Town of Framingham, MA
Department of Public Works

Draft
Water Distribution System
Master Plan

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Town of Framingham, Massachusetts
Water Master Plan
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1.1 Introduction

The Town of Framingham encompasses a total area of 26.44 square miles. With a recorded population of nearly 67,000 inhabitants, Framingham is the most populous town in the Commonwealth of Massachusetts.

Framingham's water distribution system is a large and complex system that services an estimated 15,600 homes and businesses. Its complexity is due to the existence of: five (5) different pressure zones; six (6) water tanks; seven (7) pump stations; four (4) MWRA aqueduct connections; and three (3) supply wells that are anticipated to be coming on-line in the future.

Such a large, complex water distribution system requires a Water Master Plan that will allow the town to:

1. Manage significant elements of the existing distribution system.
2. Project population growth and associated water demands.
3. Program for existing and future water supply requirements while maintaining water quality.
4. Utilize available technology such as the town's Geographical Information System (GIS) to optimize performance and maintenance of the water distribution system.
5. Determine the condition and capacity of representative water mains and flow distribution within the system.
6. Assess and maximize the capacity of the existing water distribution system including pump stations and storage facilities.
7. Recommend a program of improvements for pipes, pump stations and storage facilities to preserve or improve the efficiency and reliability of the present system.
8. Provide new pipes to improve potable water supplies and fire protection to existing and future customers.
9. Recommend the most economical and feasible means to meet future demand, and comply with current and future water supply, quality and system management regulations governing water supply, quality and system management.
10. Provide recommendations for system operation and maintenance.

This Executive Summary describes the background, development and recommendations included in this Water Master Plan.

1.2 Existing Distribution System

Drinking water is provided to the town by the Massachusetts Water Resources Authority (MWRA) from 4 locations via aqueducts. The water is distributed to the town's residential and commercial accounts through a network of 280 miles of water mains and 90 miles of service laterals. Those customers are protected through 2,180 hydrants connected to the water system by 70 miles of hydrant laterals. Five (5) emergency water connections are available from surrounding towns. The town is not required to provide any type of treatment for their drinking water.

The water distribution system is broken down into 5 pressure zones which are served by the 6 water storage tanks and 7 pump stations in the following arrangement:

Zone Name	Area Served	Water Tanks	Pump Stations	Zone Storage
Town	Majority of Town	Indian Head Merriam Hill	Edgell Road Pleasant St. Elm St.	7.0 MG
Beebe	Northwest Corner	Beebe Steel Beebe Concrete	Grove St.	1.3 MG
Goodnow	Southwest Corner	Goodnow	Goodnow	0.3 MG
Doeskin Hill	Doeskin Hill Area	Doeskin Hill	Doeskin Hill	0.2 MG
Wm. J. Heights	Wm. J. Heights	None	Wm. J. Heights	0.0 MG

In addition to these sources of service pressure, the town plans to bring the Birch Road Well Field on-line in 2011 which will reduce the demand for water from the MWRA by approximately 45 %.

The town is maintaining the integrity of its water distribution system through on-going leak detection and cross connection protection programs.

1.3 Population Projections and Water Demand

The registered population of Framingham has remained relatively "flat" for the last 20 years at approximately 66,910 (Year 2000), with possibly another 3,350 undocumented residents. Based on past population surveys and state demographic analyses, this population will probably grow by approximately 7% to 75,691 residents by 2025.

Water demand has averaged 7.5 million gallons per day (MGD), of which 77.1% is domestic, 14.7% non-domestic, and 8.2% unaccounted for (fire flows, hydrant flushing, leaks and water meter slippage). Based upon the latest population projections, future water demand in 2025 will be approximately 8.2 MGD. Since development in Framingham is almost exclusively for residential occupancy, the maximum water demand will probably not exceed 8.4 MGD.

1.4 Water Supply and Conservation

Water supply comes from 4 connections into the MetroWest Tunnel and Hultman Aqueduct with the Sudbury Aqueduct available as an emergency supply. This supply will be supplemented with flows from the three new pumps in the reactivated Birch Road Well Field in 2011.

Peak demand was 12.94 MGD in 2002 and 11.58 MGD in 2003. The town's Water Conservation Plan includes a leak detection program that, to date, has found 0.66 MGD of water leaks, all of which were repaired. Also, 100% of all services are metered, with most meters less than 10 years old. Older meters will be replaced as funding is made available.

1.5 Water Quality and Sampling Procedures

Framingham conducts ongoing tests of the water supply for: bacteria; lead and other heavy metals; herbicides and pesticides; industrial solvents; and annually for asbestos. The MWRA maintains water quality through ozone disinfection plus the injection of chloramines into the water, the addition of sodium bicarbonate for pH control, and fluoridation.

Samples are taken 80 times per month for coliform, chlorine residuals and free chlorine. Weekly sampling is taken for total chlorine as well as free chlorine, background bacteria, pH, temperature, total trihalomethanes and haloacetic acid.

The town produces a Consumer Confidence Report annually on the quality of their drinking water. The MWRA also produces a drinking water quality Annual Report which it sends to every one of its customers.

1.6 Water Distribution System GIS

Since 2003, BETA has been collecting water system data for inclusion in the Town's GIS program as well as for water system mapping for a town-wide water distribution model. Using a Global Positioning System (GPS) unit, BETA located hydrants, gate valves and other system elements for inclusion in the GIS. BETA also obtained record information including schematic maps, record plans, water service connection cards and water tank maintenance records. From this information, BETA created a geometric water system supply network map which includes a computerized database listing attributes for each water system element (i.e., pipes, service pipe ends, crossings, valves, hydrants, laterals, etc.).

The town now has a benchmark on accessing the locations, types, age, condition, operating characteristics and maintenance history of many elements of their water distribution system. Eventually, the town's GIS Department will be able to monitor and manage all water system data and to incorporate updates to that database as new projects enter the system.

1.7 System Operation and Maintenance

The Water Master Plan recommends comprehensive operation and maintenance programs for all elements of its water system. These programs includes:

1. Regular inspection, maintenance and upgrading of the 7 Town pump stations and 6 water storage tanks.
2. Water main maintenance and disinfection thorough an on-going Unidirectional Flushing Program.

3. Replacement/rehabilitation of lined and/or tuberculated water mains.
4. Regular inspection, testing and maintenance of all valves and hydrants as well as replacement of any valve or hydrant that fails to function properly.
5. Replacement of any remaining lead service connections whenever they are discovered.
6. Evaluation of service reliability, redundancy and vulnerabilities to provide for appropriate system responses during emergencies.
7. Continue investigations and follow-up work for leak detection, meter upgrades/replacement and cross-connection protection programs.

1.8 Current and Future Drinking Water Regulations

A number of existing and new regulations are going to require specific water quality maintenance procedures and programs, system testing, and regulatory reporting by Framingham. Some of the new regulations are currently in draft form and will be promulgated after the public comment periods have ended. However, the priority and focus for the existing and new regulations will be on:

1. Controlling disinfection byproducts (DBP's).
2. Implementation of the Long Term 2 Enhanced Surface Water Treatment Rule (LT2).
3. Protection from radionuclides.
4. Implementation of the new Ground Water Rule (GWR) to protect water supplies.
5. Monitoring the contaminant MTBE in drinking water.
6. Controlling the incidence of perchlorate and sulfates in drinking water.

1.9 Security

The Public Health and Bioterrorism Preparedness and Response Act of 2002 mandated that Framingham prepare a Vulnerability Assessment, Consequences Assessment, Risk Analysis, and Emergency Response Plan to determine water system vulnerabilities, threat response and system protection measures. The town has completed these documents and is implementing the required systems to protect its water distribution system. The specifics of each of the listed documents, and the systems being installed, must be kept confidential for security reasons and thus are not included in this Executive Summary.

1.10 Distribution System Analysis

Water System Model Development

To evaluate the distribution system, a computerized water system model was created to simulate and assess steady state and extended flow conditions. Simulations were based on existing and projected flow conditions during average and maximum demand days. The model was run using the current operating conditions and did not include the future Birch Road wells.

According to AWWA standards, the system is considered adequate if a minimum pressure of 35 psi is provided to all areas during peak hours. During a "maximum'' day when water is used for fire fighting, the system is considered adequate if a minimum pressure of 20 psi exists at the fire location and a minimum pressure of 30 psi is provided at all other locations in the system. These operating conditions were used as the basis for the analysis and formulation of recommendations in this section.

Field testing, consisting of hydrant flow test and pipe conditions tests, is an important part of a water distribution system analysis. Results from the field tests are compared to results obtained from the model, and the model is then calibrated to reflect actual field conditions.

Fire flow and pipe conditions tests began in a pilot area in the southern part of town on April 21, 2004. A town-wide Fire Flow and Pipe Conditions Testing Program was conducted in October 2004 to provide up-to-date information and calibrate the water model.

GIS Mapping Input for the Model

Framingham's water distribution system model was created from a combination of GIS mapping, town sources, recent construction projects and prior studies. Shapefiles and attribute data were imported from the town's GIS mapping into Haestad Methods WaterGEMS® Version 2.0 water modeling software.

Pipe sizes and materials were imported directly from GIS information. Flow control valves were inserted into the model to separate the pressure zones and limit flow of their pumps to their capacities. Estimated water usage was assigned to each individual developed parcel based on zoning and tax records. A diurnal curve was developed for residential demand to approximate daily use in extended period model simulation.

Flow Data Development

Based on Framingham's pump station flow data, an average day demand and a maximum day demand were calculated. To determine the month in which maximum use was recorded, monthly pumping totals from each MWRA-connected pump station for five years were entered into a spreadsheet and daily volumes of pumped water were totaled. From this data, the highest daily total volume of water was found to be 12.94 million gallons on August 13, 2002. This figure was used as the maximum day demand. The average daily use was 7.5 MGD as determined from the average day of the average month. These numbers were entered into the model and used to adjust flow demands throughout the system.

Model Calibration

The first step in the model calibration process involved comparing static pressure readings from field tests against the model data. The second calibration step adjusts

Hazen-Williams C-Factors (friction factors) of various pipes in the model using data from the Fire Flow and Pipe Conditions Testing Program. After the remaining C-Factors were adjusted, fire flow data was used to calibrate the system to match available fire flows at 20 psi.

The final calibration step included extended period scenario runs to show pumping and storage patterns throughout the town over a period of time. After averages were compared to output from the model, adjustments were made to match historical data.

During this process, a number of situations were encountered when field data could not be matched to the modeled data. Unresolved issues should be investigated to find the exact problem.

Water Age Analysis

Water age in a distribution system is an important factor in determining the effectiveness of disinfectants as well as their potential for generating byproducts. This type of analysis was performed using the water model. An extended period scenario was run to determine the water age in all water mains at specific times.

Chloramine Residuals Analysis

An analysis similar to the water age analysis can be done for chloramine residuals. Chloramine residuals throughout town can be estimated using the model. The Town receives chloramine residuals at concentrations ranging from 2.0 to 2.3 mg/l with 0.2 to 0.9 mg/l of free chlorine from the MWRA MetroWest Tunnel. In the model, chloramines enter the system at the reservoirs which are connected to the Aqueduct by the pump stations. The chloramines residuals are assessed a decay rate. The model then calculates what Town areas lack adequate chloramine residuals. These results can also be used to estimate the formation of disinfection byproducts based on the age of water throughout the system.

Fire Flow Requirements

Maximum day fire flow results indicate there are a few areas where the water system can not safely supply 1,000 gpm (gallons-per-minute) for fire protection. However, it should be noted that the William J. Heights area will be receiving a new booster station with a high service pump. "The Mountain" and Staples Road areas both have private fire pumps.

Storage Tank and Pump Station Adequacy Evaluation

Water levels in the storage tanks were analyzed for an average day scenario and a maximum day scenario over a one month period. This analysis was made to determine if storage quantities and pump station capacities are adequate. The analysis revealed that the Beebe tanks never completely fill during a maximum-day scenario.

Pump station flows were analyzed to determine the adequacy of the pumps in each station to meet all flow conditions and pump efficiency. It is important to note that in the Grove Street pump station contains only two pumps of which one pump runs continuously for about 50 hours at the average day demand level. One pump runs constantly and the lag pump runs for 20 hour periods during the maximum day demand level.

Storage analysis of the Beebe System indicates the existing tanks are adequate for the current population. Allowance for additional development depends on Fire Department requirements. Using a standard fire protection requirement of 1,500 gpm for a two-hour period, an additional 508 homes (total of 1,400 homes) can be safely added to the system. If a higher fire protection supply demand is required, such as 1,500 gpm for a four-hour period, an additional 283 homes (total of 1,180 homes) can be added to the system before storage becomes inadequate.

Analysis of the Goodnow system indicates that the existing tank has an adequate capacity for the current population. Using a standard fire protection requirement of 1,500 gpm for a two-hour hour period, 12 more homes (total of 250 homes) can be safely added to the system. If a greater fire protection supply demand is required, such as 1,500 gpm for a four-hour period, no more homes should be added to the system.

Storage analysis of the Doeskin Hill system indicates the existing tank is adequate for the current population. Using a fire protection requirement of 1,000 gpm for a two-hour period (due to the large spacing between houses), an additional 32 homes (for a total of 85 homes) can be safely added to the system. It should be noted that several of these additional homes are either under construction or have been recently completed. If greater fire protection supply demand is required, no more homes should be added to the system.

Storage analysis of the Town Zone is complicated due to the number of supply sources. Currently, the total approximate average day demand of 7.0 MGD equals the total storage of the zone. Typical total storage calculations, such as fire protection of 3,000 gpm for a five-hour period (for industrial/commercial fire protection demands), would yield a storage requirement of 10.8 million gallons. Since there are three independent pump stations feeding the system, fire requirements can be directly supplemented by the pump stations and emergency storage which could be reduced from a full day storage to a half-day storage. The existing storage would be adequate based on an equalization requirement of 3.07 million gallons and a reduced emergency storage of 3.5 million gallons. This assumption would mean the pump stations must be capable of pumping a combined 13 MGD at all times which is possible with only two stations on line.

The existing pump station capacities are adequate for system supply with the exception of the Grove Street pump station. The three pump stations supplying the Town Zone have adequate capacity and redundancy for future development through the next 20 years. In the near future, it is expected they will be supplemented by the Birch Road wells. In an emergency, engine driven pumps would provide enough pumping capacity during a town-wide power failure.

The Grove Street pump station does not have adequate capacity to safely supply the Beebe and Doeskin systems. In the event of an extended power outage in the summer months, the station will not be able to keep up with demand. It would also take several days for the system to fully recover from a lengthy fire demand, significant pipe break or an extended pump outage.

1.11 Distribution System Improvement Recommendations

Distribution system improvement recommendations are prioritized and intended to be completed over a 20-year period Recommendations presented are based on system observations, record information, DPW input, and the results of the analysis performed using the computerized hydraulic model of Framingham's water distribution system. The system was analyzed to determine its ability to provide sufficient fire flow, pressure, and water quality to all areas of the town. The reliability and ages of the system's individual components were also considered in the analysis.

Recommended improvements should be combined with sewer, road and drainage projects when applicable to reduce costs. At the time of completion of this Water Master Plan, the master plans for sewer, drainage and road work were not available. Therefore, it is difficult to accurately project the costs and schedule for all water-related work out to 20 years without knowing if the work will be a small or significant component of construction contracts for other municipal infrastructure work. However, the projected costs for all water system work were provided for the first 6 fiscal years since it is possible to project where other infrastructure work will be done in that time period. Costs for improvements are in today's dollars.

Costs for water system improvements, exclusive of water storage tank and pump station improvements, is approximately $58 million over 20 years, or approximately $3 million per year. Combined with the water storage tank and pump station improvements, projected CIP costs would be as follows:

Year	Total Capital Improvement Costs
2007	$2,425,000
2008	4,720,000
2009	3,420,000
2010	6,650,000
2011	6,685,000
2012	5,410,000
2013 – 2026	$3,000,000 per year

Excluded from these capital costs are any costs associated with reactivation of the Birch Road Well Field which the Town of Framingham is addressing independently of this Water Master Plan.

The specific improvements recommended in this Water Master Plan are listed in the following subsections.

Pipe Improvements

Pipe improvement recommendations are:

1. Older, damaged or malfunctioning hydrants (such as Corey, Rensellear, or Darling hydrants installed prior to approximately 1950) should be replaced with new, more reliable models. A hydrant replacement program will provide better, more reliable fire protection and reduce hydrant maintenance costs.
2. Old iron or lead services should be replaced to reduce water loss, improve customer service and water quality, and reduce maintenance.
3. Closed gate valves (except division gates) should be opened and old or broken gate valves should be replaced. This will improve flow and circulation, eliminate dead ends, possibly decrease consumption of disinfectants, and provide better and more efficient main shutdowns in case of emergencies or for construction purposes.
4. Major pipe loop deficiencies should be corrected by connecting dead ends, thereby improving water flow, circulation, and possibly decreasing consumption of chloramines.
5. Water main deficiencies should be corrected by either cleaning and lining or replacing tuberculated pipes to improve water flow, circulation, and possibly decrease the consumption of chloramines.
6. Unnecessary secondary mains should be removed and services and hydrants should be connected to larger diameter mains where applicable. These improvements will simplify the system configuration, provide less head loss due to crossovers, decrease "bottlenecks" at pipe intersections, and provide better fire protection (i.e. - less confusion on which hydrant is tied to the larger of the two mains on a given road).
7. Transmission lines should be kept in good condition to distribute water quickly and efficiently throughout the system.
8. Replace all 6-inch mains with a minimum of 8-inch mains to meet current AWWA standards.
9. The Town's ultimate goal is to eventually replace all asbestos cement pipes to eliminate potential asbestos contamination and reduce potential pipe breaks.
10. Use and update the water distribution system model to keep up with changes in the system.

System improvements are allocated one of three priority levels, the highest priority assessed to the more critical mains in the system.

Unidirectional Flushing Program

A unidirectional flushing program is highly recommended for Framingham. A unidirectional flushing program is a more effective version of a traditional flushing program. Closing valves to direct flushing water in one direction maximizes the velocity in the pipes. Unidirectional flushing is desirable despite the additional labor because it uses less water, generates higher cleaning velocities and provides the opportunity to test distribution valves and hydrants. Flushing should always begin at the source or at a tank and work outwards to ensure that mains are being flushed with clean water.

Due to the relatively large size of the system, the program should be broken up into approximately 4 or 5 sections of Town, each section to be completely flushed once per year on a rotating schedule. Provisions should be made for dealing with inevitable valve and hydrant failures as well as potential pipe breaks and dirty water stirred up by the program.

Pump Station Improvements

Pump station electronics should be replaced for all the pump stations except Doeskin Hill and William J. Heights. All fuel-driven engines should be removed and replaced with electric generators complete with automatic transfer switches. This will provide the Town with updated technology, more efficient control of the pump stations, and standardized pump controls throughout the system. The existing pump sizes have enough capacity to supply the Town adequately for the next 20 years with the exception of the Grove Street pumps.

The Grove Street Pump Station needs larger pumps to fill the Beebe tanks quicker and more efficiently. Currently, the existing pumps cannot maintain adequate water levels in the tanks. The pumps are only able to meet demand instead of filling the tanks. Fire simulations in this pressure zone show that the tanks would take almost 2 days to refill with both pumps running.

Storage Tank Improvements

Installation of a tank mixing system is recommended for each tank to improve mixing and to help prevent sediment buildup. A routine inspection program should also be instituted as part of a preventative maintenance program. One possible plan would be to inspect at least one tank every year, thereby allowing each tank to be inspected at least every 5 years.

All water storage tanks, excluding the new Doeskin Hill Tank, were recently inspected. Each tank's interior and exterior conditions were evaluated and recorded in reports through photos and notes. Water storage tanks were cleaned of sediment buildup in April 2006. The following paragraphs summarize findings of those inspection reports and include an evaluation of the adequacy of each tank for future fire flow and domestic demand. The tank rehabilitation recommendations and a prioritized list of improvements, are as follows:

Goodnow Tank (300,000 Gallon Welded Steel Elevated Tank)

Physical Condition

The tank is structurally sound. Exterior surfaces are almost completely uncoated and there is moderate corrosion on all surfaces. A majority of the interior surfaces have a coating system exhibiting some blistering, rust staining, and surface corrosion in some areas. There is adhesion failure throughout the tank. It is strongly recommended that the exterior have a new coating system applied to all surfaces in the immediate future.

Capacity

The existing tank is adequate for the current population. An additional 12 homes (total of 250 homes) can be safely added to the system depending on Fire Department requirements.

Beebe Tanks (300,000 Gallon Riveted Steel Tank and 1-Million Gallon Concrete Tank)

Physical Conditions

The 300,000 gallon riveted steel tank is structurally sound. The exterior surfaces exhibit mild corrosion, some vegetation growth, moderate mildew accumulation, and a great deal of graffiti. The finial ball vent is missing screens and there is a 1 inch hole in the screen at the bottom of the overflow pipe. The interior surfaces have coating failure where corrosion, blistering, and pitting can be seen. There is also adhesion loss in some areas.

It is recommended that both the interior and exterior have a new coating system applied to all surfaces. It is also recommended that the screen at the bottom of the overflow pipe be replaced and screening be installed on the finial ball vent.

The 1-million gallon concrete tank is also structurally sound. The exterior surfaces have nonstructural shrinkage cracks in the shotcrete coating but no voids were found. Efflorescence has formed in some of the cracks and there is also some mildew accumulation. Some of the roof panel joints were found to have some spalling of the grout between them. The interior has a small band of light nonstructural 1/8 inch deep scouring around the circumference of the tank.

It is recommended that the spalled grout in the panel joints be replaced.

Capacities

The existing tanks are adequate for the current population. Allowance for additional development depends on Fire Department requirements. Between 283 and 508 (1,180 to 1,400 total) homes can be safely added to the system depending on Fire Department requirements.

Town Zone Tanks (Indian Head 3.5-Million Gallon Welded Steel Tank and Merriam Hill 3.5-Million Gallon Welded Steel Tank)

Physical Conditions

The Indian Head welded steel tank is structurally sound. The exterior surfaces are chalky and weathered with a moderate mildew accumulation but good adhesion of the coating system. The roof has coating failure where the secondary coating is peeling and some surface corrosion can be seen. A 2-inch diameter plug in a roof panel is missing and the screen at the bottom of the overflow pipe has been dislodged. There is heavy corrosion on the vent riser tube and also steel fatigue. The screen on the vent has also been dislodged, creating a 1 inch gap. The interior surfaces have light staining, coating failure, and adhesion failure where blistering and corrosion can be seen.

It is recommended that the 2-inch diameter plug from the roof panel be replaced, and the screen at the bottom of the overflow pipe be replaced. It is also recommended that both interior and exterior receive a new coating system on all surfaces.

The Merriam Hill welded steel tank is structurally sound. The exterior surfaces have very good coating adhesion with some chips creating surface corrosion. There is some mildew accumulation and graffiti on the lower portion. The secondary coating system on the ladder and cage is failing, exposing the primer. The roof has a great deal of coating system failure where cracking and blotch rusting can be seen. A good deal of the coating system is failing on the vent creating corrosion. The interior surfaces have very good coating adhesion, some staining, and there is some corrosion on the manway and some overhead.

It is recommended that both interior and exterior receive a new coating system on all surfaces.

Capacities

Storage analysis of the Town Zone tanks is complicated due to the number of supply sources. Currently, the total Town Zone approximate average day demand of 7.0 MGD equals the total storage of the Zone. The existing storage volume is adequate as long as a minimum of two of the three pump stations can be immediately activated at all times to provide fire flow. Although not necessary at this time, consideration should be given to constructing an additional tanks with a storage capacity of 2 million gallons to reduce pump station dependency and reduce operating costs.

Doeskin Hill Tank (Doeskin Hill 0.2-Million Gallon Bolted Glass Lined Steel Tank)

Physical Condition

The tank was activated in March of 2005 and is in excellent condition. Standard, routine inspection and maintenance are required for this tank.

Capacity

The existing tank is adequate for the current population. Allowance for additional development depends on Fire Department requirements. An additional 32 homes (total of 85 homes) can be safely added to the system. Please note that several of these additional homes are either under construction or have been recently completed.

Recommended Tank Coating

Steel tanks requiring coating will first need the current coating system tested for the presence of heavy metals to determine if the sandblast waste would be hazardous. The tanks should then be drained and, if necessary, cleaned with a detergent. Sharp welds and edges should be rounded off prior to sandblasting. After this, the interior and exterior will be patched or filled where needed. Interior and exterior coatings should then be applied, tested and inspected. After the tank has cured it will be flushed and disinfected. It is recommended that an AWWA-compliant epoxy be used for the interior coating of the tank. Likewise, for the exterior of the tank it is recommended that an AWWA-compliant epoxy with a polyurethane topcoat be used. In all cases, each tank must be taken off-line for the duration of the rehabilitation.

