Facility: Forge Village 2 **Evaluation Date:** 3/9/16
Address: 65 Forge Village Road **Evaluation Time:** 9:00 AM

Additional Pumps (Present Need):

Future Need:

Needed Capital Improvements:

Fix or replace leaking packing

Replace corroded steel supports

Install generator

Security and Access (any issues?):

Chain link fence

Asphalt access road in OK condition

No security issues

Backup Power (any issues?):

1 Minneapolis-Moline auxiliary engine (not used)

Emergency Response (fail safes, equipment in place, means of alerting operators):

Pump failure alarm

Additional Comments (issues, concerns, things to improve):

There is an additional discharge in the “basement”

Facility: Howard Road **Evaluation Date:** 3/9/16
Address: 0 Howard Road **Evaluation Time:** 10:10 AM

Install Year:		*Number of Wells Served*:	7 active (8 total), run 5

Number of Pumps and Sizes:

1 can pump – vertical turbine	150 gpm winter
1 vacuum pump	230 – 235 summer

Description:

Overall Condition:	Like New		Good		Fair		Poor		

Additional Condition Comments:
Tank is in good condition

Observed Issues (corrosion, chemical spills, water leaks, water damage, cracked/broken seals, cracked concrete, potential sources of contamination, erosion or pitting):

Operational Parameters:

Operational Issues:

Typical Maintenance (pump station and wells):

Date Last Maintained:
Cleaned early March 2016 – pipe in good condition, pump was plugged
Pumps last cleaned ## years ago

Facility:	Howard Road	**Evaluation Date:**	3/9/16
Address:	0 Howard Road	**Evaluation Time:**	10:10 AM

Additional Pumps (Present Need):

Future Need:

Needed Capital Improvements:

Install generator (would have to renew/reroute natural gas line – might use propane instead)

Pump may need replacement

Security and Access (any issues?):

Chain link fence with barbed wire

No vandalism, but residents often walk through the site

Backup Power (any issues?):

None. Unless the power loss is more than a couple of days, the PS remains offline until the power returns. If the power loss is too long, action will be taken to return the PS to service.

Emergency Response (fail safes, equipment in place, means of alerting operators):

Power fail, intruder alarm, draw down, pump fail

Additional Comments (issues, concerns, things to improve):

Building painted within the past couple of years

Belowground KOH vault is out of service and filled

Facility: Nutting Road **Evaluation Date:** 3/9/16
Address: Nutting Road **Evaluation Time:** 11:15 AM

Install Year: *Number of Wells Served*:

Number of Pumps and Sizes:

100 gpm winter
250-300 gpm summer

Description:

Overall Condition:	Like New		Good		Fair		Poor		

Additional Condition Comments:

Observed Issues (corrosion, chemical spills, water leaks, water damage, cracked/broken seals, cracked concrete, potential sources of contamination, erosion or pitting):

Corrosion on pump support base

The roof leaks

Operational Parameters:

Operational Issues:

Typical Maintenance (pump station and wells):

Date Last Maintained:

The wells were maintained and the pump was replaced within the last 3 years

Facility: Nutting Road **Evaluation Date:** 3/9/16
Address: Nutting Road **Evaluation Time:** 11:15 AM

Additional Pumps (Present Need):

Future Need:

Needed Capital Improvements:

The roof is made of asbestos, and the vent pipe has an asbestos pipe around it. Replace the roof with asphalt shingles. This will also remedy the roof leaks.

Install a new light and lock for security reasons

Security and Access (any issues?):

Chain link fence

Backup Power (any issues?):

Emergency Response (fail safes, equipment in place, means of alerting operators):

Fully alarmed

Additional Comments (issues, concerns, things to improve):

The existing door to the pump station is not a standard size

Facility: Stepinski PS / Meter Building **Evaluation Date:** 3/9/16
Address: Off River Street / 31 Beacon Street **Evaluation Time:** 1:00 PM / 1:15 PM

Install Year: *Number of Wells Served*:

Number of Pumps and Sizes:

350 gpm winter

Description:

Water is pumped from the well on the south side of Stony Brook, under Stony Brook, and through the meter building on the north side of Stony Brook to the distribution system on Beacon Street.