Supply Improvements

The activation of the Birch Road Wells in the Saxonville area will provide the town with additional water and may lower costs since the town will be drawing less water from the MWRA-owned MetroWest Tunnel. One concern associated with introducing the well water into the system would be the blending of well water with MWRA water since each source has a different pH. Either the well water will need to be pH adjusted to match the MWRA water or the MWRA water will need to be pH adjusted to match the well water. Or both could be pH-adjusted to match each other. Calcium, iron and manganese precipitation has been experienced in other communities that have attempted to blend surface and groundwater supplies. The current MWRA agreement will not allow for sufficient supply in 2011 if the wells are not activated. Initial planning steps are currently being taken by the town's DPW to bring the wells on-line.

Operational Improvements

The storage tanks should be operated with more variation in water depth and a mixing system to improve water quality and rapid pump cycling, which will also reduce maintenance requirements and wear on the pumps. A unidirectional flushing program should be performed throughout Town to clear loose materials buildup in water mains and also help to find closed or broken valves. Pressure reducing valves should be installed to replace some division gates between higher and lower pressure zones. At a minimum, the division gates should be marked or locked out to prevent accidental operation. Pipe connections from the pump stations to the tanks in the Town Zone should be improved to quicken filling times.

Maintenance operations, especially pipes and gate valves, should be tracked and entered in the GIS system. This will create a service history and allow patterns of deficiency to be more easily detected. Gate valves and pipe configurations discovered in the field should be noted and GPS-located in an effort to further refine the system map and its associated data.

The leak detection program should be continued every other year to monitor the system for leakage. Also, the Water Conservation Plan enacted in 2004 should be enforced.

Security Improvements

A Vulnerability Assessment was prepared for Framingham's water system in December of 2003. It was determined that the most vulnerable assets were the Town's water tanks and pump stations (not including the booster pump at William J. Heights).

The Town has implemented a number of detect-and-delay measures employed at each of the vulnerable asset locations which are intended to raise the effectiveness ratings on the Town's vulnerable assets. These improvements would raise the effectiveness ratings on the Town's vulnerable assets. As stated previously, due to the sensitive nature of the those measures, they have not been included in this Executive Summary and are instead listed in the main text of the Water Master Plan.

Section 2 - Introduction

2.1 General

This report is an analysis of the water distribution system for the Town of Framingham. The report's goal is to provide the Framingham Department of Public Works with an interactive and diagnostic tool to facilitate comprehensive strategic planning of the water system. It is designed to help department officials assess system weaknesses and determine future improvements that are necessary to maintain high quality and secure water service throughout the Town. A 20-year Capital Improvement Plan (CIP) was developed as part of this report to provide a logical approach for distribution system upgrades.

2.2 Study Area

The study area for this investigation encompasses all of the Town of Framingham, representing a total area of 26.44 square miles. Framingham is a diverse community in eastern Massachusetts, located 20 miles west of Boston. With a recorded population of nearly 67,000 known inhabitants, Framingham is the most populous Town in the Commonwealth of Massachusetts. It is bordered by Southborough and Marlborough to the west; Sherborn and Ashland to the south; Natick to the east, Wayland to the northeast; and Sudbury to the north.

2.3 Previous Reports

Framingham's last water master plan was developed 37 years ago in a report by Metcalf and Eddy, Inc. (M&E). The report was titled "Master Plan for Improvements to the Water Supply and Distribution Facilities" and was dated February 23, 1968. The M&E master plan recommended a program of improvements to optimize use of the water facilities.

In May 1978, Whitman & Howard Inc., released an additional study titled "Report Relative to the Water System Analysis Framingham, Massachusetts". This study recommended improvements to the water system to mitigate existing problems and provide adequate supply through the year 2000. Many improvements from both of these reports have been incorporated into the Town's current water facilities.

2.4 Scope of Master Plan

This report addresses the following subjects related to Framingham's water distribution system:

1. Summary of significant elements of the existing distribution system.
2. Projected population growth and associated water demands.
3. Existing and future water supply.
4. Water quality.

5. Use of the Town's Geographical Information System (GIS) to optimize performance and maintenance of the water distribution system.
6. A program for water distribution system hydraulic measurements to determine the condition and capacity of representative water mains and flow distribution within the system.
7. Capacity of the existing water distribution system including pump stations and storage facilities.
8. Development of a computer model of the system.
9. Recommendations for a program of improvements. Consisting of:
    a. Upgrading of pipes, pump stations and storage facilities to preserve or improve the efficiency and reliability of the present system.
    b. Reinforcing the existing system with new pipes to improve service to customers.
    c. Phased improvements to expand service to new areas of demand.
    d. Improvements to ensure adequate fire flows.
    e. Recommendation of the most economical and feasible means to meet future demand.
10. Current and future regulations governing water supply, quality and system management.
11. Operation and maintenance recommendations.

Section 3 – Existing Distribution System

3.1 General

The Framingham water distribution system provides nearly all of its residents with clean, potable water. Approximately 7.5 million gallons of water flow through the system on an average day. The distribution system is operated by the Department of Public Works (DPW). **Table 3-1** provides details for the overall system.

Table 3-1
Water System Profile

Element	Approximate Quantity
Water Mains	280 miles
Service Laterals	90 miles
Main Line Valves	4,150
Storage Tanks	6
Total Storage	8.8 Million Gallons
Pump Stations	7
Hydrants	2,180
Hydrant Laterals	70 miles
Hydrant Valves	2,180
Service Accounts Linked (in GIS)	15,655
Service Account Records (Total)	17,447

3.2 System History

Construction of Framingham's water system began in 1884 by the Framingham Water Company. The initial system included: a large dug well and pump station on Farm Pond at Linden Street; a piping system to downtown Framingham; and the Normal Hill standpipe. The system was supplied by Farm Pond and the Sudbury Aqueduct. The town purchased the system in 1906 and continued to expand it throughout Framingham Center and Saxonville. The Linden Street pump station was abandoned in 1940 following activation of the Birch Road Wells. The Normal Hill standpipe was demolished around 1970.

Three (3) gravel packed wells were installed off of Birch Road in 1939. The wells had a total combined safe yield of 2.5 MGD at that time. Each well has a 75-hp vertical turbine pump rated for 1 MGD. The wells were deactivated in the mid-1980's in favor of purchasing water from the Metropolitan District Commission (MDC, which is now the Massachusetts Water Resources Authority (MWRA)) water supply system. At that time, water from the MDC supply was less expensive and the wells were shut off and abandoned.

Town service pump stations drawing from the MWRA system were constructed from 1950 to 1962 and serve a majority of the town. The high service pump station was constructed on Grove Street in 1968.

3.3 Pipes and Appurtenances

A Geographic Information System (GIS) was developed in conjunction with this report. Visible gate valves and hydrants were located using a Geographic Positioning System (GPS) device and entered into the GIS mapping and database. The system map was constructed using these points as well as the town's gate valve records, existing system mapping, and information gathered from Water Department staff. An overall water system map can be found in **Appendix A**.

3.3.1 Water Mains

Water mains range in diameter from 4 inches through 24 inches. Pipes installed prior to 1928 are typically unlined cast iron. Some of these mains have been replaced and others have been rehabilitated by in-place cement lining. Pipes installed from 1929 to 1975 are typically either asbestos cement or cement lined cast iron. Pipes installed after 1975 are typically cement lined ductile iron.

Most unlined cast iron pipes in town that have not been rehabilitated are severely tuberculated. "C" factor (coefficient of internal pipe friction) testing was conducted in many areas throughout the town in October of 2004 and the results are discussed in **Section 11.3**. Unlined cast iron mains that have been rehabilitated with cement lining are listed in **Table 3-2**.

Table 3-2
Cast Iron Pipe Rehabilitated with In-Place Cement Lining (Thru 2006)

Hollis Street	Store 24 to Ashland Line
Bethany Road	Winthrop St. to Ashland Line
Millwood Street	Belknap Rd. to Winch St.
Winch Street	Millwood St. to Grove St.
Warren Road	Oaks Rd. to Shawmut Ter.
Salem End Road	Winter St. to MDC Bridge
Salem End Road	Badger Rd. to Lantern Rd.
Grove Street	Belknap Rd. to Edmands Rd.
Edmands Road	Garvey Rd. to Edgell Rd.
Edmands Road	Beebe Tank Easement to Grove St.

3.3.2 Hydrants and Gate Valves

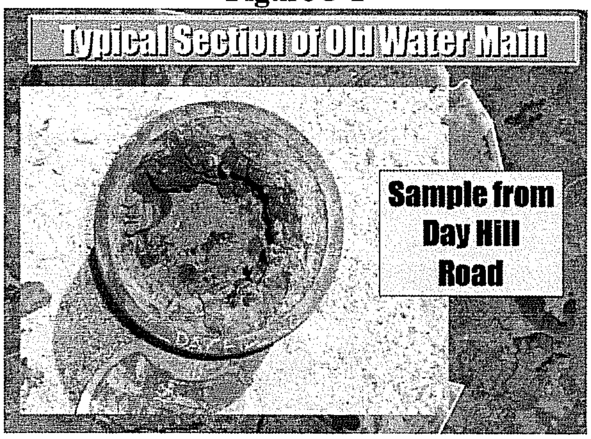
Hydrant and gate valve manufacturers vary widely throughout town. Older hydrants are generally Corey, Rensellear or Darling. Newer hydrants are generally Mueller, Kennedy or American Darling. The gate valve manufacturers are unknown. Almost every hydrant and gate valve opens counterclockwise or "left" but there are a few exceptions.

3.3.3 Tuberculation

Tuberculation is a buildup of iron oxide due to chemical reaction with the water inside an unlined cast iron water main. Pipes with tuberculation restrict flow by reducing the effective inside diameter of the pipe. Restricted flow will impact the ability to meet high demand conditions and fire flows.

Tuberculation promotes the growth of biofilm within its pore like structure reducing water quality and free chlorine. Tuberculation is also a major source of brown or rusty water during periods of high use and hydrant flushing. A pipe coupon photograph of a typical tuberculated main is shown in **Figure 3-1**.

Figure 3-1



3.3.4 Closed Valves

During the hydrant flow and pipe condition testing program conducted in October of 2004 several valves were discovered closed. Valves are typically left closed either accidentally (forgetting to re-open) or they break in the closed position. Closed valves create unnecessary dead ends in the system and create the potential for poor water quality by eliminating looping. Closed valves can also significantly reduce fire flow. All of the valves found closed (that were not broken) during the hydrant testing program were opened.

3.3.5 Valve Maintenance

A valve exercise program has not been practiced in past years. The DPW has been considering beginning a program and has just purchased an automatic valve turner for this purpose. Recommendations from this report and available funding will be considered prior to beginning a program.

3.3.6 System Flushing

A system flushing program has not been practiced with regularity. Chronic difficulties with rusty water and a lack of manpower have hampered these efforts. A unidirectional flushing program is recommended and is currently being designed in select areas.

3.3.7 Services

Service pipe materials and sizes vary widely. The majority of domestic services for residential homes and businesses are between ¾-inch and 2 inches in diameter. Numerous 4 –inch and larger services exist to provide fire protection, domestic water or both to larger buildings and institutions.

Older distribution system domestic services are either entirely lead services or unlined steel services with a lead gooseneck. Many newer services in town are polyethylene (plastic) or copper. Currently, all new services installed are copper with a minimum diameter of 1-inch unless soil conditions are corrosive, whereby plastic services are provided. Residents and businesses own and maintain their service from the property line to the house. The town owns and maintains services from the main to the property line.

3.4 Storage Tanks

In November of 2004, Underwater Solutions Inc. conducted detailed internal and external inspections of all water storage tanks in the Town of Framingham excluding the Doeskin Hill Tank, which is new. The goal was to report on the overall condition of these structures and recommend necessary repairs. The town is not aware of the last time that many of the tanks were inspected. **Table 3-3** lists key structural and capacity data for each tank. Pump, Tank and Zone locations can be seen in **Figure 3-2**. Exterior photographs of each tank from the inspections are shown in **Figure 3-3**. **Appendices B through F** contain pictures and descriptions for each tank.

Table 3-3
Storage Tank Summary

Tank	Year Constructed	Material	Type	Capacity (MG)
Beebe Steel	1935	Riveted Steel	Standpipe	0.3
Indian Head	1939	Welded Steel	Standpipe	3.5
Merriam Hill	1962	Welded Steel	Standpipe	3.5
Goodnow	1976	Welded Steel	Elevated	0.3
Beebe Concrete	1980's	Concrete	Standpipe	1.0
Doeskin Hill	2005	Bolted Steel	Standpipe	0.2

Figure 3-2

Pump, Tank and Zone Location Map

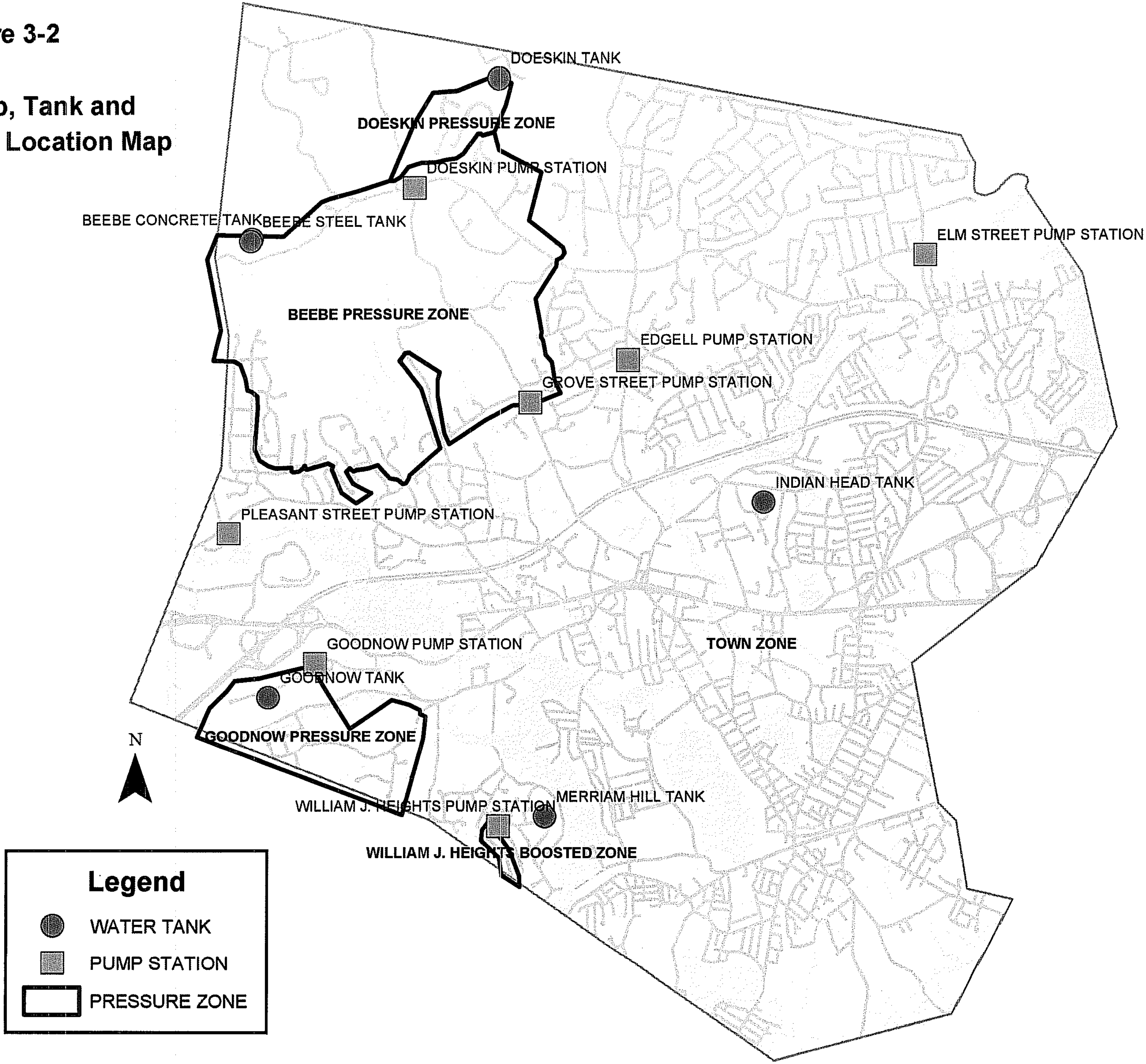
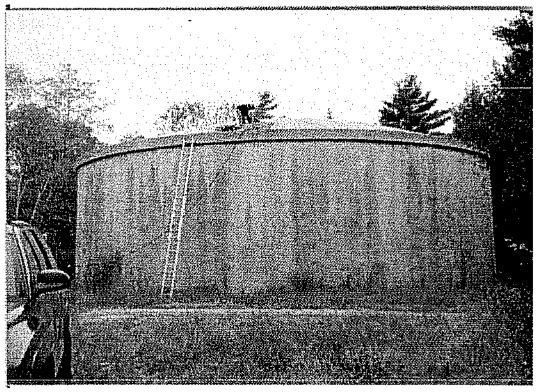
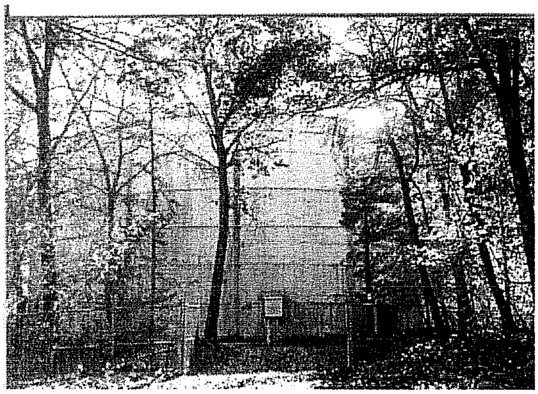


Figure 3-3
Water Storage Tanks

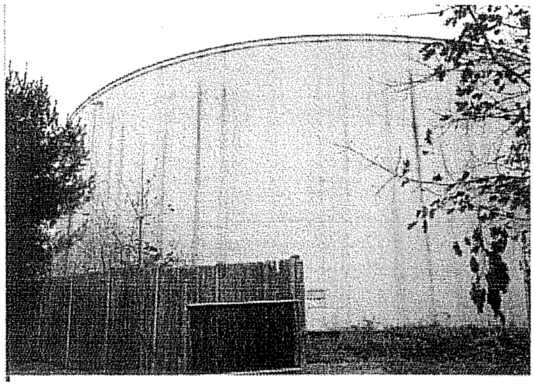
BEEBE STEEL



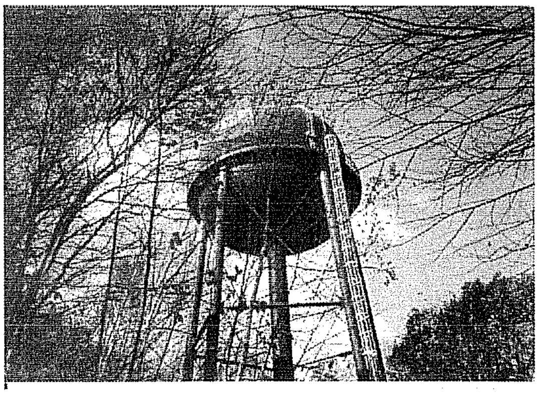
BEEBE CONCRETE



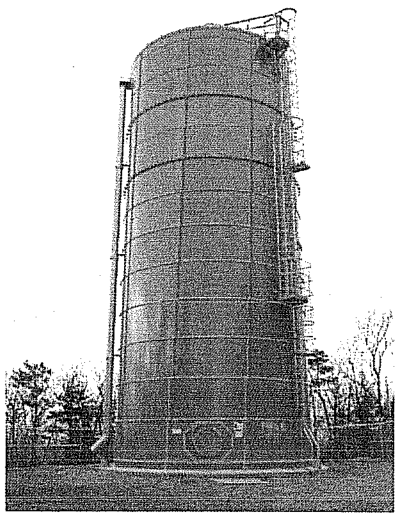
MERRIAM HILL



INDIAN HEAD



GOODNOW ELEVATED



DOESKIN HILL

3.4.1 Beebe Steel Tank

This 300,000 gallon water tank is located on Gibbs Mountain off of Edmands Road in the northwest corner of town. The tank is a riveted steel structure 48 feet in diameter and 22 feet high with an overflow elevation of 530'. The tank was built for C. Phillip Beebe in 1935 and donated to the town in 1949.

The 2004 inspection concluded that although the overall structural integrity was sound, there were sections of steel that had significantly deteriorated. The exterior surfaces have mild corrosion, some vegetation growth, moderate mildew accumulation, and a great deal of graffiti. The finial ball vent is missing screens and there is a 1-inch hole in the screen at the bottom of the overflow pipe. The interior surfaces have coating failure where corrosion, blistering, and pitting can be seen. There is also coating adhesion loss in some areas. The interior floor has approximately 1-inch of precipitate accumulation which affects the aesthetic quality of the water and could contribute to bacterial growth.

3.4.2 Beebe Concrete Tank

The 1,000,000 gallon concrete water tank is located on Gibbs Mountain off of Edmands Road in the northwest corner of town next to the 300,000 gallon steel tank. The tank is a concrete structure 88 feet in diameter and 22 feet high with an overflow elevation of 530'. The tank was built in the 1980's to add additional storage to the Beebe steel tank.

This tank was found to be in good overall condition during the 2004 inspections. The exterior surfaces have nonstructural shrinkage cracks in the shotcrete coating. No voids were found in the tank's concrete structure. Efflorescence has formed in some of the cracks and there is also some mildew accumulation. Some grout between the roof panel joints was found to have spalling. The interior has a small band of light, nonstructural, 1/8-inch deep scouring around the circumference of the tank. The interior floor has approximately 1 to 3 inches of precipitate accumulation which affects the aesthetic quality of the water and could contribute to bacterial growth.

3.4.3 Indian Head Tank

This 3.5 million gallon water tank is located off of Indian Head Heights. The tank is a welded steel structure 120 feet in diameter and 42 feet high with an overflow elevation of 368'. The tank was built in 1939. An altitude valve has been installed in the tank connection and is in operation.

The tank is structurally sound. The exterior surfaces have very good coating adhesion with some chips creating surface corrosion. There is some mildew accumulation and graffiti on the exterior lower portion. The secondary coating system on the ladder and cage is failing, exposing the primer. The roof has a great deal of coating system failure where cracking and blotch rusting can be seen. A good deal of the coating system is failing on the vent thereby causing corrosion. The interior surfaces have very good coating adhesion, some staining, and there is some corrosion on a manway and some overhead panels. The interior floor has approximately 1 inch of precipitate accumulation which affects the aesthetic quality of the water and could contribute to bacterial growth.

3.4.4 Merriam Hill Tank

This 3.5 million gallon water tank is located off of Checkerberry Lane. The tank is a welded steel structure 117 feet in diameter and 44 feet high with an overflow elevation of 368'. The tank was built in 1962 to replace the former Normal Hill Standpipe. An altitude valve has been installed in the tank connection and is in operation.

The tank is structurally sound. The exterior surfaces are chalky and weathered with moderate mildew accumulation but good adhesion of the coating system. The roof has coating failure where the secondary coating is peeling and some surface corrosion can be seen. There is also a missing 2-inch diameter plug in a roof panel and the screen at the bottom of the overflow pipe has been dislodged. There is heavy corrosion on the vent riser tube and also steel fatigue. The screen on the vent has also been dislodged creating a 1-inch gap. The interior surfaces have light staining, coating failure, and adhesion failure where blistering and corrosion can be seen. The interior floor has approximately 1-inch of precipitate accumulation which affects the aesthetic quality of the water and could contribute to bacterial growth.

3.4.5 Goodnow Elevated Tank

This 300,000 gallon elevated water tank is located off of Goodnow Lane in the southwest corner of town. The tank is a welded steel structure with an oval top and an overflow elevation of 440'. The tank was built in 1976.

The tank is structurally sound. The exterior surfaces are almost completely uncoated and there is moderate corrosion on all surfaces. A majority of the interior surfaces have a coating system with some blistering, rust staining, and surface corrosion existing in some areas. There is also coating adhesion failure throughout. A layer of precipitate averaging 10-inches was noted in the base of the bowl. This precipitate affects the aesthetic quality of the water and could contribute to bacterial growth.

3.4.6 Doeskin Hill Tank

This 200,000 gallon water tank is located off of Brimstone Lane on Doeskin Hill. The tank is a bolted, glass fused to steel structure 25 feet in diameter and 55 feet high with an overflow elevation of 635'. The tank was activated in March of 2005. An altitude valve has been installed at the tank connection. The tank was constructed to provide fire and domestic service to the homes on Doeskin Hill to replace failing wells.

3.4.7 Normal Hill Tank (Demolished)

The Normal Hill Standpipe was constructed in 1887 with a storage capacity of 700,000 gallons and an overflow elevation of 368'. The tank was 40 feet in diameter and 81 feet high with an altitude valve and was located at the current Framingham State College site. The tank was demolished in the early 1970s and was replaced by the Merriam Hill Tank.

3.5 Pressure Zones

Due to varying elevations in town, several hydraulic pressure zones were created to provide adequate service to each and every home. Pressure zones are created by hydraulic grade line differences either from storage elevation differences such as tank height or by pressure boosting from pumping. Currently there are five (5) different pressure zones throughout the town. **Table 3-4** describes key features for each of the five (5) pressure zones. **Figure 3-4** shows the location of each zone within the town.

Table 3-4
Framingham Pressure Zones

Zone Name	HGL (ft)	Pump Stations	Tanks	Storage	Area Served
Town	368	Edgell Rd. Pleasant St. Elm St.	Indian Head Merriam Hill	7.0 MG	Majority of Town
Beebe	530	Grove St.	Beebe Steel Beebe Concrete	1.3 MG	Northwest Corner
Goodnow	440	Goodnow	Goodnow	0.3 MG	Southwest Corner
Doeskin Hill	635	Doeskin Hill	Doeskin Hill	0.2 MG	Doeskin Hill Area
Wm. J. Heights	485	Wm. J. Heights	None	0.0 MG	Wm. J. Heights and Duggan Dr.

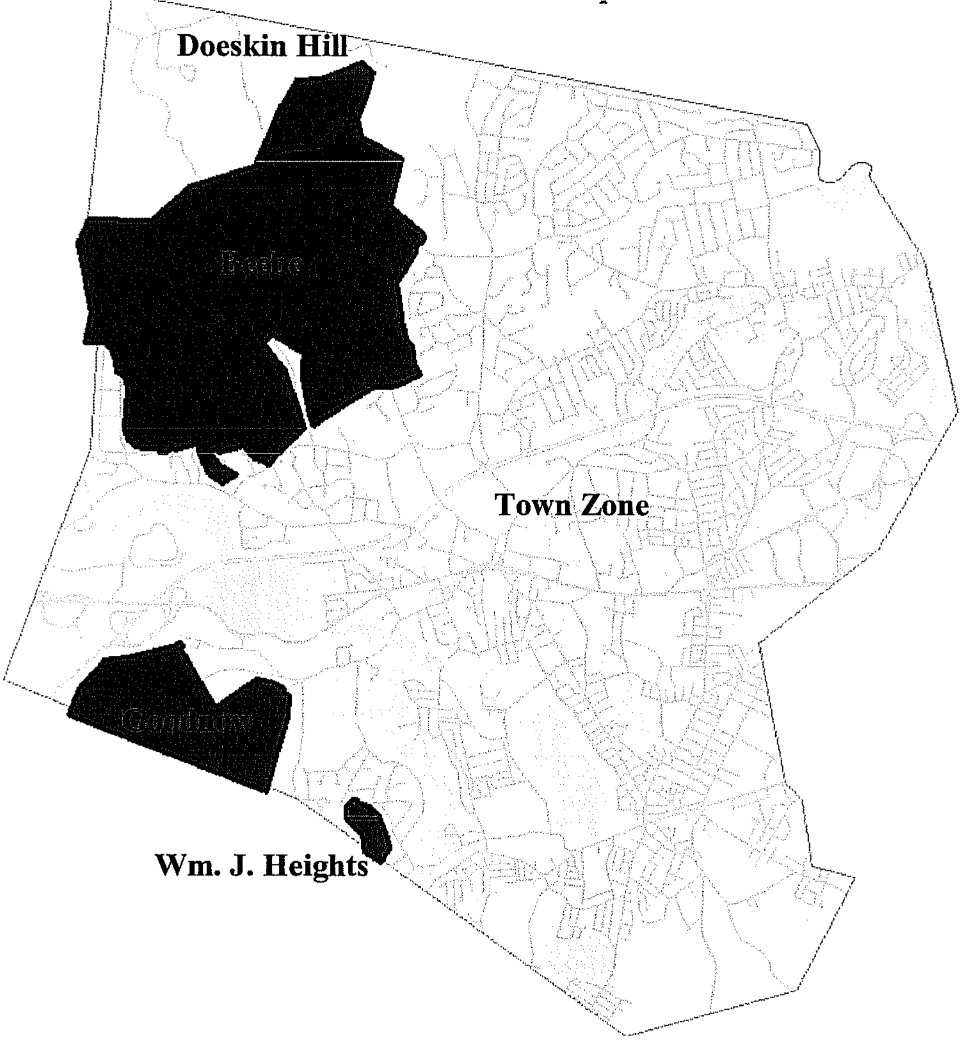
3.5.1 Town Zone

This zone provides the majority of the town's water service and is supplied by the Edgell Rd., Pleasant St. and Elm St. pump stations. Each of these stations is permanently connected to the MWRA MetroWest Tunnel and can also be supplied by the Hultman Aqueduct in an emergency. These three pump stations supply the Merriam Hill and Indian Head storage tanks as well as the entire low service area. The two tanks have a total maximum storage capacity of 7 million gallons.

3.5.2 Beebe Zone (Northwest High Service)

The Beebe Zone encompasses the area between and including most of Edmands Rd. to Tally-Ho Lane/Blackberry Lane. The zone is entirely supplied by the Grove St. pump station and contains the two Beebe storage tanks on Gibbs Hill near the Southborough border. Combined storage volume of the two tanks is 1.3 million gallons.

Figure 3-4
Pressure Zones Map



3.5.3 Goodnow Zone (Southwest High Service)

The Goodnow Pressure Zone is located in the southwest corner of town. It encompasses the area including and between Goodnow Lane and Lantern Road. The zone is fed by the Goodnow pump station which is supplied by the Town Zone via the 12" main on Gates Street. Storage is provided by the Goodnow elevated storage tank with a capacity of 0.3 million gallons.

3.5.4 Doeskin Hill Service Area

The Doeskin Hill service area was activated in March of 2005. This small zone includes some of Carter Drive as well as Mountain View Dr. and Doeskin Dr. The system is supplied by the Doeskin booster station at Edmands Rd. and Grove St. and is supplied from the 16" main on Grove St. that is part of the Northwest High Pressure System.

Storage is provided by the 0.2 million gallon standpipe off of Brimstone Lane. Currently there is a significant amount of development occurring in the area.

3.5.5 William J. Heights Boosted Zone

The William J. Heights boosted zone is located in the southern area of town on the Ashland border. This zone currently includes William J. Heights and is fed by a booster station at Duggan Drive and Jodie Road. This is a small closed system and does not have a storage tank. The zone is currently being modified with a new pump and will serve all of Duggan Drive.

3.6 Pump Stations

Framingham has four (4) pump stations that draw from the MetroWest Tunnel owned and operated by the MWRA. The four pump stations provide an average of 7.5 MGD to the residents and businesses of Framingham. Framingham also owns and operates three (3) water booster stations. These stations boost water from the larger pressure zones to smaller tanks or to a closed system. These stations are necessary to provide adequate service to homes at extreme elevations. Exterior photographs of all stations are shown in **Figure 3-5**. A summary of all major equipment, manufacturers and sizes can be found in **Table 3-5**.

3.6.1 Goodnow Lane Booster Station

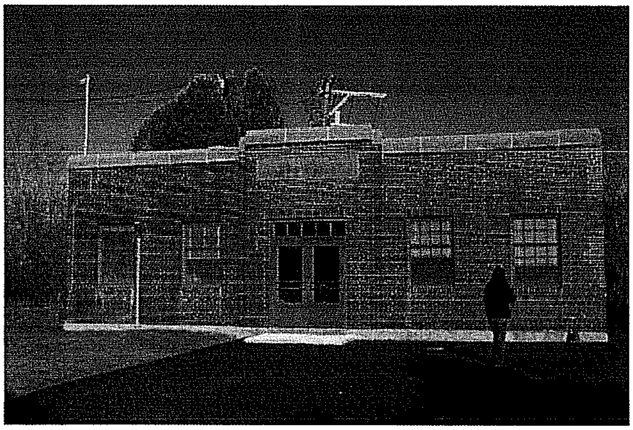
This station, with a total maximum rated capacity of 500 gpm, was built around 1970. The station has two electric pumps with capacities of 200 and 300 gpm. The 300 gpm pump can also be driven by a natural gas engine. The station draws water from a 12" main in the low service system on Gates Street. The Goodnow pump station supplies the Goodnow pressure zone in the southeast portion of town. The booster supplies the Goodnow elevated tank on Goodnow Lane. Treatment is not provided at this station.

3.6.2 Grove Street Pump Station

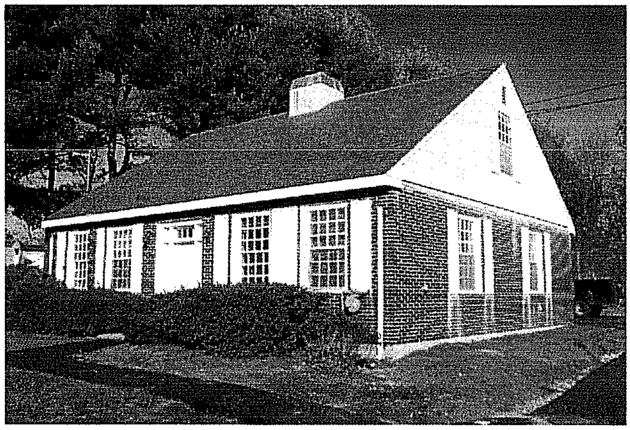
This station, with a total maximum rated capacity of 0.9 mgd, was built in 1968. The station has two electric pumps with capacities of 350 gpm each. One pump can also be driven by has a natural gas engine. The station draws water directly from the Metro West Tunnel owned by the MWRA.

The Grove Street station supplies water exclusively to the northeast pressure system. The distribution piping in the system directs flow to the Beebe tanks. The station is controlled by levels in the Beebe tanks. Consideration has been made to coordinate activation of these pumps with the Doeskin booster station to ensure higher chlorine residuals in the Doeskin Hill tank.

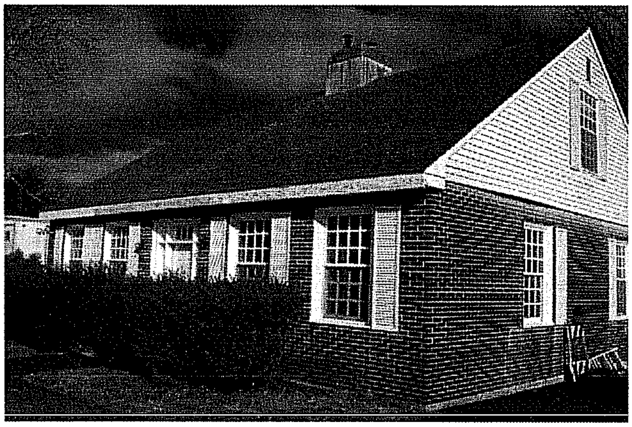
Figure 3-5
FRAMINGHAM PUMP STATIONS



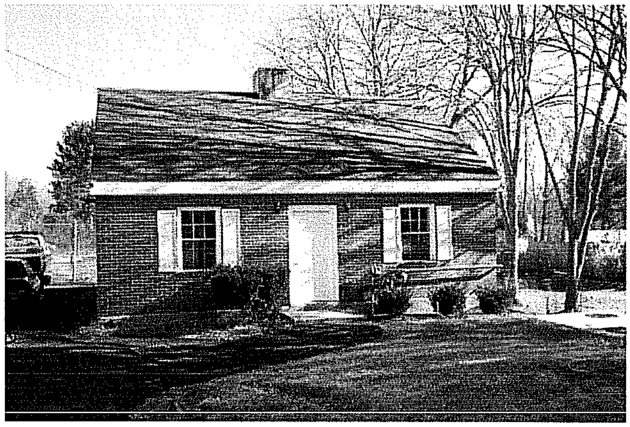
EDGELL ROAD PUMP STATION



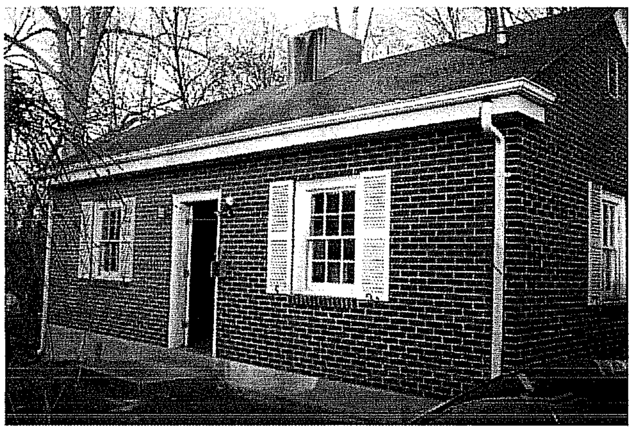
ELM STREET PUMP STATION



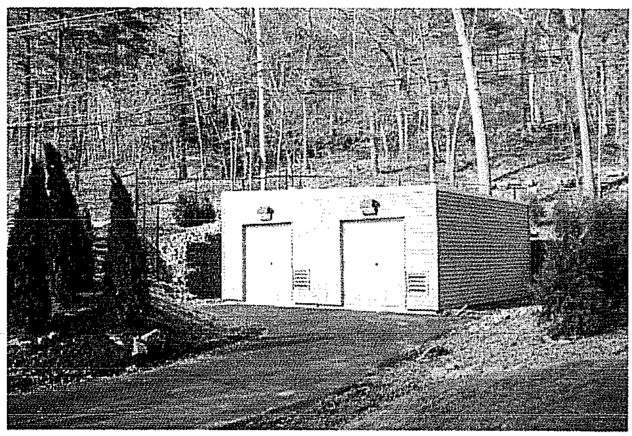
PLEASANT STREET PUMP STATION



GROVE STREET PUMP STATION



GOODNOW LANE PUMP STATION



DOESKIN HILL PUMP STATION

Table 3-5
Framingham, Massachusetts
Water System Components

STORAGE

TANK NAME	ZONE	CAPACITY	HGL	HEIGHT	DIAMETER	LOCATION
IERRIAM HILL	TOWN	3.5 MIL. GAL.	368'	44	117'	Between 1012-1014 Pleasant Street
NDIAN HEAD	TOWN	3.5 MIL. GAL.	368'	42	120'	Between 645-681 Edgell Road
EEBE STEEL	BEEBE	0.3 MIL GAL.	530'	22'	50'	Between 527-559 Grove Street
EEBE CONCRETE	BEEBE	1.0 MIL GAL.	530'	22'	88'	Between 527-559 Grove Street
OODNOW	GOODNOW	0.3 MIL GAL.	440'	30'	42'	Opposite # 5 Goodnow Lane
OESKIN HILL	DOESKIN	0.2 MIL GAL.	635'	55'	25'	Off Brimstone Lane
	TOTAL	8.8 MIL GAL.				

PUMPING

STATION NAME	ZONE	PUMP NO.	PUMP MAKE	MOTOR MAKE	HORSE POWER	CAPACITY (GPM)	VOLTS
DGELL ROAD	TOWN	1	F-M	US	75	1750	230/460
DGELL ROAD	TOWN	2	F-M	US	100	2333	230/460
DGELL ROAD	TOWN	3	F-M	US	100	2570	230/460
LEASANT STREET	TOWN	1	PACO	BALDOR	100	2600	460
LEASANT STREET	TOWN	2	PACO	BALDOR	100	2600	460
LM STREET	TOWN	1	PEERLESS	US	50	1155	230/460
LM STREET	TOWN	2	AL. CH.	AL. CH	100	2605	220/240
ROVE STREET	BEEBE	1	PEERLESS	LINCOLN AC	50	350	230/460
ROVE STREET	BEEBE	2	PEERLESS	US	50	350	230/460
OODNOW LANE	GOODNOW	1	AL. CH.	AL. CH	10	200	230/460
OODNOW LANE	GOODNOW	2	AL. CH.	AL. CH	15	300	230/460
OESKIN HILL	DOESKIN	1	GOULDS	BALDOR	10	150	120/208
OESKIN HILL	DOESKIN	2	GOULDS	BALDOR	10	150	120/208
VM. J. HEIGHTS	WM. J. HEIGHTS	1	UNK.	UNK.	7.5	100	120/208
VM. J. HEIGHTS	WM. J. HEIGHTS	2	UNK.	UNK.	7.5	100	120/208
VM. J. HEIGHTS	WM. J. HEIGHTS	3	UNK.	UNK.	40	1000	120/208

AUXILLIARY PUMPING

STATION NAME	PRESSURE ZONE	FUEL	PUMP MAKE	ENGINE	CYLINDERS	CAPACITY (GPM)	CAPACITY (MGD)
DGELL ROAD	LOW	DIESEL	CATERPILLAR	CATERPILLAR	6	3470	4.97
LEASANT STREET	LOW	NATURAL GAS	AL. CH.	WAUKESHA	6	3470	4.97
ROVE STREET	BEEBE	NATURAL GAS	PEERLEES	WAUKESHA	6	1745	2.51
LM STREET	LOW	NATURAL GAS	AL. CH.	WAUKESHA	6	4860	6.99
OODNOW LANE	GOODNOW	NATURAL GAS	AL. CH.	WAUKESHA	4	300	0.43

PERMANENT GENERATORS

STATION NAME	PRESSURE ZONE	FUEL	POWER (KW)	ENGINE	CYLINDERS	CAPACITY (GPM)	VOLTS
OESKIN HILL	DOESKIN	NATURAL GAS	45	KRAFT	6	300	120/208

WATER SUPPLY

SUPPLY NAME	NUMBER	OWNER	STATUS
IETROWEST TUNNEL	4 CONNECTIONS	MWRA	ACTIVE
AXONVILLE WELLS	3 WELLS	TOWN	OFFLINE

PUMP MAKES: F-M = FAIRBANKS MORSE; AL. CH. = ALLIS CHALMERS
MOTOR MAKES: GE = GENERAL ELECTRIC; AL. CH. = ALLIS CHALMERS

Chloramination was incorporated into the pumping station prior to November 2004 using two 60 lb. gas cylinders and a portable ammonia trailer supplied by the MWRA.

3.6.3 Edgell Road Pump Station

This station, with a total maximum rated capacity of 16.4 mgd, was built in 1950. The station has three electric pumps with capacities of 2.5, 3.2, and 3.7 mgd. The station also has a diesel driven auxiliary pump with a capacity of 7.0 mgd. The station draws water directly from the MetroWest Tunnel owned by the MWRA.

The Edgell Road station supplies water to the majority of the low service system. The distribution piping in the system directs the majority of the flow to the Indian Head tank. The station is controlled by levels at both the Meriam Hill and Indian Head tanks depending on the season.

Chloramination was incorporated into the pumping station prior to November 2004 using two 100 lb. gas cylinders and a portable ammonia trailer supplied by the MWRA.

3.6.4 Pleasant Street Pump Station

This station, with a total maximum rated capacity of 10 mgd, was built in 1962 and is located in the western portion of town near the Southborough line. The Pleasant Street station serves the southwestern portion of town feeding mainly the Miriam Hill tank as well as supplying the Goodnow Pump Station.

The station has two electric pumps with 1.2 mgd and 3.8 mgd capacities. The station also has a natural gas driven auxiliary pump with a capacity of 5.0 mgd. Pump operation is controlled by Merriam Hill tank levels.

Chloramination was incorporated into the pumping station prior to November 2004 using two 60 lb. gas cylinders and a portable ammonia trailer supplied by the MWRA.

3.6.5 Elm Street Pump Station

This station, with a total rated capacity of 10.4 mgd, was built in 1962 and is located in the Saxonville section of town in the northeast. The Elm Street station serves the northeastern portion of town feeding mainly the Indian Head tank.

The station has two electric pumps with 1.6 mgd and 3.8 mgd capacities. The station also has a natural gas driven auxiliary pump with a capacity of 5.0 mgd. Operation of the pumps is controlled by the level in the Indian Head tank.

Chloramination was incorporated into the pumping station prior to November 2004 using two 60 lb. gas cylinders and a portable ammonia trailer supplied by the MWRA.

3.6.6 Doeskin Hill Booster Station

This station, with a total rated capacity of 0.43 mgd, was activated in March 2005 and is located at the intersection of Grove Street and Edmands Road in the northwest section of town. The Doeskin station serves the Doeskin Hill section of town feeding mainly the Doeskin Hill tank.

The station has two electric pumps with 150 gpm capacity each. The station also has a natural gas driven electric generator to power the electric pumps. Operation of the pumps is controlled by the Doeskin Hill tank levels. No treatment is provided at this station.

3.6.7 William J. Heights (WJH) Booster Station

This station, with a domestic design capacity of 100 gpm and fire flow capacity of 1,000 gpm was built in 2006. The station is located in an underground concrete vault at the intersection of Duggan Drive and William J. Heights and consists of two electric 7.5 HP 100 gpm domestic pumps and one electric 1,000 gpm, 40 HP fire pump. The station does not have a permanent generator but has a plug adapter to accept an emergency generator.

The system is configured to strictly boost water pressure to Duggan Drive and William J. Heights and to provide fire protection. Therefore, no treatment is provided. The station draws water from the low service system, specifically from the 8" main on Jodie Lane. The former station that was located at the same site contained one 5 HP electric pump that ran constantly and supplied only domestic water to the residents of William J. Heights.

3.7 Treatment

Beginning in November 2004, water treatment was no longer provided at each of the pump stations drawing from the MWRA. The MWRA supply water is chloraminated by the MWRA and provides chloramine residuals of 2.0-2.3 mg/l with free chlorine residuals of 0.09-0.2 mg/l. Chlorine gas cylinders, as well as connections and injection points, are still available if disinfection becomes necessary.

3.8 Emergency Connections

There are five emergency water connections between Framingham and bordering towns. The five locations with associated towns are:

1. Parker Road at the Ashland town line.
2. Fountain Street at the Ashland town line.
3. Hollis Street at the Ashland town line.
4. Speen Street at the Natick town line.
5. Hartford Street at the Natick town line.

3.9 SCADA and Controls

Prior to June 2005 the town used VTS brand SCADA software, supplied by Ian Technologies, with Windows NT. The system ran on telephone lines with modems at each location reporting to a central RTU at the DPW office on Western Avenue. The system had separate alarm dialers for paging operators.

In June 2005, the town converted to wireless telemetry (Motorola MOSCAD®) that provides more capabilities to control from remote locations. The upgrade included two new computers running Windows XP® and Interlution Ifix® software. The system also runs alarming software (Win911®) to alert operators. Each station has its own RTU which communicates to the Western Avenue DPW office over a licensed frequency. There is a redundant computer located at the Edgell Road pumping station that communicates with Western Avenue over a sub-network to the town's network with the capability of viewing and controlling remotely. All of the water distribution system pump stations operated by the Town of Framingham have the same monitoring system.

3.10 Leak Detection Program

The latest leak detection survey was conducted by Flow Metrix, Inc. in June and September of 2004. The survey covered 255 miles of water main throughout town and was completed using the DigiCorr Digital Leak Correlator with DigiCorr Pro Leak management software. Correlating loggers were also installed on some transmission mains.

The leak detection survey pinpointed 24 leaks including 5 mains, 13 services and 6 appurtenances (valves or hydrants). The detected leaks totaled 458 gallons per minute (240.7 million gallons annually). All of these leaks were repaired by the DPW soon after they were detected. A copy of the summary sheet from the leak detection report is provided on the following page.

3.11 Cross Connection Protection Program

The Town of Framingham is responsible for the water quality from the source (MWRA connections) to the last free flowing tap within a structure for each customer. To ensure protection of the water system from non-potable water sources, the town is required by 310 CMR 22.22 to have an active cross connection protection program (CCPP). The town has also established additional cross connection control requirements applicable to all of its customers.

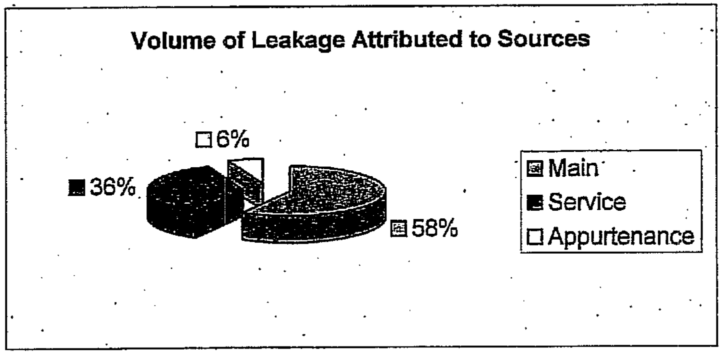
While the CCPP is managed by the Department of Public Works Water Division, it is really a collaborative effort requiring assistance from the Fire, Engineering, Planning, and Building Departments. Inter-departmental assistance is necessary to communicate the changes and additions to the water system from development, renovations and permits. Framingham requires customers to protect the water system through the use of backflow prevention devices. The type of device and testing frequency are dependent upon level of

Table of Leaks with Estimated Loss Rates

Report #	Address	Source	Estimate (GPM)	File Reference
1	Cedar St. at Cypress St.	Main	15	1778-1777
2	#21 McAdams Rd.	Service	7	18-17
3	#19 McAdams Rd.	Service	7	18-17
4	Edgell R., Riley's Roast Beef	Service	7	169-554
5	#37 Stearns St.	Service	7	1418-1417
6	#29 Lockland Ave.	Service	80	1271-1270
7	#5 Chapelwood Rd.	Service	7	585-586
8	Caldor Rd. (Hydrant 356)	Hydrant	10	355-356
9	#2A Catherine Rd. (Hydrant 70)	Hydrant	3	70-1757
10	#7 Highgate Rd.	Service	7	480-481
11	#27 East St.	Main	10	1182-2 - KS at 27
12	Hartford St. (Hydrant 443)	Hydrant	8	443-457
13	Old Conn Path at Stop'n'Shop	Valve	3	226-MV at Lights
14	Old Conn Path at Concord	Main	80	227-226
15	Belvedere St.	Service	7	933-934
16	Sealtest Dr.	Main	150	848-849
17	Flanagan Dr.	Service	7	532-531
18	Wildwood Terr.	Service	7	35-34
19	Beulah St.	Service	7	318-317
20	Rickey Rd.	Service	7	1668-681
21	Colby	Service	7	720-721
22	Salem End Rd (Hydrant 1147)	Hydrant	1	1147-1803
23	Alan St	Main	12	1332-1334
24	Cherry St (Hydrant 868)	Hydrant	2	868-869
Total Losses			458	

Volume of Leakage Attributed to Sources

Source of Leakage	Number	Estimated Leakage (GPM)	% of Number	% of Estimation
Main	5	267	22%	58%
Service	13	164	57%	36%
Appurtenance	5	27	22%	6%
Total	23	458	100%	100%



Annualized Losses

Source of Leakage	Estimated Leakage (GPM)	GPD	GPY
Main	267	384,480	140,335,200
Service	164	236,160	86,198,400
Appurtenance	27	38,880	14,191,200
Total	458	659,520	240,724,800

risk and type of plumbing system. The town also ensures the water system is protected through regular cross connection surveys at customer premises.