Overall Condition:	Like New	X	Good		Fair		Poor		

Additional Condition Comments:

Both buildings are like new

Observed Issues (corrosion, chemical spills, water leaks, water damage, cracked/broken seals, cracked concrete, potential sources of contamination, erosion or pitting):

Operational Parameters:

Operational Issues:

Typical Maintenance (pump station and wells):

Date Last Maintained:

Facility:	Stepinski PS / Meter Building	**Evaluation Date:**	3/9/16
Address:	Off River Street / 31 Beacon Street	**Evaluation Time:**	1:00 PM / 1:15 PM

Additional Pumps (Present Need):

Future Need:

Needed Capital Improvements:

Security and Access (any issues?):

Monitoring building is enclosed by a chain link fence and barbed wire

PS building access road is long and gravel; vandalism

Backup Power (any issues?):

Generator

Emergency Response (fail safes, equipment in place, means of alerting operators):

Additional Comments (issues, concerns, things to improve):

Facility: Water Department Garage **Evaluation Date:** 3/9/16
Address: 65 Forge Village Road **Evaluation Time:** 9:10 AM

Year Constructed:

Description:

This pre-engineered building used to be the Water Department offices. When the new WTP was built across the street, the offices were moved to the WTP building. This building is now used as a location for vehicle storage, vehicle and equipment maintenance, water meter testing and rehabilitation, and materials storage (including spare pipes and parts; hydrants; gas, diesel, and waste oil; etc.). The facility has a tight tank for the sanitary facilities and floor drains which is pumped regularly. In the rear of the facility is a yard for materials storage as well as a building for cold storage (e.g., trailers, plows, water main fittings, and spare parts inventory). There is also a storage container used for the storage of hydrant extensions and other valuable equipment and parts.

Overall Condition:	Like New		Good		Fair		Poor		

Additional Condition Comments:

The garage roof leaks above the heater, and in other spots when there is heavy rain or snowmelt.

The cold storage building is in good condition, and experiences no leaks

Observed Issues (corrosion, chemical spills, water leaks, water damage, cracked/broken seals, cracked concrete, potential sources of contamination, erosion or pitting):

Holes were created in gutters in downspouts to relieve flow instead of replacing the gutters and downspouts

Organize all equipment and materials to decrease clutter

Recent Maintenance:

Most garage doors were replaced 3 years ago

All screws on the exterior of the building were tightened recently

Needed Capital Improvements:

Replace roof

Install security system

Open a section of the rear fence to provide immediate access to the areas behind the yard

Facility:	Water Department Garage	**Evaluation Date:**	3/9/16
Address:	65 Forge Village Road	**Evaluation Time:**	9:10 AM

Security and Access (any issues?):

The yard and cold storage building are enclosed by a chain link fence with barbed wire

There are no security alarms or cameras at this facility

Backup Power (any issues?):

There is a portable generator that can run the major lighting, garage doors, and heat

Additional Comments (issues, concerns, things to improve):

Facility: Francis Hill **Evaluation Date:** 3/9/16
Address: 25 Hunt Road **Evaluation Time:** 11:50 AM

Install Year: *Tank Size*: *Tank Style*:

Description:

Overall Condition:	Like New		Good		Fair		Poor		

Additional Condition Comments:

Observed Issues (corrosion, chemical spills, water leaks, water damage, cracked/broken seals, cracked concrete, potential sources of contamination, erosion or pitting):

Stained roof

Operational Parameters:

Operational Issues:

The WST experienced freezing this winter

Power loss is a common issue

Water Quality Issues:

Typical Maintenance:

Date Last Maintained:

Inspected recently, has not been cleaned recently

Facility:	Francis Hill	**Evaluation Date:**	3/9/16
Address:	25 Hunt Road	**Evaluation Time:**	11:50 AM

Additional Storage Tanks (Present Need):

Future Need:

Needed Capital Improvements:

Rehabilitate tank (cleaning, painting)

The discharge pipe needs to be cut and a flap added

The fall protection is not covered

Add a fence for security

Investigate permanent interconnection with Chelmsford water system on Spaulding Road

Raise PLC, which is currently below grade in a pit

Security and Access (any issues?):

The access road is gravel

There is no fence at this site. There are instances of vandalism on the WST.