Framingham has approximately 3,100 known backflow devices in their water system. Of the 3,100, they test 500 double check valves once per year and 1,600 reduced pressure devices twice per year for a total of 3,700 backflow tests annually.

The remaining known backflow devices (approximately 1,000) are located on residential property. Regulations do not currently require the town to test residential devices. Within the next few years, however, more emphasis will be given to protecting water systems and will most likely include a testing policy for the backflow devices installed at residential locations.

Section 4 – Population Projections and Water Demand

4.1 General

This Section contains a population growth and build-out analysis used in projecting the Town of Framingham's future population and density. This will provide information needed to project future water demand and to model Framingham's water distribution system accurately.

4.2 Historical Population and U.S. Census

Framingham's population growth since 1920, as recorded by United States Census data, is shown in **Table 4-1**. Growth has been relatively flat over the past twenty years, representing a 2.8% increase in population from 1980 to 2000.

Table 4-1
Population History

Town of Framingham	
Year	**Population**
1920	17,033
1940	23,214
1960	44,526
1970	64,048
1980	65,113
1990	64,989
2000	66,910

Source: U.S. Census Bureau

4.3 Population Projections

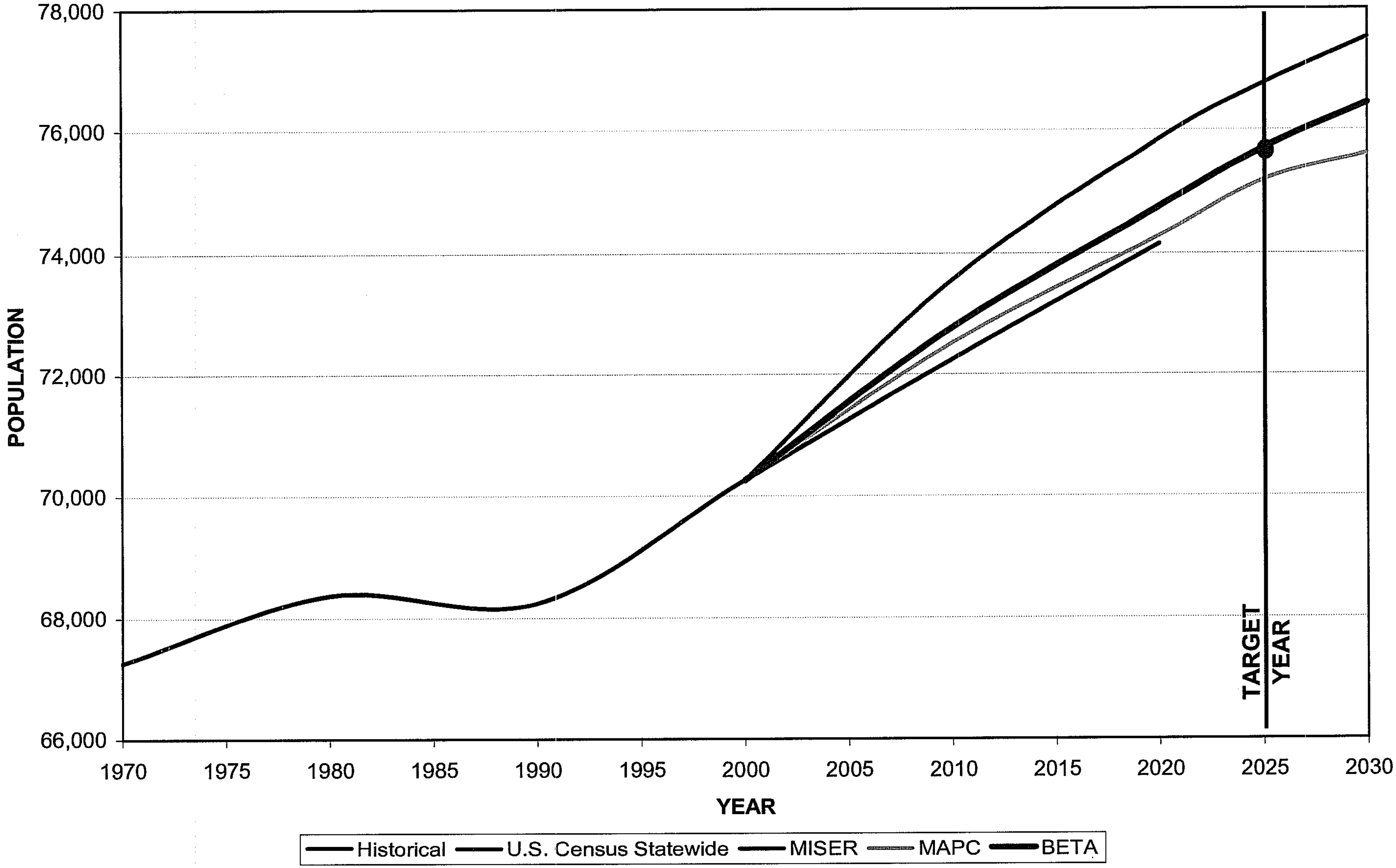
Datum from three sources were used to estimate future growth. The first was the Massachusetts Institute for Social and Economic Research (MISER), the second was the United States Census, and the last was the Boston Metropolitan Area Planning Council (MAPC).

BETA assumed linear growth to estimate populations in years not provided by the data sources. All of the sources were then averaged over each time period to obtain the projections used. **Figure 4-1** indicates projections for each source as well as BETA's interpolation. It is the Town of Framingham's policy to add 5% in recent years to any population projections to account for the undocumented residents so this was included in all projections.

4.3.1 Massachusetts Institute for Social and Economic Research (MISER)

FIGURE 4-1

FRAMINGHAM PROJECTED POPULATION



*Projections increased by 5% to account for undocumented residents.

MISER is an interdisciplinary research institute of the University of Massachusetts. Its research involves planning, strategy and forecasting with a focus on social, economic, and demographic issues. MISER's Population Studies Program works with the U.S. Census Bureau in collecting, analyzing, and disseminating population information for Massachusetts. For further information on MISER, go to its website at: www.umass.edu/miser/.

MISER has projected population growth for the Town of Framingham for the years 2010 and 2020. These projections employ a cohort-component model in which fertility, mortality, and migration are projected independently. The projections were produced in ten year increments with the "launch" year being the Census 2000 population. MISER develops low, mid and high series projections. The differences among the three are approaches are produced by using different assumptions regarding fertility, mortality, and migration rates. MISER's mid-series data for 2010 and 2020 projected a small decline in population, thus the high-series projections have been chosen for this report. We believe a small decline in population was unrealistic given the three large residential projects described in Section 4.5.3 which will add approximately 945 new housing units over the next decade.

MISER's high-series projections average a 2.7% increase for each ten-year period. This reflects the state population increase recorded in the U.S. Census Bureau for the decade from 1990 to 2000. This study assumes there will be marginal growth (0.5%) from 2020 to 2025.

4.3.2 U.S. Census

The U.S. Census Bureau does not project population growth for individual Massachusetts communities but it does project growth at the state level. Projection figures for the Commonwealth of Massachusetts were published for July 1 of 2010, 2015, 2020, 2025 and 2030. The Census Bureau predicts a total increase of 9.3% over the 2000 level for the year 2025. These statewide projections were applied to Framingham's population for thi study.

4.3.3 Boston Metropolitan Area Planning Council (MAPC)

The MAPC is a regional planning agency representing 101 cities and towns in the metropolitan Boston area. Created by an act of the Legislature in 1963, it serves the Commonwealth as an independent public body through which state and local officials can address issues of regional importance. As one of 14 members of the Metropolitan Planning Organization (MPO), MAPC has oversight responsibility for the region's federally funded transportation program. Framingham is included in this organization.

Growth projections were published for Framingham for the years 2010, 2020 and 2030. A total increase of 7.6% over the 2000 U.S. Census records is predicted for the year 2030.

4.4 Existing Water Demand

4.4.1 Flow Records from Pump Stations

The flow records from the pump stations were obtained from chlorination reports from each of the four MWRA aqueduct-connected pump stations. Chlorination reports from 2000 through 2004 were provided by the town. Monthly totals from each of the four pump stations can be seen in **Figure 4-2.** Total flow from all four pump stations combined can be seen in **Figure 4-3.**

4.4.2 Information from Water Billing System

Water billing data was not available at the time this Water Master Plan was prepared.

4.4.3 Develop Per Capita Flows

The average daily demand of 7.5 million gallons per day (MGD) for the five-year period from 2000 to 2004 was calculated using the flow records described above in Section 4.4.1. Domestic (or residential) water use has averaged 77.1% of the total water demand (see **Table 4-2**). Non-domestic usage includes industrial, commercial, institutional and municipal users. Unaccounted for water includes water lost through leakage, fire fighting, hydrant flushing, meter slippage and other losses that are not measured.

Table 4-2
Distribution of Water Usage*

Usage Type	% of Total Water Demand
Domestic	77.1 %
Non-Domestic	14.7 %
Unaccounted for	8.2 %

* Source: Framingham's MWRA Continuation of Contract Water Supply Supplementary Report

Based on the previous figures and the U.S. Census population count of 70,256 (with 5% added for undocumented residents and growth occurring since the census data was created) BETA calculates the per capita flows will be 82.3 gpcd (gallons per capita per day).

4.4.4 Large Water Users

Large water users who are defined as using greater than 20 million gallons per year are listed in **Table 4-3.**

Figure 4-2
Monthly Water Consumption per Pump Station vs Time

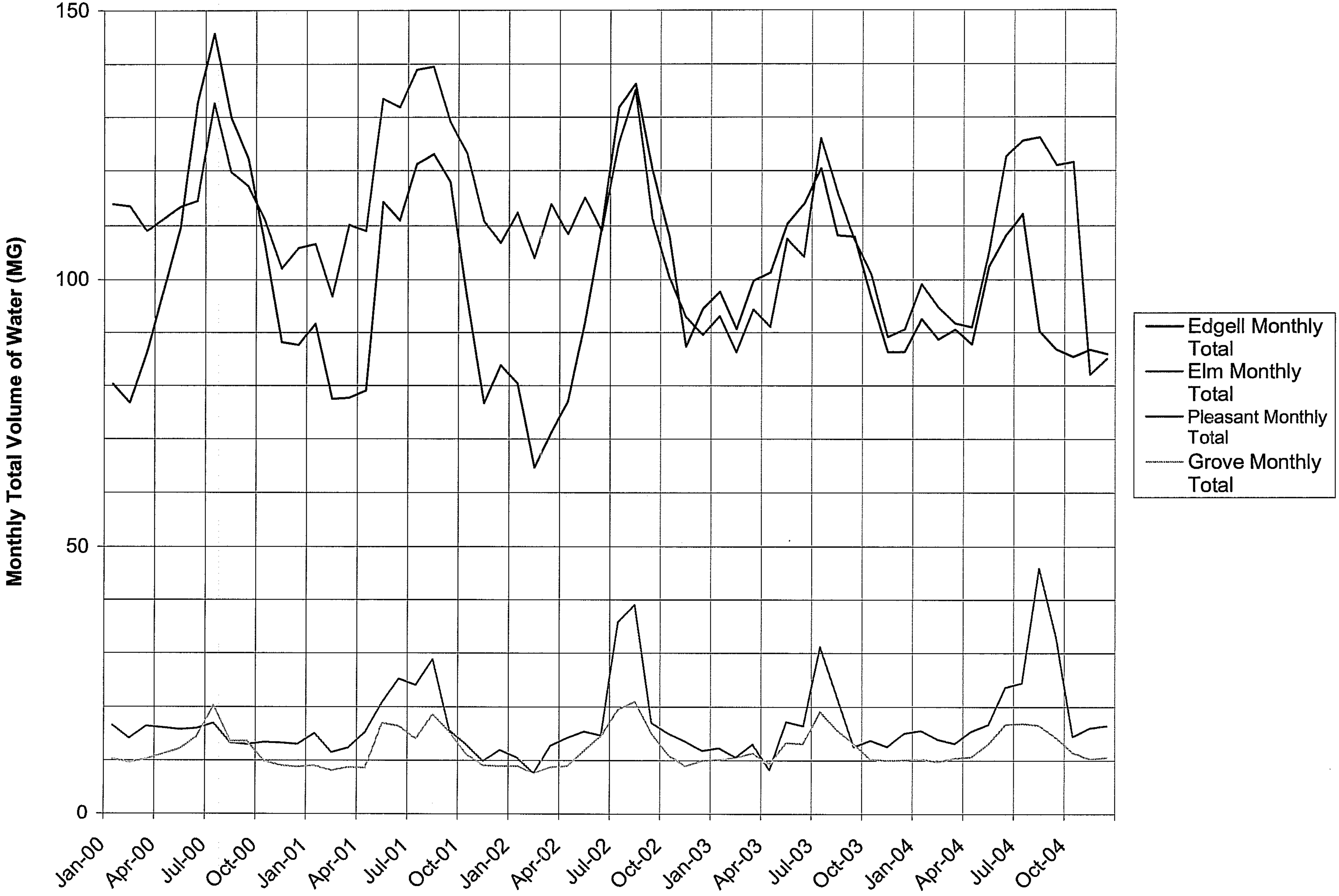


FIGURE 4-3
Total Monthly Pumped Water Volume vs Time

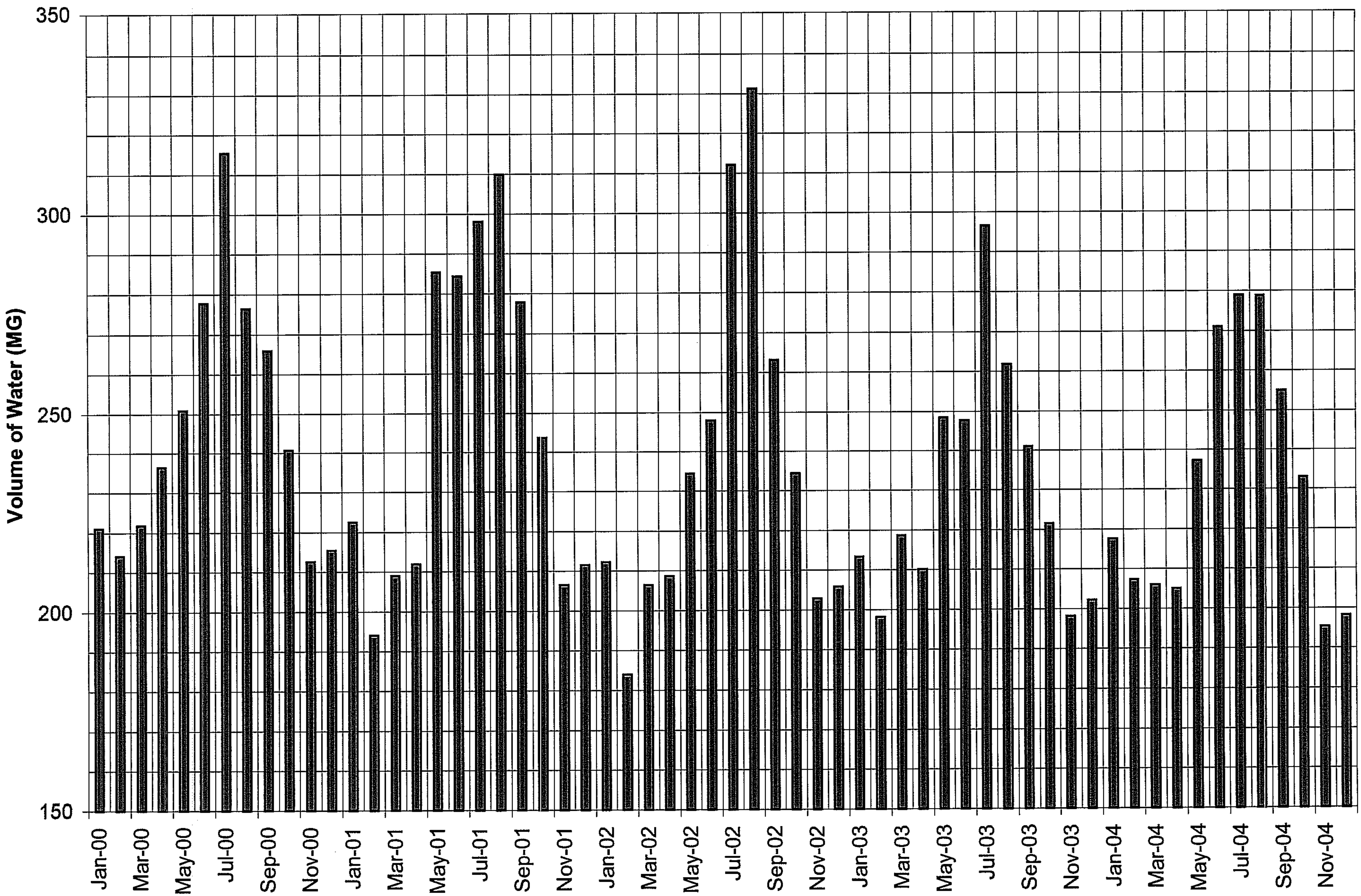


Table 4-3
Large Water Users
(>20 Million Gallons Per Year)

Company	Business Type
Good Humor Breyers	Manufacturing
Capital Properties Management	Commercial
Massachusetts Department of Correction	Institutional
Nestle	Manufacturing
Genzyme Corporation	Manufacturing
Metrowest Medical Center, Inc.	Institutional

4.5 Build-out

A build-out analysis is utilized to determine how much future development can be expected based upon environmental constraints, recent development trends and existing zoning. Build-out occurs when every buildable lot is developed based upon existing zoning controls.

4.5.1 Zoning

The current residential zoning for Framingham is shown in **Table 4-4**:

Table 4-4
Residential Zoning

Zoning District	Description of Zoning Districts
G	General Residence (8,000 sf lots)
R-1	Single Family Residence (8,000 sf lots)
R-2	Single Family Residence (12,000 sf lots)
R-3	Single Family Residence (20,000 sf lots)
R-4	Single Family Residence (43,560 sf lots)

Current zoning, as provided by the town, can be seen in **Figure 4-4.**

4.5.2 Current Development

The 2000 U.S. Census lists the number of homes in Framingham as 26,734 and the density of these homes to be 1,064.3 housing units per square mile (hupsm). When these numbers are separated by zip code which uses Route 9 is the divider, the density differences between north and south Framingham are clear. North Framingham has a density of 725 hupsm (as of 2000) and South Framingham has a density of 1787 hupsm. This difference is due primarily to large portions of undeveloped land in north Framingham, particularly the northwest area.

4.5.3 Planned Development

There are three large residential/commercial projects currently under way in Framingham. The largest of the three is a 525-unit development located in the northeast corner of town. It is being called The Villages at Danforth Farms. It will encompass 170 acres of land with approximately 40 acres of this area located in Wayland. The developer hopes to begin construction soon and the entire project is estimated to take 8-10 years to complete. This development will include 4,000 square feet of convenience retail space. Ten percent of the 525 units are to be sold at below market rate and twenty-five percent will be designated as age-restricted units in which at least one resident over 55 years old.

Framingham's two other large projects (described below) have been approved by the Planning Board. These projects call for mixed-use apartments or condominiums above commercial/retail space in districts previously zoned business or industrial. This mixed-use development is a recent trend in the area and other similar projects have been talked about for the town, however, no hard numbers have been proposed as of yet.

<u>The Arcade</u> – This is a large mixed-use project located on Concord Street across from the Memorial Building which holds the town offices. Current plans call for the construction of a new building and the rehabilitation of four historic buildings. The 400,000 square feet of space created is slated to include 260 apartments, 40 hotel rooms and 50,000 square feet for commercial and retail use.

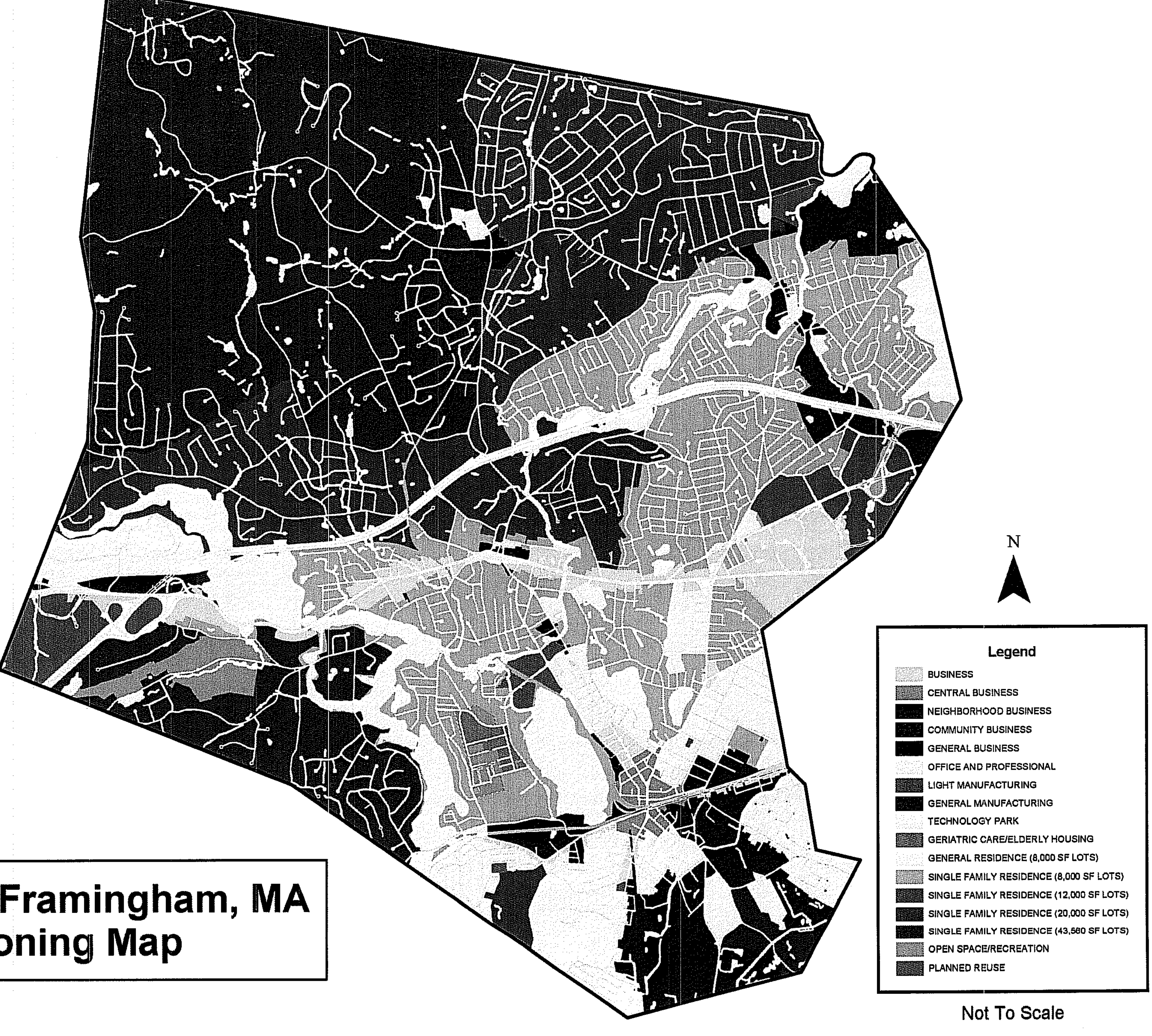
<u>The Dennison Complex</u> – The other mixed-use project is located at the former Dennison factory near the intersection of Route 135 and Bishop Street. The Dennison Complex will include two commercial buildings and 160 one- and two-bedroom luxury condominiums.

4.5.4 Full Build-out

Full build-out results when every buildable lot is developed based upon existing zoning controls. The likelihood that Framingham or any other community will reach total build-out is unlikely, but this type of theoretical analysis helps to theoretically determine the maximum water demand a community might need in the future.

The first step in this full build-out analysis is to identify undeveloped land zoned for residential use. All five Residential Districts listed in **Table 4-4** were included. Using a GIS map of the town with assessor and zoning information, residentially zoned parcels were selected and put into a database. This database included the area of each parcel, its zoning designation and the owner's name. The parcels owned by the Commonwealth of Massachusetts and land trust parcels were removed from the database. The area of each parcel was then divided by the applicable minimum square footage for its zoning area and the number was rounded down to a whole number. This gave the number of lots possible on this parcel. Ten percent of the lots were removed for road allowances. By this method, it was determined there are 2,746 lots yet to be developed. In addition to these

Town of Framingham, MA
Zoning Map



undeveloped lots, we can factor in the 945 units expected to be built in the three proposed developments listed above. This brings the potential total of un-built units/lots to 3,691.

The 2000 U.S. Census calculated the average household size in Framingham at 2.4 persons. Using this figure, we can estimate that 3,691 new units will result in an additional 8,858 residents in Framingham. This would represent a 12.6% increase in population if residential land in Framingham was fully developed excluding any future zoning changes.

This is obviously a very rough and conservative projection. Land that could not be developed because of wetlands, cemeteries, access limitations and other restrictions was not taken into account and was excluded from the database. It also seems plausible, given the current housing demand in the greater Boston area, that more business and industrial districts will be converted to residential or mixed-use zoning increasing the prospect for this build-out projection. Potential additional commercial/industrial development as well as facility closures are difficult to predict. Large users added or removed from the system may change these projections accordingly.

4.6 Future Water Demand

Future water demand projections used the chlorination reports from the four MWRA aqueduct-connected pump stations and equating those numbers to town demands. Assuming that no new large-demand users established themselves in town, the estimated percentage increase in population between 2000 and 2010 and between 2010 and 2020 was used to project the maximum day, the average summer day, and the average winter day demands for use in the future water demand analysis. The projections are listed in **Table 4-5** below.

Table 4-5
Projected Water Demands

	US Census	Population Projections				
Year	2000*	2005*	2010*	2015*	2020*	2025*
Population	70,256	71,471	72,772	73,739	74,757	75,691
		% Increase				
		1.70%	1.79%	1.31%	1.36%	1.23%

		Current Day	Projected Demands (GPD)				
		2000-2004	**2005**	**2010**	**2015**	**2020**	**2025**
July/Aug.	**MAX DAY**	12,943,000	13,163,000	13,398,000	13,574,000	13,759,000	13,929,000
-	**AVG DAY**	7,500,000	7,628,000	7,757,000	7,889,000	8,023,000	8,160,000
Oct.-Apr.	**AVG WINTER**	5,997,000	6,099,000	6,203,000	6,308,000	6,415,000	6,525,000
May-Sept.	**AVG SUMMER**	8,953,000	9,105,000	9,260,000	9,418,000	9,578,000	9,449,000

* Includes an additional 5% for undocumented residents.

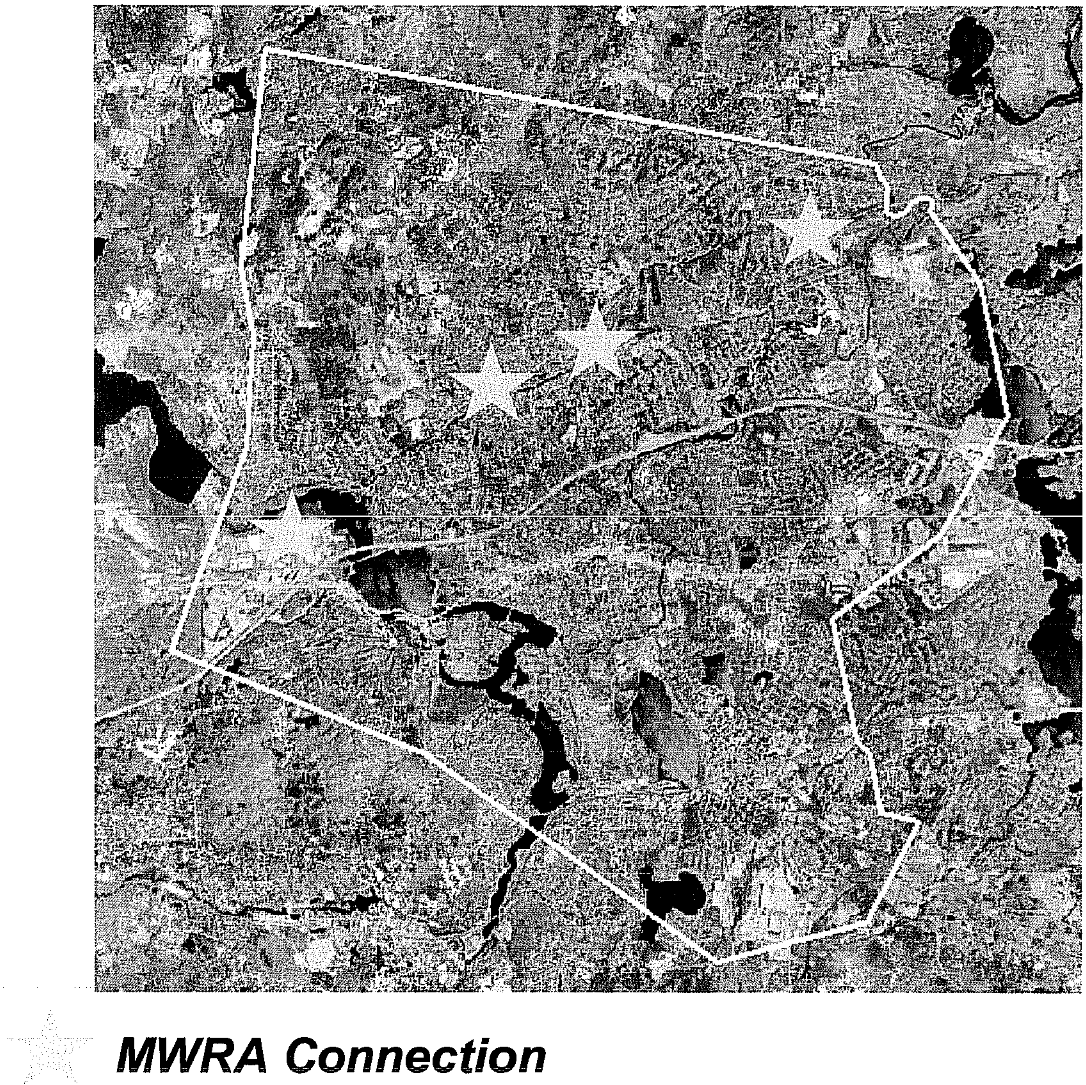
The average day water demand for the projected full build-out conditions is 8,445,750 GPD with the maximum day being 14,575,110 GPD.

Section 5 – Water Supply and Conservation

5.1 General

Potable water in Framingham is currently supplied by the MetroWest Tunnel which is owned and operated by the Massachusetts Water Resources Authority (MWRA). Framingham began drawing water from the Metro West Tunnel soon after it was activated in November, 2004. Prior the tunnel's opening, Framingham was supplied by the Hultman Aqueduct, also owned by the MWRA (formerly the MDC) and can still draw from it if necessary. The Sudbury Aqueduct can supply water to Framingham in an emergency. **Figure 5-1** shows the locations of the MWRA connections.

Figure 5-1
MWRA Connection Locations



In the past, the town has used three (3) wells located off of Birch Road (in the Saxonville area of north Framingham) which have a combined total safe yield of 2.5 MGD. These wells were deactivated and abandoned in the 1980's. However, the town plans to reactivate this well field in 2011, which will effectively reduce town demand on the MWRA supply system. Further detail about the distribution system is located in **Section 3**.

5.2 MWRA Water Supply

Historical water use by the town is shown in **Table 5-1** and **Table 5-2**.

Table 5-1
Historical Water Use
(Million Gallons Per Year)

1999	2000	2001	2002	2003
3,053.00	**2,882.00**	**2,955.40**	**2,881.02**	**2,755.40**

Table 5-2
Historical Maximum Day Demand
(Million Gallons Per Day)

1999	2000	2001	2002	2003
13.55	**12.42**	**12.94**	**13.06**	**11.58**

5.2.1 MWRA Water Supply Agreement

The Town of Framingham first entered into an agreement with the MDC (the MWRA's predecessor) on February 17, 1966 and subsequently with the MWRA in 1989, and 2004. A copy of the most recent agreement is included in **Appendix G.** The current agreement is valid from January 1, 2004 through December 31, 2014.

During the period covered by the agreement, the MWRA agreed to supply the town with water on an annual water volume basis as shown on **Table 5-3**:

Table 5-3
Town of Framingham
MWRA Water Supply Permit
(Million Gallons Per Year)

2005	2006	2007	2008	2009
2,884	**2,895**	**2,989**	**3,052**	**3,103**
2010	2011	2012	2013	2014
3,172	**2,304**	**1,728**	**1,763**	**1,829**

The current agreement specifies a maximum daily water volume of 13.94 million gallons. The MWRA agrees that to make its best efforts to supply water beyond the agreed-upon the maximum allowable in the event of unexpected shortfalls.

5.2.2 Future Water Supply and Demand

Projected future use compiled by the DPW used to establish permitting with the MWRA is noted in **Table 5-4**.

Table 5-4
Projected Water Use for MWRA Agreement
Projected Average Daily Demand
(Million Gallons Per Day)

Water Source	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
MWRA	7.9	7.93	8.19	8.34	8.5	8.69	6.32	4.72	4.83	5.01
Birch Rd. Wells	0	0	0	0	0	0	2.5	4.3	4.3	4.3
Total Demand	7.9	7.93	8.19	8.34	8.5	8.69	8.82	9.02	9.13	9.31

Projected Maximum Day Demand
(Million Gallons Per Day)

Water Source	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
MWRA	12.48	12.53	12.94	13.18	13.43	13.73	13.94	9.25	8.43	8.71
Birch Rd. Wells	0	0	0	0	0	0	0	5.0	6.0	6.0
Total Demand	12.48	12.53	12.94	13.18	13.43	13.73	13.94	14.25	14.43	14.71

It is important to note the projected average and maximum day demands specified in the MWRA agreement are greater than the projected demands specified in Table 5-4.

5.2.3 Birch Road Well Field

The Birch Road Well Field (also known as the "Saxonville wells") consists of three (3) gravel-packed wells that are currently not used. The previously rated capacity of Well #1 was 1.6 mgd, Well #2 was 1.6 mgd and Well #3 was 1.1 mgd for a total combined dependable yield of 2.5 MGD as stated in the 1968 Water Master Plan and the 1978 Water System Analysis Report. All three wells cannot be run simultaneously at their rated capacity to allow for well rest and groundwater recharge.

Each of these wells is expected to be replaced before reactivation of the well field. The target date for wells reactivation is January 2011. The projected supply from the Birch Road well fields is indicated in **Table 5-5**.

Table 5-5
Projected Birch Road Well Field Supply
(Million Gallons Per Year)

2009	2010	2011	2012	2013	2014
0	**0**	**915**	**1,574**	**1,570**	**1,570**

Several factors must be weighed prior to activating the well field. The anticipated new federal Groundwater Rule regulations (described in **Section 9.3.3** of this report) will need to be addressed including virus and bacteria monitoring. Water blending with the MWRA supply must also be evaluated, tested and monitored to ensure that chemical precipitation or undesirable reactions do not occur. The wells must also be operated, maintained and monitored by Framingham staff.

5.3 Water Conservation Plan

Framingham has taken several productive steps to conserve water. Annual leak audits are contracted out by the DPW. All leaks detected during this process are repaired immediately. The last leak detection audit was completed in June 2004. See **Section 3.10** for results. A total leakage rate of 659,000 gallons per day was detected and repaired.

Framingham implemented a water conservation plan on December 20, 2004. Larger users have been identified and contacted to promote water conservation. The block rate structure has been changed to encourage water retrofitting and conservation by larger users. This program has been successful in reducing overall water demand. The water conservation plan is included in **Appendix H**.

One hundred percent (100%) of all services are metered including public buildings. Seventy-eight percent (78%) of the meters are less than 10 years old. The remaining meters more than 10 years old will be replaced when funds are available. The town is also retrofitting public buildings with water saving when funds are available.

Section 6 – Water Quality and Sampling Procedures

6.1 General

The principal law governing drinking water safety in the U.S. is the Safe Drinking Water Act (SDWA) first enacted in 1974. The SDWA authorizes the U.S. Environmental Protection Agency (USEPA) to establish comprehensive national drinking water regulations that protect public health by ensuring drinking water safety.

To this end, both the USEPA and the Massachusetts Department of Environmental Protection (DEP) maintain exacting standards. DEP requires Framingham to perform ongoing tests for the presence of:

- Bacteria
- Lead and other heavy metals
- Herbicides and pesticides
- Industrial solvents

If testing reveals an excess of any of the prior substances, the water supplier is required to notify customers through local news media. If bacteria or chemicals are found at levels that threaten public health, the water supply is treated to remove the contaminants or taken out of service if there is an imminent public health threat.

6.2 MWRA Water Treatment

The Massachusetts Water Resources Authority (MWRA) treats drinking water according to state and federal regulations. Water supplied to Framingham is treated at the new John J. Carroll Water Treatment Plant at Walnut Hill in Marlborough. Water from the Quabbin and Wachusett Reservoirs enters the plant through either the Cosgrove or Wachusett Aqueducts. The following treatment steps are taken when delivering water to the Town:

1. Water is disinfected with ozone gas which is a safe, natural disinfectant derived from oxygen.
2. Chloramines are added to protect water from potential contamination as flows over long distances through pipelines.
3. Sodium bicarbonate is added to adjust pH. This reduces the solubility of metal in domestic plumbing.
4. Fluoride is added to promote healthy teeth.
5. Water leaves the plant through the MetroWest Tunnel.
6. Due to the prior measures, treatment by the DPW is no longer necessary.

6.3 Sampling Practices

6.3.1 Sample Locations

Per Code of Massachusetts Regulations 310 CMR 22.00 Framingham must collect total coliform samples at sites that are typical of water throughout the distribution system. Total coliform is sampled as an indicator of the presence of bacteria known to cause ill-effects on human health. The samples must be collected at sites according to an agreement between DEP and the town. The original agreement originally called for 20 sampling locations, since then, two (2) sampling locations have been discontinued with the approval of the DEP. For each location, three alternative sampling sites have been established to ensure access to adequate sampling locations when necessary. The table on the following page lists all of the approved coliform sampling locations and **Figure 6-1** indicates the sampling location sites.

6.3.2 Sampling Frequency

State DEP regulations stipulate the number of total coliform samples that must be taken every month from the public water system. The sample number is based on the number of people served by the distribution system. Framingham currently has between 59,001 and 70,000 residents. Therefore, 310 CMR 22.00 requires that approximately 80 samples per month must be collected and analyzed for total coliform. **Table 6-1** indicates the minimum number of samples per month as related to population served.

Table 6-1
310 CMR 22.00
Total Coliform Monitoring Frequency
For Community Water Systems

Population Served	Minimum # of Samples per Month
50,001 to 59,000	70
59,001 to 70,000	**80**
70,001 to 83,000	90
96,001 to 130,000	100

Framingham samples weekly for coliform at each sampling location.

6.3.3 Sampling Constituents

In addition to total coliform, all of the sample locations are sampled weekly for:

1. Total Chlorine
2. Free Chlorine
3. Heterotrophic Plate Count (HPC) (Background Bacteria)
4. pH
5. Temperature

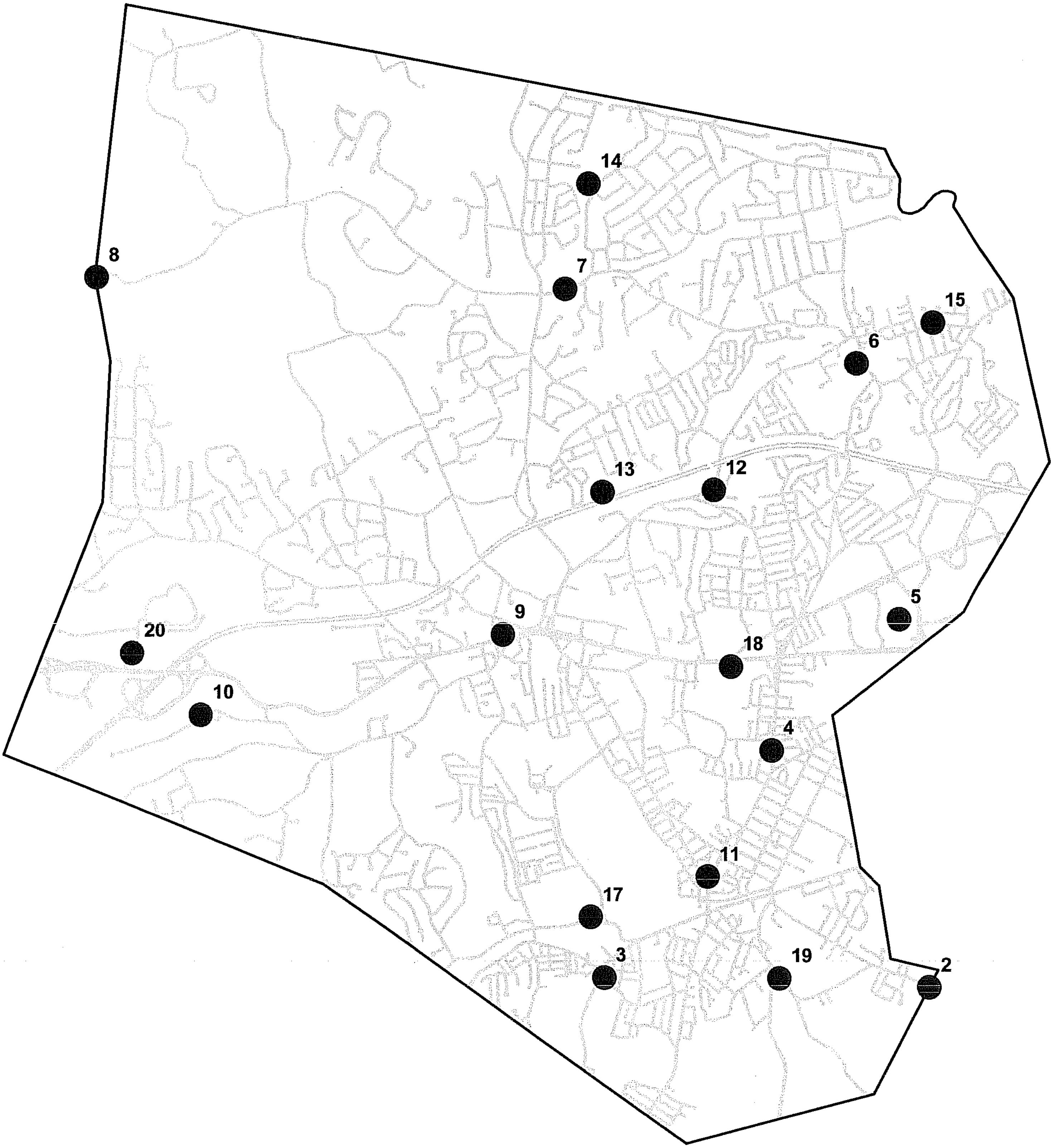
COLIFORM SAMPLING LOCATIONS

SAMPLING POINT	ADDRESS	FEED	SAMPLING FREQUENCY
1. Fire Station (Loring)	Hollis Street	Discon-tinued	Weekly
1a. Car Wash	105 Hollis Street		
1b. Store	205 Hollis Street		
2. Sunshine Dairy	Kendall Ave. Sherborn	**	Weekly
2a. Residence	131 Kendall Ave.		
2b. Geohegan Residence	Kendall Ave. Sherborn		
3. Bethany Convent	57 Bethany Road	**	Weekly
3a. Residence	76 Bethany Road		
3b. Bethany Hospital	97 Bethany Road		
4. Fire Station	520 Concord Street	##	Weekly
4a. Gas Station	506 Concord Street		
4b. Hardware Store	541 Concord Street		
5. Shoppers World	1 Worcester Road	##	Weekly
5a. Lechmere's	400 Cochituate Road		
5b. Post Office	330 Cochituate Road		
6. Fire Station	4 Watson Place	##	Weekly
6a. Antheneum Hall	Concord St. @ Watson Place		
6b. Sewer Pump Station	Watson Place		
7. Fire Station	765 Water Street	**	Weekly
7a. School	745 Water Street		
7b. Cleaners	795 Water Street		
8. Eastleigh Farm	Edmands Road	@@	Weekly
8a. Residence	1147 Edmonds Road		
8b. Chicken Coop	1147 Edmonds Road		
9. Fire Station	1055 Worcester Road	**	Weekly
9a. Office Building	1001 Worcester Road		
9b. Gas Station	1063 Worcester Road		
10. Pumping Station	Goodnow Lane	^^	Weekly
10a. Residence	69 Gates Street		
10b. Residence	20 Goodnow Lane		
11. Memorial Building	Concord Square	**	Weekly
11a. Credit Union	200 Concord Street		
11b. Pharmacy	145 Concord Street		
12. Sewer Station	Central @ Fenwick	##	Weekly
12a. Residence	1 Haynes Road		
12b. Residence	472 Central Street		

SAMPLING POINT	ADDRESS	FEED	SAMPLING FREQUENCY
13. Burger King	Mass Pike of Florita		
13a. Gas Station	Mass Pike of Florita	##	Weekly
13b. Sewer Station	Woodland Drive		
14. Sewer Station	Hemenway Road		
14a. Residence	66 Hemenway Road	**	Weekly
14b. Residence	68 Hemenway Road		
15. New England Sand & Gravel	Danforth Street		
15a. Residence	189 Danforth Street	##	Weekly
15b. Residence	220 Danforth Street		
16. Commercial Building	11 California Ave		
16a. Westinghouse	10 California Ave	Discon-tinued	Weekly
16b. World Gym	4 California Ave		
17. Loring Arena	Fountain Street		
17a. American Maze Products	184 Fountain Street	**	Weekly
17b. Web Converting	160 Fountain Street		
18. Mass State Police Troop A	490 Worcester Road		
18a. Mass Dept. of Public Safety	490 Worcester Road	##	Weekly
18b. Civil Defense Headquarters	400 Worcester Road		
19. Fire Station	Loring Drive		
19a. Store	290 Irving Street	**	Weekly
19b. Donut Shop	292 Irving Street		
20. Health Club	4 California Ave.		
20a. Westinghouse	10 California Ave.	**	Weekly
20b. Restaurant	1699 Worcester Road		

##	feed by Indian Head Tank
**	feed by Merriam Hill Tank
@@	feed by Beebe Tank
^^	feed by Goodnow Ln. Tank

Figure 6-1
Town of Framingham, MA
Sampling Locations



6. Total Trihalomethanes (TTHM)
7. Haloacetic Acids – 5 (HAA5)

6.3.4 Asbestos Sampling

Framingham currently has less than 30 miles of asbestos cement (AC) pipe. According to state regulations, one (1) water sample must be collected annually for the first 3 years of each 9-year recurring monitoring program. This procedure is being conducted by the DPW and no asbestos has been detected.

6.3.5 Chlorine Residual/Free Chlorine

Chlorine residual and free chlorine are also analyzed at every coliform sampling location. Results for each sampling location have been compiled from January 2005 through November 2005. Seasonal variation in chlorine residual has not been identified.

6.4 Water Quality Publications

6.4.1 Consumer Confidence Report

The 1996 Safe Drinking Water Act Amendments require that, beginning in October 1999, all community water systems provide customers with an annual report on the quality of their drinking water. The law calls this a Consumer Confidence Report (CCR). CCRs must include -- at a minimum -- the following elements:

1. The type and source of the water (i.e., ground water, surface water, a combination of the two, or water obtained from another system) and the commonly used name(s) and location of the body or bodies of water.
2. Specific definitions of the following terms: Maximum Contaminant Level Goal (MCLG), Maximum Contaminant Level (MCL), variances, exemptions, and, if applicable, treatment technique and action level.
3. If any regulated substance subject to an MCL (except turbidity and total coliforms) is detected in the water: a statement setting forth the MCLG, the MCL, the highest level used to determine compliance, and the range of detected levels. If there has been a violation of the MCL: a brief statement regarding the health concerns of that substance. If there is no MCL for a detected substance: information about treatment techniques or the action level.
4. If a source water assessment (SWA) has been completed, information on the availability of the SWA and how to obtain a copy must be provided. If a system has received an SWA from its primacy agency, the CCR must also include a brief summary of the system's susceptibility to potential sources of contamination.
5. If a violation occurs, the CCR must identify potential effects on health and what steps have been taken to restore safe water.
6. Information on compliance with national primary drinking water standards.
7. A notice if the system is operating under a variance or exemption and the basis on which the variance or exemption was granted.