Backup Power (any issues?):

Emergency Response (fail safes, equipment in place, means of alerting operators):

Water level controls

Additional Comments (issues, concerns, things to improve):

This WST used to operate the Nutting Road WST

Facility: Hildreth Hills **Evaluation Date:** 3/9/16
Address: Monadnock Drive **Evaluation Time:** 10:25 AM

Install Year: 1982 *Tank Size*: 2 MG *Tank Style*: Concrete reservoir

Description:

Partially buried concrete reservoir with domed roof

Building is used to monitor the tank level and as a sampling location

Winter turnover 12.5 to 14'

Summer turnover 14 to 16.5'

Overall Condition:	Like New		Good		Fair		Poor		

Additional Condition Comments:

Observed Issues (corrosion, chemical spills, water leaks, water damage, cracked/broken seals, cracked concrete, potential sources of contamination, erosion or pitting):

Stained roof

Building door are in OK/fair condition

Operational Parameters:

Hildreth Hills tank controls the Forge Village WTP

No mixing system

Operational Issues:

Tank is on a wet site

Water Quality Issues:

None

Typical Maintenance:

Tank cleaning, rehabilitation

Date Last Maintained:

Cleaned 12 inches of sediment out of the tank 1.5 to 2 years ago

Rehabilitated 1 year ago

A rubber membrane was added around the roof of the building 3 years ago

Facility:	Hildreth Hills	**Evaluation Date:**	3/9/16
Address:	Monadnock Drive	**Evaluation Time:**	10:25 AM

Additional Storage Tanks (Present Need):

Future Need:

Needed Capital Improvements:

May need mixing system to increase turnover – would likely need multiple systems due to the size of the tank

Security and Access (any issues?):

No fence or security around the storage tank; the building has a chain link fence with barbed wire

No issues

Backup Power (any issues?):

Emergency Response (fail safes, equipment in place, means of alerting operators):

Additional Comments (issues, concerns, things to improve):

If a monitoring station or booster pump station are added, the existing building on the site would be utilized

The Hildreth Hills booster pump station is privately owned – the association maintains it and is responsible for the hydrants, services, etc. after Westford's meter. The booster pump station has an emergency generator.

Facility: Nutting Road **Evaluation Date:** 3/9/16
Address: 19 Nutting Road **Evaluation Time:** 11:25 AM

Install Year:									
Description:									
Sources Treated:									
Overall Condition:	Like New		Good		Fair		Poor		
Additional Condition Comments:									
Observed Issues (corrosion, chemical spills, water leaks, water damage, cracked/broken seals, cracked concrete, potential sources of contamination, erosion or pitting): Concrete pad to the south of the WTP is experience cracking and staining. The pad was recently powerwashed.									
Operational Parameters:									
Operational Issues:									
Chemicals Used:									

Facility: Nutting Road **Evaluation Date:** 3/9/16
Address: 19 Nutting Road **Evaluation Time:** 11:25 AM

Water Quality Issues:

Additional Treatment (Present Need):

Future Need:

Needed Capital Improvements:

Recoat the concrete pad

Replace missing shingles around the vent stack

Security and Access (any issues?):

Backup Power (any issues?):

Emergency Response (fail safes, equipment in place, means of alerting operators):

Additional Comments:

The perchlorate treatment facility treats the raw water prior to the Nutting Road WTP intake.

Facility: Prospect Hill **Evaluation Date:** 3/9/16
Address: Main Street **Evaluation Time:** 12:15 PM

Install Year: *Tank Size*: *Tank Style*:

Description:

Overall Condition:	Like New		Good		Fair		Poor		

Additional Condition Comments:

Observed Issues (corrosion, chemical spills, water leaks, water damage, cracked/broken seals, cracked concrete, potential sources of contamination, erosion or pitting):

Corrosion at panel joints, bolts

Operational Parameters:

There are two water mains at the site (6” and 10”)

Operational Issues:

Water Quality Issues:

Typical Maintenance:

Date Last Maintained:

Recently inspected

Facility: Prospect Hill **Evaluation Date:** 3/9/16
Address: Main Street **Evaluation Time:** 12:15 PM

Additional Storage Tanks (Present Need):

Future Need:

Needed Capital Improvements:

The existing standpipe is to be replaced with a composite elevated storage tank (already planned)

Access road to be improved when the tank is replaced

May be able to reroute access road

Security and Access (any issues?):

Tank and telecommunications building enclosed by chain link fence with barbed wire

No parking area for unlocking the access gate – have to park on and cross a busy residential street

Backup Power (any issues?):

Emergency Response (fail safes, equipment in place, means of alerting operators):

Additional Comments (issues, concerns, things to improve):

AT&T, Fire Department, Police Department, and Water Department have active antennae on tank

Water Department gets $55,000 per year in rental income

Building owned and operated by AT&T

AT&T owns generator