8. Information on levels of unregulated substances for which monitoring is required, including levels of radon and *Cryptosporidium.*
9. Educational information regarding the risk posed by nitrates, arsenic and lead when detection of these substances exceeds half of their respective MCL or action level.
10. A specific statement regarding the vulnerability of certain subpopulations, like children or the elderly, to drinking water substances and where these people can obtain additional information.
11. Additional information as required by the EPA Administrator, such as reporting on the health effects of total trihalomethanes if a system exceeds the stricter 80 micrograms/L standard. EPA can also require such information for two other new or revised regulations in the future.
12. Notice in the native language of non-English-speaking residents on the importance of the water quality information and the need to get it translated.
13. A brief and clear explanation about what substances may be reasonably expected to be found in drinking water, including bottled water.
14. A specific statement that the presence of certain substances in drinking water does not necessarily indicate that the drinking water poses a health risk.
15. Notice of opportunities, such as water board meeting times or public forums, for residents to discuss water issues.

A copy of the most recent published CCR is included in **Appendix I**. The Town of Framingham includes the MWRA's Annual Drinking Water Test Results Report to the CCR and distributes both to all its water customers. That Report includes much of the information required in the CCR.

6.4.2 MWRA Annual Drinking Water Test Results

The MWRA publishes an annual report summarizing drinking water quality. The report includes the following:

1. Where source water originates.
2. How the water is treated.
3. Test results including MCLs and violations (if any).
4. Recent system improvements (if any).
5. Information about lead
6. Special notice for the immunologically compromised.
7. List of further resources.

A copy of the MWRA annual report is sent to every MWRA customer in June and is available from the MWRA directly upon request.

Section 7 – Water Distribution System GIS

7.1 General

The town of Framingham is developing a comprehensive Geographic Information System (GIS) program that includes planimetric mapping. The GIS program would feature detailed utility data layers for the water, sewer and drainage systems. The GIS gives the town the ability to collect, display, and manage geographic information throughout the community by utilizing GIS software (ESRI's ArcGIS®). In 2003, BETA began collecting data from the water distribution system in order to map the system using information collected in the field and found in available records. Mapping the water system includes the following features:

- Pipes
- Valves
- Hydrants
- Tanks
- Pressure Zones
- Pump Stations

Water system features will serve as the basis for a townwide water distribution model. In addition to modeling, water system data provides the town with a wide range of other functions such as thematic mapping and project tracking and analysis. The town can also use the system for accounting and record keeping, including GASB 34 financial reporting requirements.

7.2 Base Mapping

The town provided 100-scale base **maps** which were generated by photogrammetric methods over the past several years. Data layers provided by the town's GIS department included parcels, roads, buildings, water bodies, streams, easements and other features. MassGIS developed over the past decade were also used when required to establish a complete base map.

7.3 GPS Data Collection

BETA utilized sub-meter Geographical Positioning System (GPS) technology (Trimble GeoXT® and ProXr®) shown in **Figure 7-1** to locate visible water gate valves, hydrants and other system features throughout the community. Field crews collected x, y, z coordinates on all visible water gate valves and hydrants along with required attribute information, demonstrated in **Table 7-1**. GPS information was then downloaded to the Trimble Pathfinder Office Version 3.0® and post-processed using the 1-second epoch GPS data collected by a stationary base station. **This instrument ensures the accuracy of field locations and other information.** All features were then exported from Trimble Pathfinder Office Version 3.0®, as an ESRI shape file and database file.

Figure 7-1
GPS Unit

Table 7-1
Field Attributes

Hydrant Manufacturer
American Darling (ADV)
Cambridge MV
Corey
Kennedy
Mueller
Rensellear
Unknown

Water Gates	
Gate Type	Water Gate/Hydrant Gate
Damaged	Yes/No

7.4 Mission Planning

Mission planning is the first phase of managing a GPS project. Its objective is to define all significant aspects of the project so that it can be performed effectively and efficiently under all foreseeable conditions. Mission planning allows GPS users to predict satellite availability at each mark and to determine the best observation periods for a given session, given any necessary constraints on PDOP (Positional Dilution of Precision) and on the hours during which the field crew can work.

On several occasions poor satellite reception, inclement weather or other factors stopped or delayed field crews from collecting GPS data. Field crews also determined that a large number of the water gate valves could not be captured because they had been paved over.

In addition, field crews could not gather information about some structures that were blocked by easements or on private property.

7.5 Record Data

BETA obtained information about the water system through public records or people familiar with its workings. BETA used the following information to map the water system:

- A schematic map of the water system which was last updated in 1991.
- 11" x 17" water gate intersection record plans.
- A listing of fixed municipal assets including valves, hydrants and mains.
- Water service tie cards record.
- Design plans from larger projects.
- Maintenance records.
- Pump station plans.
- Water tank records.
- Other information obtained directly from DPW personnel.

This project also included scanning available Water Service Connection Cards. Each side of available Service Cards was scanned into a unique ".tif" file format and saved. Service Card account number. Scans were then reconciled into the town's MUNIS accounting database and parcel layer to provide a hyperlink in ArcMap® and VueWorks®. This connection allowed for specific Service Cards to be queried via the parcel layer and viewed on screen. Service Cards could also be printed if required.

7.6 Water System Network Automation and Attribution

BETA created a geometric water system network based on the previously mentioned GPS system point features. Water pipe connections were based on available source material, planimetric data, recorded plans and additional information provided by town staff. In addition to a water pipe layer, other water system features were constructed digitally as part of the automation effort. This included the creation of the following:

- Service Pipe Ends
- Crossings
- Pipe Ends
- Water Emergency Connections
- Water Supply Locations
- Aqueduct
- Valve Chambers
- Hydrant Laterals

The pipe network was created in ArcMap by creating a water main between two nodes (water system gate valves) and attaching associated data gathered from the record plans or other sources. Attributes, as required for this task, were collected from various records and inserted into the GIS database. Additional attribute data was provided by the town in the absence of record information.

The record plans mentioned above were used as the initial reference for water pipe connectivity and data coding. DPW personnel later indicated that these records were not entirely accurate and recommended using the schematic system map (prepared by Haley & Ward) as the main reference for data and pipe connectivity. With this information, pipe layers in the schematic system map were used as a guide for pipe connectivity and attribute data.

Later in the process, DPW personnel indicated that the majority of the 11" x 17" records were correct and should be used for system generation. The final steps of the initial process added configuration and attribute data which were refined using the 11" x 17" record information and the Fixed Asset Management Report (a listing of water system assets published in April, 1992). Attribute data was populated and pipe connectivity was adjusted. Valves that were indicated on the 11" x 17" plans that were not collected via GPS were also added and coded as such. These valves were assumed to be paved over and were scheduled to be collected by town staff over a period of time.

Some information was unavailable or conflicted with record information. To address this issue, draft plots were created and distributed to the town for verification of configurations, sizes, locations, etc. in an attempt to increase system information accuracy. Information was periodically updated and uploaded to the VueWorks System®. Data layers (shapefiles) that were generated and the creation sources are indicated in **Table 7-2.**

7.7 Current GIS System Contents

System data provided on VueWorks® consists of the most up-to-date information available at the time of this report. Data also provides links to documents such as the 11" x 17" record plan scans (through the gate valves) and the Service Card scans (via parcels). The current number of features/miles in each GPS based layer is presented in **Table 7-3.**

Table 7-2
Generated Data Layers

Coverage		Extent
Water Emergency Connections	-	Locations
Parcels	-	Locations
Pressure Districts	-	Boundaries
Water Ends	-	Locations
Water Junctions	-	Locations
Hydrant Laterals	-	Locations
Hydrants	-	Type
	-	Manufacturer
Water Gates	-	Type
	-	Age
	-	Category
	-	Damaged
	-	Opening Direction
	-	Number of Turns
	-	Plan Number
Hydrant Gates	-	Damaged
	-	Opening Direction
	-	Number of Turns
Water Pipes	-	Diameter
	-	Material
	-	Length
	-	Date of Installation
Water Supply	-	Locations
	-	Elevation
	-	Name
Aqueducts	-	Locations
Valve Chambers	-	Locations

Table 7-3
Approximate Water System Pipe Assets

No. Water Gates	No. Hydrant Gates	No. Hydrants	Miles of Water Main
4,166	**1,554**	**2,190**	**280**

7.8 Future Applications

The town's GIS Department has been assigned to manage all of the water system data, including the GPS data collection activities and system updates. This data will allow the DPW to track maintenance records and record inconsistencies found in the field through the GIS. All new updates and projects would need to be entered into the system in order to maintain a up-to-date system map.

Section 8 – System Operation and Maintenance

8.1 General

The objective of water system maintenance is to obtain continuous service at the lowest possible cost to the community. Both preventative and corrective maintenance are necessary to ensure reliable, continuous operation.

One of the most important components of a successful operation and maintenance program is record keeping. System records must be sufficient to document the system's facilities, their condition, completed and proposed maintenance, problems found and corrective measures taken. The newly developed Framingham GIS system can easily be used for these purposes once procedures are is implemented to collect important information and then update the GIS system.

8.2 Pump Station Maintenance

The DPW has consistently inspected and maintained water pump stations on a daily basis for many years. This practice should continue. Inspection and maintenance is based partially on the pumps' ages, operating hours, maintenance history and demand requirements. The town is planning to allocate funds to replace pumps as they approach the end of their useful lives and/or to improve demand servicing.

The town's SCADA (Supervisory Control and Data Acquisition) system allows operators at the DPW headquarters and from portable laptops to monitor each station's status and to track important information that can be analyzed to measure operating trends and improve efficiency. The town has also implemented a remote control system to optimize pump utilization. Station requirements for upgrading of pumps and controls are recommended in **Section 12** of this report.

8.3 Water Storage Facilities Maintenance

The most recent inspection water storage tanks was conducted in November 2004. Several deficiencies, which were found during the investigation, are presented in **Section 12** of this report. All recommendations should be completed as soon as capital and operating budgets allow.

A permanent tank inspection schedule is recommended to ensure proper tank maintenance. The town currently owns six (6) storage tanks in five (5) locations. According to industry standards, the DPW should inspect at least one location each year with the goal of inspecting all of the tanks every five years.

8.4 Water Main Maintenance and Disinfection

8.4.1 Unidirectional Flushing Program

The main benefits of a uni-directional flushing program are identifying operational problems in hydrants and valves, flushing rust and bacteria from the system and improving water quality. Unidirectional flushing removes the greatest amount of rust and bacteria by increasing water velocity through the pipe while reducing the amount of water necessary.

The system should be flushed in sections to maximize control of the source water while yielding the greatest velocity in the main. A complete system map including valve and hydrant locations is necessary to effectively implement the program. The following critical points should be considered:

1) Flushing should begin at either the pump stations or tanks depending on the ability of each pump station to provide the required flow rate. Fresh water should always be used to flush stagnant water.
2) A large main should not be flushed from a single smaller main to ensure adequate water volume for effective flushing.
3) Fire hydrants should be flushed until the volume of water in the main for that flushing area is replaced or until the water runs clear, whichever is longer.
4) To avoid stirring up the system, only water from clean areas or large mains should be directed into secondary pipes.
5) Water should be kept moving in one direction.
6) The flow from the hydrant should be proportionate size of the pipe being flushed. Water velocities between 4-5 feet per second are considered optimal to remove sediment and prevent pipe damage due to unreasonably high velocities. To achieve adequate flushing velocity, it may be necessary to open more than one hydrant port or open more than one hydrant to achieve an adequate flushing velocity. **Table 8-1** indicates the ideal hydrant flow rates for each water main based on its size.

Table 8-1
Required Uni-Directional Hydrant Flows (gpm)

Flushing	**Pipe Diameter (in)**						
Velocity (fps)	**6**	**8**	**10**	**12**	**14**	**16**	**24**
4	352	626	979	1,409	1,918	2,506	5,638
5	440	783	1,223	1,762	2,398	3,132	7,047

Flushing can be accomplished with a two person crew and is best conducted at night to minimize the number of rusty water complaints and traffic complications. Residents should be informed about flushing in their area ahead of time.

Presently, Framingham does not have an organized system flushing program. A program is being developed but details are not yet available.

8.4.2 Disinfection

Disinfecting water mains is extremely important in meeting the total coliform rule. Currently, all new water mains must be disinfected and sampled to meet AWWA (American Water Works Association) specifications. Sample results are considered acceptable if the total coliform count is zero and the heterotrophic plate count (HPC, or background bacteria) is less than 500.

Disinfecting water mains under repair is just as important as disinfecting new water mains. Whenever repairs are made, it is critical to keep soil and groundwater out of the pipe. All pieces used for repairs should be swabbed with a 4% chlorine bleach solution and the main should be flushed out of the nearest hydrant to remove chlorine and debris.

8.4.3 Pipe Coupons

A pipe coupon is a short length of functioning water main that is removed and inspected to determine the interior condition of the pipe in that general location. Pipe coupons should be taken during repairs, whenever practicable, to determine the likely condition of other pipes in that immediate area. Photos of the coupon should be taken and logged and the pipe condition should be entered into the GIS system.

8.4.4 Replacement/Rehabilitation of Unlined Mains

All pipes installed before 1928 are made of unlined cast iron pipe. It is possible that pipes installed after this are also made unlined cast iron, but there are no records to confirm this. Most older pipes have a reduced flow capacity due to tuberculation and this condition will continue to deteriorate as metallic salts continue to deposit inside the pipes.

There is also the possibility that exterior corrosion has weakened pipes making them more susceptible to breakage, especially at high pressures. In older pipes, leakage through joints and services is also more prevalent in older pipes due to soil settlement and corrosion of materials. If a pipe is significantly corroded or weakened in any way, the town should consider full replacement.

Tuberculation buildup in pipes also increases the demand for free chlorine. A decrease in free chlorine reduces system's ability to disinfect; thereby reducing the overall quality of water delivered to users farthest from the sources. Tuberculation also causes rusty water during hydrant flushing.

Recommended practices for maintaining the water system include a program of either cleaning and lining unlined pipe or replacing them with new cement-lined ductile iron pipe. To improve fire suppression capabilities, pipelines with a diameter of 6 inches and should be replaced with a minimum of 8-inch diameter pipes as recommended by the AWWA. During the cleaning and lining process, all valves, hydrants and - in many cases - all services should be replaced. Cleaning and lining is generally the less expensive option than replacing the pipeline. However; planners must consider the structural condition of old pipes as weakened pipes need to be replaced.

Several old mains listed in **Table 3-2** have already been cleaned and lined.

8.5 Valve Maintenance

Valve maintenance plays a crucial role in the operation and maintenance of the overall system. AWWA recommends that valves on large and feeder mains be checked annually with the remainder inspected every two to three years. The following steps should be taken during inspections:

- Locate gate box and verify its location with the GIS system.
- Remove gate box cover and inspect for damage.
- Ensure gate box is clear of debris. Clean out the box if necessary.
- Fully close and open the gate and note of the number of turns needed to close it.
- Check for leaking seals.
- Enter the date of inspection, valve condition and number of turns into the GIS database.
- Repair and replace the box and valve if necessary.

Valve turning can be accomplished manually or with an automatic valve turner. Numerous valves in town are more than 100 years old and may not function properly. The town should be aware of and prepared for the possibility of valve failure when it's in the closed position. It is recommended the valve maintenance program coincides with the unidirectional flushing program.

8.6 Hydrant Maintenance

Hydrants throughout Framingham vary widely in age and operational status. During a 2004-2005 hydrant maintenance program, approximately 85 malfunctioning hydrants throughout the town were replaced. The total number of additional hydrants requiring replacement is not known.

Ideally, every hydrant in town should be inspected twice a year in the spring and fall. Since there are more than 2,100 town-owned hydrants, it is not practicable to inspect all hydrants twice annually. However a comprehensive annual hydrant inspection program should be undertaken. Each hydrant should be fully opened and checked for proper drainage, leakage, number of turns for opening and closing, difficulty of turns, corrosion, condition of the caps and flow rate. Once gathered, the information should be added to the GIS system.

The hydrant inspection program can be used in conjunction with Fire Department system maintenance activities. The hydrant inspection program can and is recommended to coincide with the unidirectional flushing program.

8.7 Service Connections

The majority of residential service connections in Framingham are either steel or plastic. However, most services installed since 2003 are copper. Most of the lead service pipes have been found and removed, but it is possible some lead service pipes remain. Numerous service pipes are "green pipe" steel which is notorious for corrosion and leakage.

In 2004 and 2005, 1,100 feet of new copper services were installed throughout town to replace failing and lead services as part of the hydrant replacement contract. The town's current policy is to remove lead services to the property line when they are discovered and notify homeowners that the service was detected and removed.

8.8 System Reliability and Redundancy

For a water distribution management plan to be effective, its critical components and reliability must be examined. Planners should analyze the supply, pumping, storage and distribution system components to determine the effect of losing one or more elements. Due to recent concerns about confidentiality and vuenerability, the exact critical system components are not **identified** in this Water Master Plan.

8.9 Emergency Planning (Emergency Response Plan)

Framingham currently has an Emergency Response Plan (ERP) for its water system. The town commissioned SEA Consultants Inc. to prepare a report titled "Framingham Water System Emergency Response Plan, June 2004" to meet State DEP requirements for all communities to develop ERPs. The report detailed specific, customized responses for emergencies. The ERP also identifies potential emergency situations and outlines procedures to provide a continuous supply of safe water to the residents of Framingham.

8.10 Leak Detection Program

The latest leak detection survey was conducted by FlowMetrix, Inc. in June and September of 2004. The survey covered 255 miles of water main throughout the town. The survey pinpointed 24 leaks including 5 mains, 13 services and 6 valves or hydrants. The detected leaks totaled 458 gallons per minute which represents 240.7 million gallons annually. The DPW repaired all of these leaks soon after they were detected.

Continuation of the water leak detection program will benefit Framingham. An effective program will minimize leakage, reduce water demand, assure accurate revenue collection and keep the system in good working order. The State DEP recommends the entire distribution system be checked for leaks every other year but at the very least every five (5) years.

8.11 Water Audit/Meter Upgrades/Replacement Program

A water audit procedure involves checking the town's master meters and selected private and public meters to determine the approximate amount of water lost through leakage and malfunctioning meters. To ensure the town collects proper revenue, it is crucial consumer water use is measured accurately. To this end, inaccurate meters should be upgraded and/or replaced.

By improving accuracy for revenue collection, replacing imprecise meters often pays for itself depending on their age. The town has been considering a meter modernization program that includes a remote radio "read" feature that allows automatic readings to be taken from a vehicle without requiring house-to-house visits.

As part of the water audit, hydrant flows should be metered and recorded when possible.

8.12 Cross Connection Protection Program

To protect the water system from non-potable water contamination, the town is required by Massachusetts regulation 310 CMR 22.22 to have an active cross connection protection program (CCPP). This cross connection protection program is discussed in detail in **Section 3.11.**

Section 9 – Current and Future Drinking Water Regulations

9.1 General

Current Massachusetts drinking water regulations are described in detail in 310 CMR 22.00 under the Guidelines and Policies for Public Water Systems. These regulations are based on the United States Environmental Protection Agency (USEPA) regulations required by the Safe Drinking Water Act (SDWA). The majority of the information presented in this Section found on the USEPA SWDA website. This Water Master Plan includes all applicable updated regulations through May 2006. The National Primary and Secondary Drinking Water Standards are included in **Appendix J**.

9.2 Current Regulations

DEP has established standards and guidelines for testing and monitoring drinking water quality that apply to the Town of Framingham's water distribution system. DEP will modify these when necessary to comply with future federal and state regulations.

9.2.1 Current Massachusetts Drinking Water Standards and Guidelines

The entire 14-page "Spring 2006 Standards and Guidelines for Contaminants in Massachusetts Drinking Waters" document from DEP is included in **Appendix K**. This document summarizes updated modifications to those standards and guidelines. MADEP updates this document annually.

9.2.2 Current Massachusetts Drinking Water Testing Requirements

Appendix L includes a 6-page document from the DEP entitled "Summary of Massachusetts Drinking Water Program Testing Requirements for Public Water Systems" which was last updated in December 2003. This document summarizes the full range of testing requirements necessary to ensure municipal water systems comply with USEPA and DEP regulations.

9.2.3 Arsenic

The SDWA requires USEPA to revise the level for arsenic in drinking water from the current 50 parts per billion (ppb) standard to the stricter 10 ppb. Since the USEPA adopted the new standard on January 22, 2001, public water systems are obligated to comply with the new 10 ppb standard after January 23, 2006. The applicable regulation is included in **Appendix M.**

9.2.4 Asbestos Cement Pipe

Under the USEPA Phase II Synthetic Organic Chemical/Inorganic Chemical (SOC/IOC) Rule, all community public water systems (PWS) are required to monitor for asbestos in the distribution system every nine (9) years, starting in the first three (3) years of the 9-

year monitoring period, unless a waiver is granted. **Appendix N** includes the DEP asbestos monitoring requirements which were last updated in April 2005.

Source Sampling

Currently, a statewide waiver has been approved that exempts Public Water Systems (PWS) in Massachusetts from sampling for asbestos at the water source.

Distribution System Asbestos Sampling

Table 9-1 includes the current distribution system asbestos sampling requirements for a PWS with a population of greater than 1,000.

Table 9-1
Asbestos System Sampling Requirements
By Size of System

1 Sample	0.01 to 30 miles of AC pipe
2 Samples	30 to 60 miles of AC pipe
3 Samples	>60 miles of AC pipe

Since Framingham currently has less than 30 miles of AC pipe; a sample from a tap must be collected and analyzed each year for the first three (3) year monitoring period of each 9-year sampling/monitoring program. Future asbestos monitoring regulations are not known at this time.

9.2.5 Total Coliform

Detailed coliform testing requirements are stipulated in "310 CMR 22.05 DEP Maximum Microbiological Contaminant Levels, Monitoring Requirements, and Analytical Methods". This document is included in **Appendix O**. Specific requirements for Framingham were discussed in Section 6.3

9.2.6 Lead and Copper

EPA recently completed a year-long review of the 1991 Lead and Copper Rule. No changes to the regulations have been proposed as of June 2006. But proposed actions may include changes in monitoring, treatment processes, customer awareness, lead service line management and lead in schools. A quick reference guide for the current Lead and Copper Rule can be found in **Appendix P**.

9.2.7 Disinfection Byproducts (DBPs)

General

On January 4, 2006, USEPA promulgated the new Stage 2 Disinfectants and Disinfection Byproducts Rule (Stage 2 D/DBPR) to reduce disease incidence associated with the disinfection byproducts (DBPs) that form when disinfectants are added to public water supply systems. The Stage 2 D/DBPR supplements existing regulations by requiring water systems to meet disinfection byproduct Maximum Contaminant Levels (MCLs) at each monitoring site in the distribution system. The Stage 2 D/DBPR also contains a risk-targeting approach to improve identification of monitoring sites where customers are exposed to high levels of DBPs. By reducing DBP exposure, this regulation will result in lower cancer, reproductive and developmental risks. The Stage 2 D/DBPR schedule for implementation of elements of the Rule is included in **Appendix Q**. Additional information is included in **Appendix R.**

Initial Distribution System Evaluation (IDSE)

Under the Stage 2 D/DBPR, communities must perform an Initial Distribution System Evaluation (IDSE) of their distribution system to identify locations with high DBP concentrations. These locations will then be used as the sampling sites for DBP compliance monitoring for the system.

Based upon size of the community, Framingham will be required to complete the following IDSE-related tasks within the following timelines:

- Submit an IDSE monitoring plan, system-specific study plan, or 40/30 certification by April 1, 2007.
- Complete an IDSE by March 31, 2009.
- Submit an IDSE report by July 1, 2009.
- Begin subpart V (Stage 2) compliance monitoring by October 1, 2012.

Massachusetts is allowed to grant up to an additional two years for systems making capital improvements.

Locational Running Annual Average

Under the Stage 2 D/DBPR, each monitoring location in the town's distribution system must comply with the maximum contaminant levels for two groups of disinfection byproducts (total trihalomethanes (TTHM) and haloacetic acids (HAA5)). Called the locational running annual average, this approach differs from prior requirements which determined compliance by calculating the running annual average of samples from all monitoring locations throughout the system.

Other Requirements

The Stage 2 D/DBPR also requires systems to determine if they are experiencing short term peaks in DBP levels which are referred to as "significant excursions." Systems experiencing significant excursions will be required to review their operational practices and work with their State to determine actions that may be taken to prevent future excursions.

9.2.8 Long Term 2 Enhanced Surface Water Treatment Rule (LT2)

On January 5, 2006, the Long Term 2 Enhanced Surface Water Treatment Rule (LT2) was promulgated to improve drinking water quality and protect users from disease-causing microorganisms and contaminants that can form during drinking water treatment. Pathogens, such as Giardia and Cryptosporidium, are often found in water and can cause significant health risks.

LT2 applies to surface water reservoirs such as the Quabbin and Wachusett Reservoirs, or ground water that is affected by surface waters. Accordingly, MWRA is currently responsible for compliance with LT2 for the potable water supplied to Framingham. However, prior to bringing the Birch Road wells on line, Framingham must determine whether those wells are affected by any surface. If so, the town will be required to monitor the wells' output to comply with LT2. A fact sheet on LT2 is included in **Appendix S.**

9.2.9 Radionuclides

Groundwater that moves through fractures in bedrock, that groundwater may become exposed to naturally-occurring radioactive materials (radionuclides) which dissolve easily in water. Drinking water containing radionuclides above certain specified levels presents a health concern. Therefore, MADEP has set limits on for those elements in drinking water and has recently established a higher threshold for one category of radionuclide.

Table 9-2 presents recent changes to radionuclide MCLs.

Table 9-2
Radionuclide MCLs

Radionuclide	2005 Standard	2006 Standard
Compliance Gross Alpha	15 pCi/L	15 pCi/L
Radium 226 + Radium 228	5 pCi/L	5 pCi/L
Uranium	None	30 ug/L

9.3 Future Regulations

9.3.1 Aldicarb

Aldicarb is a white crystalline solid with a sulfurous odor. Aldicarb is an insecticide applied to the soil for control of chewing and sucking insects like aphids and on nematodes. It is used in greenhouse and outdoor ornamentals, and on crops: primarily cotton, but also sugar beet, strawberries, potatoes, onions, hops, and others. The current MCL (Maximum Contaminate Limit) is 3ppb. Samples must be taken quarterly for any new well start-up.

9.3.2 Total Coliform Rule (TCR)

The TCR requires all public water systems (PWSs) to monitor for the presence of total coliforms in the distribution system. Total coliforms are a group of closely related bacteria that are (with few exceptions) not harmful to humans. Because total coliforms are common inhabitants of ambient water and may be injured by environmental stresses (e.g., lack of nutrients) and water treatment (e.g., chlorine disinfection) in a manner similar to most bacterial pathogens and many viral enteric pathogens, EPA considers them a useful indicator of these pathogens. More important, for drinking water, total coliforms are used to determine the adequacy of water treatment and the integrity of the distribution system. The absence of total coliforms in the distribution system minimizes the likelihood that fecal pathogens are present. Thus, total coliforms are used to determine the vulnerability of a system to fecal contamination.

An update to this regulation is currently under consideration and the proposed rule is expected mid 2006 and final promulgation is anticipated in 2010. **Appendix T** contains a fact sheet about the current TCR.

9.3.3 Groundwater Rule

USEPA is proposing a rule which specifies the appropriate use of disinfection in ground water and addresses other components of ground water systems to assure public health protection. The Ground Water Rule (GWR) establishes multiple barriers to protect against bacteria and viruses in drinking water from ground water sources and will establish a targeted strategy to identify ground water systems at high risk for fecal contamination. The GWR is scheduled to be issued as a final regulation in August 2006. A fact sheet providing details for the proposed GWR is included in **Appendix U**.

- System sanitary surveys conducted by the State and identification of significant deficiencies;
- Hydrogeologic sensitivity assessments for undisinfected systems;
- Source water microbial monitoring by systems that do not disinfect and draw from hydrogeologically sensitive aquifers or have detected fecal indicators within the system's distribution system;

- Corrective action by any system with significant deficiencies or positive microbial samples indicating fecal contamination; and
- Compliance monitoring for systems which disinfect to ensure that they reliably achieve 4-log (99.99 percent) inactivation or removal of viruses.

The proposed requirements are discussed in greater detail below:

Sanitary Surveys

Applies to: All ground water systems

Frequency: Every 3 years for community water systems; 5 years for non-community water systems, consistent with the 1998 Interim Enhanced Surface Water Treatment Rule (Community water systems serve the same populations year round, e.g., houses and apartment buildings. Non-community water systems do not serve the same people year round, e.g., schools, factories, office buildings, hospitals, gas station and campgrounds.)

Key components:

1. State must perform each system's sanitary survey and satisfy the eight elements from the joint USEPA and Association of State Drinking Water Administrators guidance.
2. State must have authority to enforce corrective action requirements.
3. State must provide a list of significant deficiencies in the system requiring corrective action within 30 days of identification.

Hydrogeologic Sensitivity Assessment

Applies to: All ground water systems which do not provide 4-log (99.99%) virus inactivation/removal

Frequency: One-time assessment of sensitivity should be made within six years of the final rule's publication for community water systems and within eight years for non-community water systems. Sensitive systems must monitor monthly (see below).

Key components:

1. State must conduct a one-time assessment of all systems that do not provide 4-log virus inactivation/removal to identify those systems located in sensitive aquifers.
2. USEPA considers karst, gravel, or fractured bedrock aquifers to be "sensitive" to microbial contamination. States may waive source water monitoring for sensitive systems if there is a hydrogeologic barrier to fecal contamination.

Source Water Monitoring

Applies to: Ground water systems that are sensitive or have contamination in their distribution system ("triggered monitoring") and do not treat to 4-log removal or inactivation of viruses

Frequency: Monthly for sensitive systems; once for triggered monitoring

Key Components:

1. Routine Monitoring. For systems determined by the State to be hydrogeologically sensitive, the system must conduct monthly source water monitoring for fecal indicators. Sampling frequency may be reduced after twelve negative samples.
2. Triggered Monitoring. If a total coliform-positive sample is found in the distribution system, then the system must collect one source water sample and monitor for a fecal indicator.

Corrective Actions

Applies to: Ground water systems that have a significant deficiency or have detected a fecal indicator in their source water

Frequency: Correct within 90 days or longer with a State-approved schedule

Key components:

1. Significant Deficiency or Source Water Contamination - If a ground water system is notified of significant deficiencies by the State, or notified of a source water sample positive, within 90 days it must correct the contamination problem by eliminating the contamination source, correct the significant deficiencies, provide an alternative source water or install a treatment process which reliably achieves 4-log removal or inactivation of viruses. A system may take longer than 90 days for corrective action with a State-approved plan. Systems must notify the State of completion of the corrective action or the State must confirm correction within 30 days after the 90 day period or scheduled correction date.
2. Treatment - Systems providing treatment must monitor treatment to ensure at least 4-log virus inactivation and/or removal.

Compliance Monitoring

Applies to: Applies to all ground water systems that notify States they disinfect in order to avoid source water monitoring, and to systems which disinfect as a corrective action.

Frequency: Systems serving less than 3,300 must monitor disinfection treatment once daily, while systems serving 3,300 or more people must monitor their disinfection treatment continuously.

Key components:

1. If monitoring shows the disinfection concentration to be below the required level, the system must restore the disinfection concentration within 4 hours or notify the State.

9.3.4 MTBE

Massachusetts currently has an advisory SMCL of 0.020-0.040 for MBTE.

As part of implementing the SDWA Amendments of 1996, the Office of Water has placed MTBE on the drinking water Contaminant Candidate List (CCL) for further evaluation to determine whether or not regulation with a National Primary Drinking Water Regulation (NPDWR) is necessary. The CCL divided the contaminants among those which are priorities for additional research, those which need additional occurrence data, and those which are priorities for consideration for rulemaking. The Agency determined that MTBE needs more health effects research and occurrence data before a regulatory determination can be made. Information gathered from the Agency's research and data collection efforts will assist our regulatory determination.

In addition, MTBE has been included in the final Unregulated Contaminant Monitoring Regulation that will require all large public water systems and a statistical sampling of small and medium public water systems to monitor and report the presence of MTBE in their water supplies.

As an additional interim measure, USEPA responded to requests for guidance by reviewing and updating an advisory for MTBE in December 1997. This Drinking Water Advisory: Consumer Acceptability and Health Effects Analysis provides guidance to communities that may become exposed to drinking water contaminated with MTBE. The advisory recommends control levels that prevent adverse taste and odor (i.e. 20 to 40 parts per billion). Managing water supplies to avoid the unpleasant taste and odor effects at levels in this range also provides protection against any potential adverse health effects with a very large margin of safety.

9.3.5 Perchlorate

Perchlorate (ammonium perchlorate) is both a naturally occurring and man-made chemical. Most of the perchlorate manufactured in the United States is used as the primary ingredient of solid rocket propellant and also as an ingredient in some explosives. Wastes from the manufacture and improper disposal of perchlorate-containing chemicals and from blasting during excavation activities are increasingly being discovered in soil and water.

USEPA has established an official reference dose for perchlorate which is consistent with the recommended reference dose included in the National Academy of Science's January 2005 report. A reference dose is a scientific estimate of a daily exposure level that is not expected to cause adverse health effects in humans. The reference dose will be used in

USEPA's ongoing efforts to address perchlorate in drinking water. It is important to note that the reference dose in USEPA's draft assessment represents a preliminary estimate of a protective health level and is not a drinking water standard.

MADEP is proposing a perchlorate standard much more stringent than the proposed USEPA standard. The proposed MADEP MCL is 2 ppb and is currently under consideration. The public hearing and comment period was completed in May, 2006. A perchlorate fact sheet can be found in **Appendix V**.

9.3.6 Sulfate

Sulfate is a substance that occurs naturally in drinking water. Health concerns regarding sulfate in drinking water have been raised because of reports that diarrhea may be associated with the ingestion of water containing high levels of sulfate. Of particular concern are groups within the general population that may be at greater risk from the laxative effects of sulfate when they experience an abrupt change from drinking water with low sulfate concentrations to drinking water with high sulfate concentrations.

Sulfate in drinking water currently has a secondary maximum contaminant level (SMCL) of 250 milligrams per liter (mg/L), based on aesthetic effects (i.e., taste and odor). This regulation is not a Federally enforceable standard, but is provided as a guideline for States and public water systems. USEPA estimates that about 3% of the public drinking water systems in the country may have sulfate levels of 250 mg/L or greater.

Sulfate is one of the 50 chemical and 10 microbiological contaminants/contaminant groups included on the Drinking Water Contaminant Candidate List published on March 2, 1998 (63 FR 10273). SDWA, section 1412 (b)(12)(B)(ii), directs USEPA to include sulfate among the five or more contaminants for which the Agency will determine whether or not to regulate.

USEPA will be further evaluating the two documents, analyzing all public comments on the documents, reviewing all comments on its previously proposed National Primary Drinking Water Regulation for sulfate (December 20, 1994; 59 FR 65578) and reviewing any other pertinent information that could have a bearing on its decision of whether or not to regulate sulfate as a NPDWR. In so doing, USEPA will be evaluating whether or not the statutory tests provided at Section 1412(b)(1)(A) of SDWA for proceeding with such regulation are met:

- "....the contaminant may have an adverse effect on the health of persons;
- the contaminant is known to occur or there is a substantial likelihood that the contaminant will occur in public water systems with a frequency and at levels of public health concern; and
- in the sole judgment of the Administrator, regulation of such contaminant presents a meaningful opportunity for health risk reduction for persons served by public water systems."

9.3.7 Contaminant Candidate List 2 (February 23, 2005)

The most recent EPA drinking Water Contaminate Candidate List information is located in **Appendix W**. These regulations change regularly and should be frequently reviewed.

Section 10 – Security

10.1 General

The Public Health and Bioterrorism Preparedness and Response Act (P.L. 107-188) was signed into law on June 12, 2002. This Act amends the Safe Drinking Water Act (SDWA) by adding Section 1433. The amended SDWA requires public water suppliers to prepare a Vulnerability Assessment (VA) and an Emergency Response Plan (ERP). The VA was prepared in December 2003 by SEA Consultants, Inc. and the subsequent ERP was prepared by SEA Consultants Inc. and submitted to the town in June 2004. Due to security considerations, this Section includes a broad, non-specific summary of the contents of the VA and ERP.

10.2 Vulnerability Assessment

As its name suggests, the VA assesses potential risks to the water distribution system and identifies possible methods to protect. The VA also serves as a benchmark for establishing the level of security needed for the existing system. The VA is a confidential document and is only summarized and discussed in general in this Water Master Plan.

The Doeskin Hill water distribution system was not included in the VA because it was not completed until after the VA had been submitted to the Town. The VA should be amended to include this station as soon as possible.

The prioritized objectives for the Framingham water system addressed in the VA are:

1. Protection of employees and the public.
2. Adequate supply for fire fighting and sanitation.
3. Consumptive value to the end user.

In order to accomplish those objectives, the VA included the following:

- A Threat Assessment
- Vulnerabilities Identification
- A Consequences Assessment
- A Risk Analysis

10.2.1 Threat Assessment

A Threat Assessment (TA) evaluates actual and potential threats to the system based on available intelligence, information from local, state and national law enforcement, and information from town employees. As part of the TA, a Threat Spectrum was developed to identify degrees and categories of threat to the water system.

10.2.2 Vulnerabilities Identification

The water system was evaluated to identify potential vulnerabilities including: security weaknesses chemical contamination risks; and SCADA deficiencies. Other areas of evaluation included security for pump stations, DPW operations, communications, storage and the water supply. A detailed list of security practices and deficiencies was prepared for each pumping station and storage tank.

10.2.3 Consequence Assessment

The Consequence Assessment (CA) analyzed the outcome of losing elements of the water distribution system to assist the town in prioritizing security measures to protect them and restore service. Each asset was categorized as having a "Low", "Medium", "High" or "Very High" consequence based on human effects, financial cost, probable duration of loss and number of customers impacted by disruptions.

10.2.4 Risk Analysis

The Risk Analysis (RA) identifies potential weaknesses in the water system infrastructure. It suggests specific security upgrades for each asset in the system as well as for overall operations. The RA also compares the relative significance of suggested upgrades within the system.

10.3 Emergency Response Plan

The ERP provides a comprehensive response document which suggests appropriate responses during emergencies. The plan contains detailed procedures for the DPW and town emergency staff and outside agencies to implement quickly and efficiently during water supply emergencies. The ERP is a confidential document and is only summarized and discussed in general in this Water Distribution System Master Plan.

The ERP contains samples of forms to be distributed to end users, regulatory agencies and the media. It identifies initial response procedures to be implemented in the event of an emergency. The report details step-by-step procedures, including specific actions, on dealing with routine to major problems in the entire water system. The ERP also contains step-by-step procedures on dealing with a water quality emergency including coliforms and Maximum Contaminant Level (MCL) violations.

Section 11 – Distribution System Analysis

11.1 General

The section is designed to assess the current condition of the water system, identify deficiencies and recommend improvements. Recommendations are intended to improve the efficiency, water quality and fire protection capability of the system.

To evaluate the distribution system, a water system model was created to simulate and assess steady state and extended flow conditions. The simulations were based on existing and projected flow conditions during average and maximum demand days.

11.2 Assumptions

Analysis of the distribution system assumed that only current active facilities were in service. Recommendations in this section are based on observations of the system, information from the DPW and the results of the analysis.

Cast iron pipe installed prior to 1928 was assumed to be in some state of tuberculation except those that had been previously cleaned and lined. For the model, gate valves were initially assumed to be open except for zone division gates. The model was run using the current operating conditions and did not include the Birch Road wells.

According to AWWA standards, the system is considered adequate if a minimum pressure of 35 psi is provided to all areas during peak hours. During a "maximum'' day when water is used for fire fighting, the system is considered adequate if a minimum pressure of 20 psi exists at the fire location and a minimum pressure of 30 psi is provided at all other locations in the system. These operating conditions were used as the basis for the analysis and formulation of recommendations in this section.

11.3 Field Testing

Field testing is an important part of a water distribution system analysis. After results from the field tests are compared to results obtained from the model, the model is then calibrated to reflect actual field conditions.

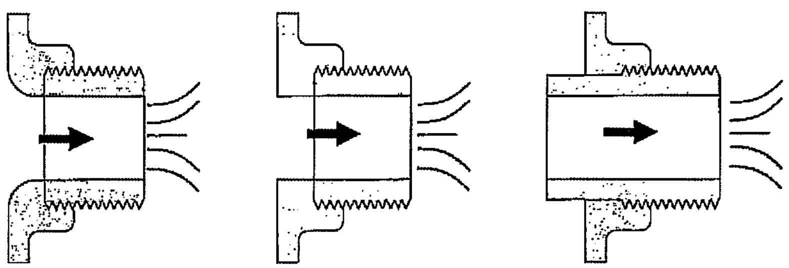
Two types of testing are typically conducted - hydrant flow tests and pipe condition tests. Hydrant flow tests are used to determine the volume and pressure of water that can be provided from a hydrant. Tests were also conducted to evaluate the condition of pipes' interiors. Testing procedures met standards cited in NFPA 291 "Recommended Practice for Fire Flow Testing and Marking of Hydrants," 2002 Edition, and the AWWA "Water Distribution Systems Handbook," 1999.

Testing of fire flow and pipe conditions began in a pilot area in the southern part of town on April 21, 2004. The pilot area was used to provide a preview of the problems that could be encountered during town-wide testing. A Town-wide Fire Flow and Pipe

Conditions Testing Program was conducted in October 2004 to provide up-to-date information and calibrate the water model. The town was divided into four roughly equal sections and tests were conducted from October 4 to October 29, 2004 between 10:00 PM and 6:00 AM. This time period was selected to ensure fewer fluctuations in tank levels due to pump operations and minimize traffic disruptions. The testing locations are noted in **Figure 11-1** and the testing schedule can be seen in **Figure 11-2.**

During fire flow tests, static readings are taken at two hydrants in a particular area. The coefficient of discharge is measured according to the graphic shown in **Figure 11-3**. The flow hydrant is then opened and its discharge is measured at the same time the other hydrant's residual static pressure is measured. The results are recorded and calculations are made to determine the available flow at 20 psi.

Figure 11-3
Hydrant Coefficients of Discharge

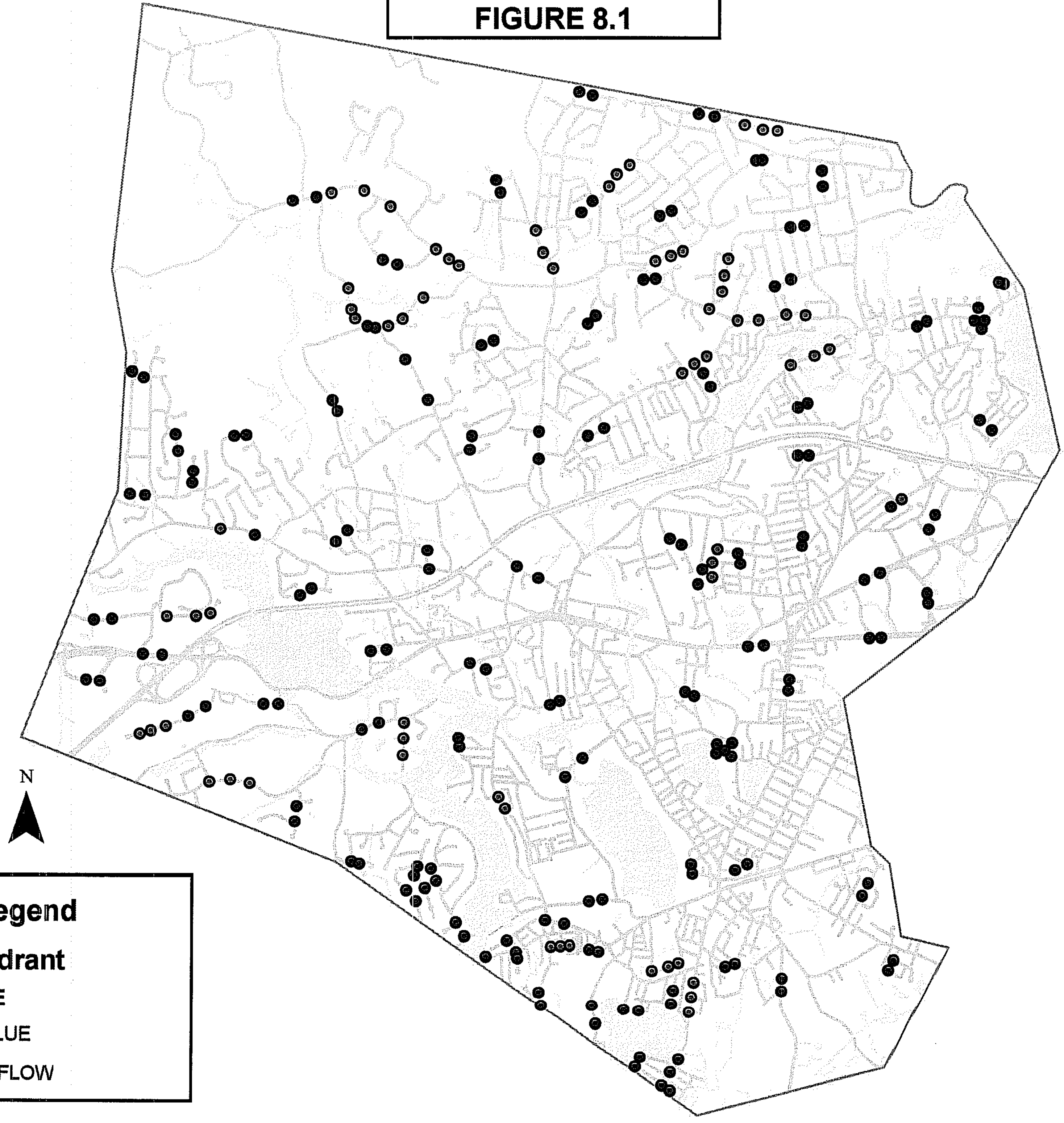


To test a pipe's condition, flow is measured in a relatively straight section of water main between three fire hydrants. Then static readings are taken at all three hydrants. Once completed, the main being tested is shut down immediately past the flow hydrant and all pipe connections between the flow hydrant and the furthest hydrant in the test are closed. The hydrant's coefficient of discharge is determined then the flow hydrant is opened and its flow is measured while the residual pressures of the other two hydrants are measured. The results are recorded and calculations are performed to determine the Hazen-Williams C-Factor.

Adequate fire flow in any area depends on several factors. According to the American Water Works Association and the Insurance Services Office, the factors are: type of buildings in the area; distance between buildings and the buildings' footprints. For example, **Table 11-1** shows the residential standard used to determine adequate fire flows for one- and two-family buildings. Results of the testing program can be seen in **Tables 11-2 and 11-3**. Required fire flow quantities in this report are estimated and not intended to supersede Fire Department or Insurance Services Offices (ISO) requirements.

Adequate fire flow in any area depends on a number of factors. The factors involved, (according to the American Water Works Association and the Insurance Services Office) are: the type of buildings in the area; the distance between buildings; and the building footprint area. For example, **Table 11-1** shows the residential standard used to determine

FIGURE 8.1



Legend

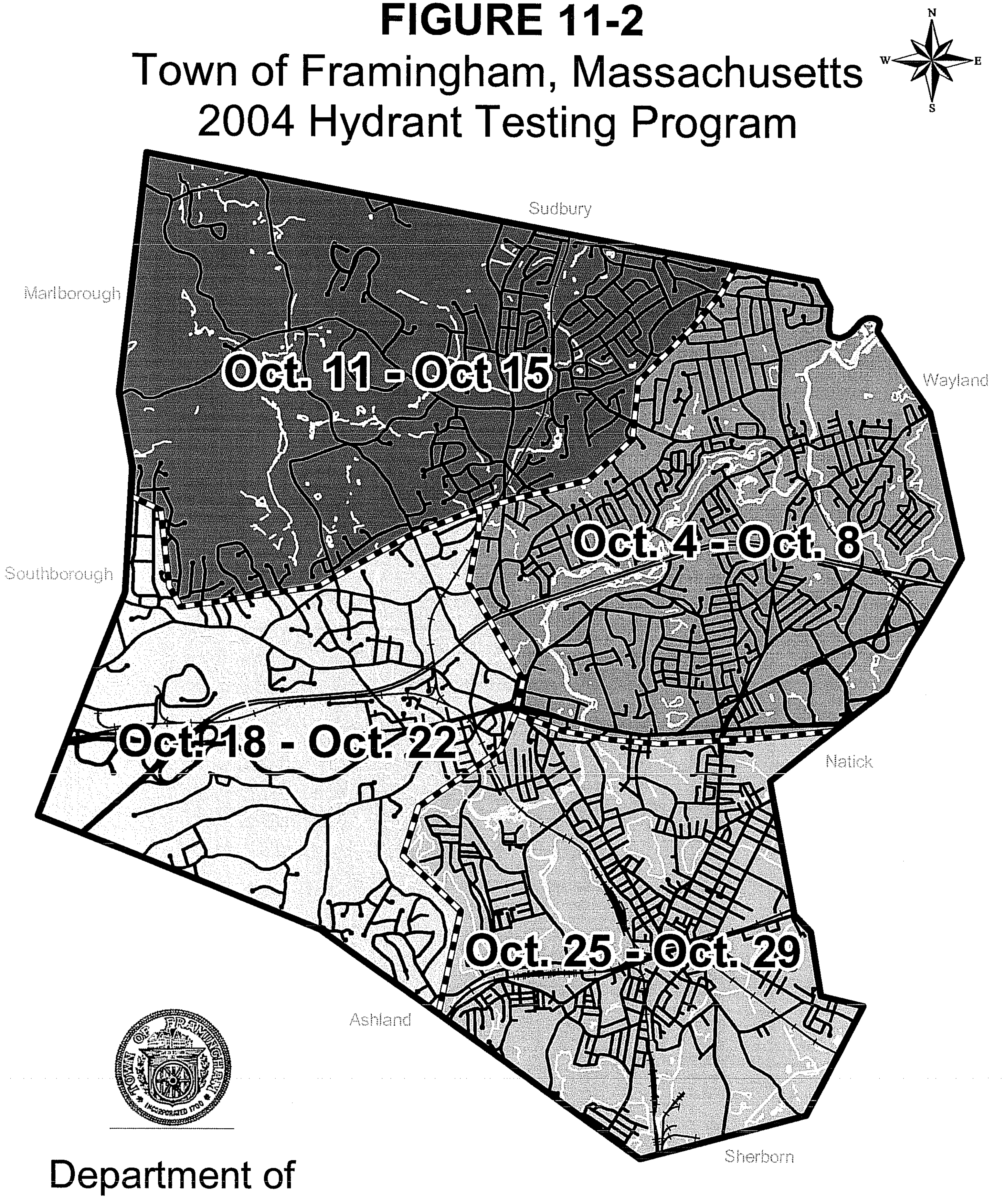
Water Hydrant

TEST TYPE

- C VALUE
- FIRE FLOW

FIGURE 11-2

Town of Framingham, Massachusetts
2004 Hydrant Testing Program



Department of
Public Works

adequate fire flows for one- and two-family buildings. Results of the testing program can be seen in **Tables 11-2 and 11-3.** Required fire flow quantities in this report are estimated and not intended to supersede Fire Department or Insurance Services Offices (ISO) requirements.

Table 11-1
AWWA Recommended Fire Flow for One and Two-Family Dwellings*
AWWA M31

Distance Between Buldings	Needed Fire Flow
More than 100'	500 gpm
31' - 100'	750 gpm
11' - 30'	1,000 gpm
Less than 11'	1,500 gpm

*dwellings not to exceed two stories in height

11.4 ISO Tests

BETA was unable to obtain previous ISO testing results from the town. Normally these tests would be used for additional checking and calibration of the model.

11.5 Model Creation

Framingham's water distribution system model was **created from a combination of GIS mapping, town sources, recent construction projects and prior studies.** Shapefiles and attribute data were imported from the town's GIS mapping into Haestad Methods WaterGEMS® Version 2.0 water modeling software. All data points, such as junctions, valves and end caps, from the GIS are imported as nodes and water mains were imported as lines. Feature information imported from the GIS is compiled in **Table 11-4**. Ground elevations for nodes, flow control valves, water tanks, wells and water pumps were generated by assigning the closest 2-foot contour elevations provided by the town to each particular feature location using a spatial join in the ESRI ArcMap® GIS program.

Pipe sizes and materials were imported directly from GIS information. Reservoirs were created to simulate the four aqueduct connections at the pump stations. To simulate Parco-type flow control valves on the discharge of most pumps, flow control valves were inserted into the model to separate the pressure zones and limit flow of their pumps to their capacities. In the model, pumps were defined along with their heads, discharges and on/off tank level controls. Pump control tank level set points, which were provided by the town, are shown in **Table 11-5.**

11.6 Water Consumption

Recent quarterly water billing data was unavailable from the town before completion of this report. In lieu of actual billing data, estimated usage was assigned to each individual developed parcel based on zoning and tax records. Estimated demands were distributed

2004 Fire Flow Test Results
Town of Framingham, Massachusetts

TABLE 11-2

				FLOW RATE (GPM)			
TEST	TEST	STATIC HYDRANT PRESSURE (PSI)		ACTUAL	AVAILABLE	ESTIMATED	
NO.	LOCATION	STATIC	RESIDUAL	TESTED	@ 20 PSI	REQUIRED @ 20 PSI	ADEQUATE
PA1	ROCK @ VOSE	61	24	692	731	750	NO
PA2	7-9 CONANT	72	50	870	1,384	750	YES
PA3	#80 BETHANY	80	62	1,126	2,156	750	YES
PA4	#1059 WAVERLEY	65	9	444	394	750	NO
PA5	WAVERLEY @ WINTER	72	69	1,267	5,912	750	YES
PA6	SEMINOLE @ PALMETTO	64	38	775	1,030	750	YES
1	#40 JEAN ST.	88	84	1,363	6,295	750	YES
2	#11 LINDA AVE.	88	81	1,248	4,260	750	YES
3	#38 PINEWOOD	87	80	1,353	4,581	750	YES
4	JOSEPH @ DORIS	79	74	1,055	3,999	750	YES
5	#18 TEMI ROAD	74	68	1,076	3,523	750	YES
6	DANFORTH @ MEADOW	78	73	1,136	4,267	750	YES
7	LAKE @ OLD CONN. PATH	80	68	731	1,744	750	YES
8	#45 BIRCH ROAD	76	16	517	498	750	NO
9	LACLEDE @ BELLAFONTAINE	93	78	1,136	2,670	750	YES
10	SAXONY @ DANFORTH	80	78	1,055	6,618	750	YES
11	OLD CONN. PATH @ GREENLEAF	84	80	1,363	6,092	750	YES
12	#19 LEGGATT MCCALL	89	82	1,404	4,830	3,000	YES
13	RUTH @ CHERRY	74	70	1,055	4,300	750	YES
14	LAKE RD. @ OLD CONN. PATH	80	74	1,087	3,771	750	YES
15	#45 BIRCH ROAD	74	25	667	703	750	NO
16	BABIES-R-US ON N-S CONN. RD.	89	71	1,300	2,685	3,000	YES
17	#350 COCHITUATE RD.	82	80	1,300	8,302	2,500	YES
18	RT 9, WEST HYD BY STATE POLICE	80	66	1,021	2,240	1,500	YES
19	#142 RT 9, BEST WESTERN	84	72	1,155	2,853	1,500	YES
20	LOHNES @ BANTRY	88	81	1,248	4,260	750	YES
21	#159 LOCKLAND	62	56	967	2,764	750	YES
22	CARLING @ MAUREEN	90	80	1,174	3,359	1,000	YES
23	EDGEBROOK @ BROOK	76	71	1,001	3,688	750	YES
24	#29 CRESTWOOD	39	35	949	2,202	750	YES
25	#8 HANNA	67	56	955	2,092	750	YES
26	#66 HADLEY	72	64	1,278	3,511	750	YES
27	#33 EATON ROAD WEST	89	78	1,300	3,503	750	YES
28	JUNIPER @ HURON	62	52	967	2,098	750	YES
29	#12 CLAUDETTE	56	44	817	1,479	750	YES
30	#159 MILLWOOD	72	48	993	1,507	750	YES
31	#35 LEDGEWOOD	89	76	1,300	3,201	750	YES
32	#51 FLANAGAN	106	66	1,061	1,604	750	YES
33	#24 GARVEY	87	28	993	1,063	500	YES
34	#59 EATON	88	79	1,353	4,032	1,000	YES
35	#15 JANEBAR	61	45	1,001	1,663	1,000	YES
36	#73 MERRILL	84	74	1,353	3,686	750	YES
37	#719 POTTER	76	66	1,126	2,855	1,000	YES
38	#439 POTTER	58	52	1,061	2,875	750	YES
39	#101-108 CONDOS EDGELL	68	61	1,044	2,953	1000	YES
40	#271 EDMANDS	124	86	888	1,529	500	YES
41	#19 MONTGOMERY	74	64	1,033	2,569	750	YES
42	#29 BRIARWOOD	118	96	1,443	3,234	750	YES
43	#8 CURRIER DRIVE	90	77	1,126	2,794	750	YES
44	GROVE @ WINCH 8"	108	107	1,678	18,828	500	YES
45	GROVE @ WINCH 8"	108	105	1,317	8,167	750	YES
46	#749 EDMANDS ROAD 8"	106	62	978	1,405	500	YES
47	#4 GROVE	93	84	1,155	3,578	750	YES
48	RALEIGH @ LAMPHERE	71	55	978	1,829	750	YES
49	#256 PLEASANT	78	71	1,001	3,134	750	YES
50	WOODMERE @ BERKELEY	79	70	1,256	3,466	750	YES
51	#6 ANGELICA	70	61	1,126	2,841	750	YES
52	#74 NEW YORK	76	70	1,332	4,449	3,000	YES
53	#1661 WORCESTER	58	53	1,061	3,173	1,500	YES
54	CROSSING	102	101	1,592	17,193	2,500	YES
55	JODIE @ PAVIA	80	76	1,289	5,563	750	YES
56	#23 WILLIAM J. HEIGHTS	72	18	0	0	750	NO
57	#4 DUGGAN	43	36	822	1,563	750	YES
58	#50 RICKY	58	54	1,126	3,796	750	YES

2004 Fire Flow Test Results
Town of Framingham, Massachusetts

TABLE 11-2

TEST NO.	TEST LOCATION	STATIC HYDRANT PRESSURE (PSI) STATIC	RESIDUAL	FLOW RATE (GPM) ACTUAL TESTED	AVAILABLE @ 20 PSI	ESTIMATED REQUIRED @ 20 PSI	ADEQUATE
59	#2 CAHILL PARK	58	38	817	1,155	750	YES
60	#5 LANTERN	60	22	750	771	750	YES
61	#918 GROVE 8"	110	36	805	894	750	YES
62	#918 GROVE ST. 8"	110	46	750	902	750	YES
63	#20 KINGS ROW	82	44	993	1,293	750	YES
64	#9 OAKCREST	90	62	1,150	1,887	750	YES
65	#16 WINTER	82	78	1,278	5,614	750	YES
66	#58 SINGLETARY	88	86	1,472	9,886	750	YES
67	#14 DUGGAN	38	32	605	1,095	750	YES
68	#451 SALEM END	87	80	1,482	5,018	750	YES
69	GATES @ COUNTRY CLUB	77	74	1,278	6,266	1000	YES
70	#19 GOODNOW	54	52	1,166	5,479	750	YES
71	#24 GARVEY	90	56	1,244	1,838	500	YES
72	#749 EDMANDS 8"	102	100	1,353	10,049	500	YES
73	#918 GROVE ST. 8"	110	68	919	1,387	750	YES
74	#918 GROVE ST. 8"	110	106	1,126	6,047	750	YES
75	#720 GROVE 8"	100	70	1,198	2,035	1000	YES
76	#801 PLEASANT	80	62	1,278	2,448	750	YES
77	#20 KINGS ROW	84	66	1,278	2,535	750	YES
78	#5 LANTERN	62	37	822	1,088	750	YES
79	#31 LORING	92	82	1,342	3,898	1,500	YES
80	#38 AMERICA	83	45	1,001	1,315	1,000	YES
81	#70A SECOND	91	77	1,106	2,658	1,000	YES
82	#115 ALEXANDER	93	81	1,163	3,082	1,000	YES
83	#43 CYPRESS	92	65	1,126	1,912	750	YES
84	DOW @ LAKE	88	10	0	0	1,000	NO
85	#622 DRAPER	90	35	817	931	750	YES
86	FOSS @ HOLLIS	91	80	822	2,250	1,000	YES
87	#622 DRAPER	90	55	1,001	1,455	750	YES
88	MILLER @ WHITNEY	88	62	1,033	1,737	1,000	YES
89	RICKY @ JODIE	57	54	1,087	4,223	750	YES
90	FAY @ OLD CENTRAL	70	0	581	485	750	NO
91	HOLLIS @ GEORGE	89	82	1,453	5,000	1,000	YES
92	ICE RINK	84	79	1,212	4,801	2,500	YES
93	DUNSTER @ EDGEWATER	82	72	1,106	2,963	1,000	YES
94	#526 WINTER	72	71	1,256	10,605	1,000	YES
95	FREDERICK @ KENDALL	92	69	712	1,318	3,000	YES
96	FREDERICK @ KENDALL	92	88	769	3,662	3,000	YES
97	BISHOP @ EVERIT	90	80	1,244	3,559	3,000	YES
98	HARTFORD @ HOWE	87	82	1,443	5,862	1,000	YES
99	SHAWMUT @ BRIGHAM	88	18	395	388	1,000	NO
100	#10 ROBERTSON	78	76	1,332	8,206	750	YES
101	#200 WARREN	78	76	517	3,184	1,000	YES
102	#123 FLAGG	92	89	1,222	6,796	1,000	YES
103	PALMER @ CONCORD	84	72	1,061	2,621	1,000	YES
104	MAPLE @ BARBER	86	82	1,210	5,498	1,000	YES
106	PARK @ PEARL	87	74	1,353	3,279	1,500	YES
107	DUDLEY ROAD	90	80	1,332	3,809	1,500	YES
108	#39 BERRY	92	62	919	1,475	1,500	NO
109	#561 WATER	74	50	993	1,538	750	YES
110	WATER @ BROOK	92	86	1,126	4,307	750	YES
111	#201 WATER	82	78	1,021	4,484	1,000	YES

2004 Pipe Conditions Testing Results
Town of Framingham, Massachusetts

TABLE 11-3

TEST NUMBER	STREET NAME	PIPE DIAMETER (IN)	PIPE MATERIAL	C FACTOR	ACTUAL Q (GPM)
PA1	SEMINOLE AVENUE	6	CI		
PA1	SEMINOLE AVENUE	6	CI	16	258
PA1	SEMINOLE AVENUE	6	CI		
1	CENTRAL STREET	12	CI		
1	CENTRAL STREET	12	CI	64	1248
1	CENTRAL STREET	12	CI		
3	DONNA ROAD	8	CI		
3	DONNA ROAD	8	CI	90	907
3	DONNA ROAD	8	CI		
4	BROOK STREET	8	CI		
4	BROOK STREET	8	CI	130	1155
4	BROOK STREET	8	CI		
6	JOSEPH ROAD	8	CI		
6	JOSEPH ROAD	8	CI	30	298
6	JOSEPH ROAD	8	CI		
8	OVERLOOK DRIVE WEST	12	CI		
8	OVERLOOK DRIVE WEST	12	CI	135	1321
8	OVERLOOK DRIVE WEST	12	CI		
9	HEMENWAY ROAD	12	CI		
9	HEMENWAY ROAD	12	CI	69	1332
9	HEMENWAY ROAD	12	CI		
10	POTTER ROAD	8	CI		
10	POTTER ROAD	8	CI	145	761
10	POTTER ROAD	8	CI		
11	EDGELL ROAD	8	CI		
11	EDGELL ROAD	8	CI	142	1001
11	EDGELL ROAD	8	CI		
12	WINCH STREET	8	CI		
12	WINCH STREET	8	CI	140	1334
12	WINCH STREET	8	CI		
13	EDMANDS ROAD	6	CI		
13	EDMANDS ROAD	6	CI	59	411
13	EDMANDS ROAD	6	CI		
14	EDMANDS ROAD	8	CI		
14	EDMANDS ROAD	8	CI	87	597
14	EDMANDS ROAD	8	CI		
16	PENNSYLVANIA AVENUE	12	CI		
16	PENNSYLVANIA AVENUE	12	CI	100	1126
16	PENNSYLVANIA AVENUE	12	CI		
17	JOSEPH ROAD	8	CI		
17	JOSEPH ROAD	8	CI	109	1001
17	JOSEPH ROAD	8	CI		
18	SINGLETARY LANE	6	CI		
18	SINGLETARY LANE	6	CI	67	1472
18	SINGLETARY LANE	6	CI		
19	GOODNOW LANE	8	DI		
19	GOODNOW LANE	8	DI	153	822
19	GOODNOW LANE	8	DI		

2004 Pipe Conditions Testing Results
Town of Framingham, Massachusetts

TABLE 11-3

TEST NUMBER	STREET NAME	PIPE DIAMETER (IN)	PIPE MATERIAL	C FACTOR	ACTUAL Q (GPM)
20	GROVE STREET	16	CI		
20	GROVE STREET	16	CI	25	375
20	GROVE STREET	16	CI		
21	SALEM END ROAD	8	CI		
21	SALEM END ROAD	8	CI	111	907
21	SALEM END ROAD	8	CI		
22	CYPRESS STREET	6	AC/DI		
22	CYPRESS STREET	6	AC/DI	96	856
22	CYPRESS STREET	6	AC/DI		
23	HOLLIS STREET	8	CI		
23	HOLLIS STREET	8	CI	142	1278
23	HOLLIS STREET	8	CI		
24	WINTER STREET	12	CI		
24	WINTER STREET	12	CI	110	1278
24	WINTER STREET	12	CI		
25	WATER STREET	8	CI		
25	WATER STREET	8	CI	72	444
25	WATER STREET	8	CI		
26	WATER STREET	8	CI		
26	WATER STREET	8	CI	132	934
26	WATER STREET	8	CI		

Table 11-4
Imported Water Model Feature Information

Water Model Data Layer	***Imported Data from GIS***
Pipe Layer	To/From Node Numbers
	Pipe Diameter
	Pipe Material
	Hazen-Williams 'C' Factor
Node Layer	Ground Elevations
Flow Control Valves	Ground Elevations
Water Tanks	Ground Elevations
Water Pumps	Ground Elevations
Reservoirs	None

throughout the system using anticipated flows obtained from the Wastewater Master Plan under current development. Data was then transferred to the closest node as a water demand using the Load Builder® feature in WaterGEMS®. Total water consumption was increased or decreased based on maximum and average day conditions. Consumption was increased to match the overall flow provided by the pump stations and to include unaccounted-for water.

A diurnal curve was developed for residential demand accordingly to approximate daily use in extended period model simulation. This curve is provided in **Figure 11-4.**

11.7 Water Supply and Peaking Factors

Based on Framingham's pump station flow data from the chlorination reports from 2000-2004 for four pump stations connected to the MWRA aqueduct, an average day demand and a maximum day demand were calculated. To determine the month in which maximum use was recorded, monthly pumping totals from each MWRA-connected pump station for all five years were entered into a spreadsheet and daily volumes of pumped water were totaled. From this data, the highest daily total volume of water was found to be 12.943 million gallons on August 13, 2002. This figure was used as the maximum day demand. The average daily use was 7.5 MGD as determined from the average day of the average month. These numbers were entered into the model to be used to adjust flow demands throughout the system.

TABLE 11-5
PUMP TANK LEVEL CONTROLS

PUMP STATION

EDGELL

		TANK LEVELS (FT)				TANK ELEVATIONS (FT)			
		SUMMER		WINTER		SUMMER		WINTER	
	HORSEPOWER	ON	OFF	ON	OFF	ON	OFF	ON	OFF
LEAD	75	39	41.8	39	41.8	362	364.8	362	364.8
LAG	100	37	40	37	40	360	363	360	363
LAG	100	36	40	36	40	359	363	359	363

CONTROLLED BY INDIAN HEAD TANK

GROVE

		SUMMER		WINTER		SUMMER		WINTER	
	HORSEPOWER	ON	OFF	ON	OFF	ON	OFF	ON	OFF
LEAD	50	15	20	13	20	523	528	521	528
LAG	50	14	19	12	19	522	527	520	527

CONTROLLED BY BEEBE CONCRETE TANK

PLEASANT

		SUMMER		WINTER		SUMMER		WINTER	
	HORSEPOWER	ON	OFF	ON	OFF	ON	OFF	ON	OFF
LEAD	100	38	40	38	40	361	363	361	363
LAG	100	36.5	39	36.5	39	359.5	362	359.5	362

CONTROLLED BY MERRIAM HILL TANK

ELM

		SUMMER		WINTER		SUMMER		WINTER	
	HORSEPOWER	ON	OFF	ON	OFF	ON	OFF	ON	OFF
LEAD	50	38.5	40.5	37.5	40.5	361.5	363.5	360.5	363.5
LAG	100	36.5	39	35.5	39	359.5	362	358.5	362

CONTROLLED BY INDIAN HEAD TANK

GOODNOW

		SUMMER		WINTER		SUMMER		WINTER	
	HORSEPOWER	ON	OFF	ON	OFF	ON	OFF	ON	OFF
LEAD	10	24	28	24	28	434	438	434	438
LAG	15	17	26	17	26	427	436	427	436

CONTROLLED BY GOODNOW TANK

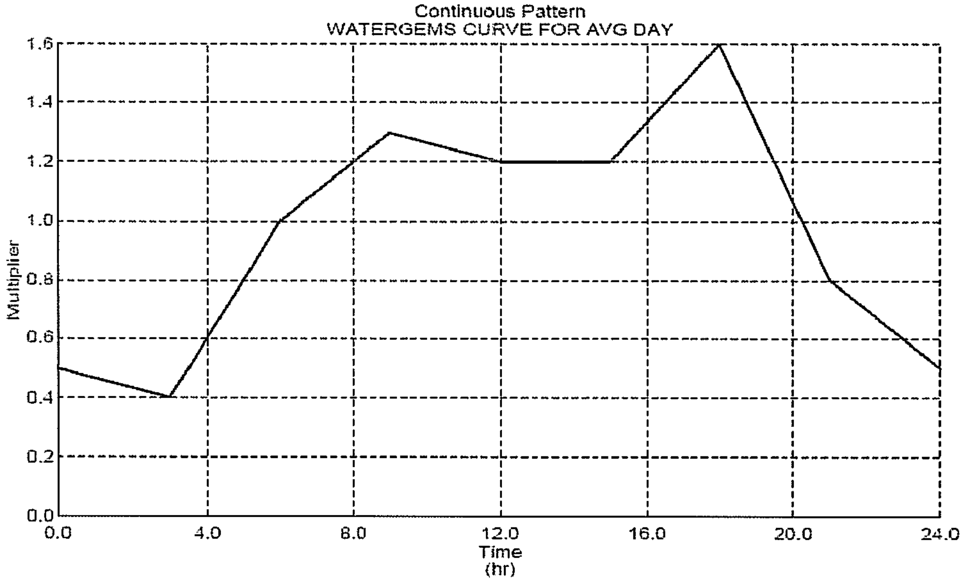
DOESKIN

		SUMMER		WINTER		SUMMER		WINTER	
	HORSEPOWER	ON	OFF	ON	OFF	ON	OFF	ON	OFF
LEAD	10	33	50	33	42	613	630	613	622
LAG	10	32.5	46	32.5	38	612.5	626	612.5	618

CONTROLLED BY DOESKIN TANK

NOTE: SMALLEST PUMP IS LEAD AND LARGEST PUMP IS LAST LAG
(ENGINE DRIVEN PUMPS NOT SHOWN SINCE THEY ARE MANUALLY CONTROLLED)

Figure 11-4
Typical Diurnal Curve for Residential Demands



Average summer and winter flows/demands were calculated based on seasonal averages. For this purpose, summer usage was based on total usage from May through September and winter usage was based on total usage from October through April. Totals for these months were divided by the number of days in those periods. The average summer day and average winter day were found to be 8.95 MGD and 6.0 MGD, respectively.

11.8 Model Calibration

The first step in the calibration process involved comparing static pressure readings from field tests against the model data. **During the comparison**, several items were considered including: actual location of the hydrant versus location of the node; proximity to pump stations; operating conditions of the system when tested; and the height of the hydrant above the ground.

The second calibration step adjusts Hazen-Williams C-Factors of various pipes in the model using data from the Fire Flow and Pipe Conditions Testing Program. Since a limited number of water mains could be tested in this program, the remaining C-Factors were either adjusted from prior tests or initially assumed based on age, material, location, rehabilitation history and other town information.

The Hazen-Williams C-Factor is a measure of the hydraulic capacity of a water main. These values are calculated using the Hazen-Williams formula is based on a known flow rate and head loss through a specified length of pipe. In this formula, a smaller C-Factor is proportionate to a higher surface roughness and larger pressure drop in the given pipe. Partially closed valves or other pipe obstructions will lead to indications of a reduced C-Factor. During the testing and modeling process, the partial shutdown of the Franklin Street water main during construction was taken into account. Typical C-Factors of specific pipe materials are shown in **Table 11-6**. The C-Factors used in the model ranged from 16 to 150.

Table 11-6
Typical C-Factors

Pipe Material	Typical C-Factor Range		
PVC and PE	140	-	150
Ductile Iron	135	-	140
Steel	135	-	140
Asbestos Concrete	135	-	140
Cement-Mortar Lined (24" and larger)	120	-	130
Cement-Mortar Lined (smaller than 24")	115	-	125
Unlined Cast Iron	40	-	120

After the remaining C-Factors were entered, fire flow data was used to calibrate the system to match available fire flows at 20 psi. The calibration process consisted of running fire flow simulations in the model to match field data by adjusting the model to yield the desired results.

The final calibration step included extended period runs to show pumping and storage patterns throughout the town over a period of time. Daily tank level graphs and pump flow rates that were obtained from the town indicated trends during average and maximum day demands. For this measurement, tank and pump levels for an entire month included one day equal to the maximum flow. After averages were compared to output from the model, adjustments were made to match historical data.

During this process, a number of situations were encountered when field data could not be matched to the modeled data. Unresolved issues are outlined in **Table 11-7** and should be investigated to find the exact problem.

11.9 Water Age

Water age in a distribution system is an important factor in determining the effectiveness of disinfectants as well as their potential for generating byproducts. This type of analysis was performed using the water model. An extended period scenario was run to determine the water age in all water mains at specific times. **Figure 11-5** shows the water age ranges in the distribution system over a one-week period.

11.10 Chloramine Residuals and Disinfection By-Products

An analysis similar to the water age analysis can be done for chloramine residuals. Chloramine residuals throughout town can be estimated using the model. The town receives chloramine residuals, at concentrations ranging from 2.0 to 2.3 mg/l with 0.2 to 0.9 mg/l of free chlorine from the MWRA MetroWest Tunnel. In the model, chloramines enter the system at the reservoirs which are connected to the Aqueduct by the pump

Figure 11-5
Water Age

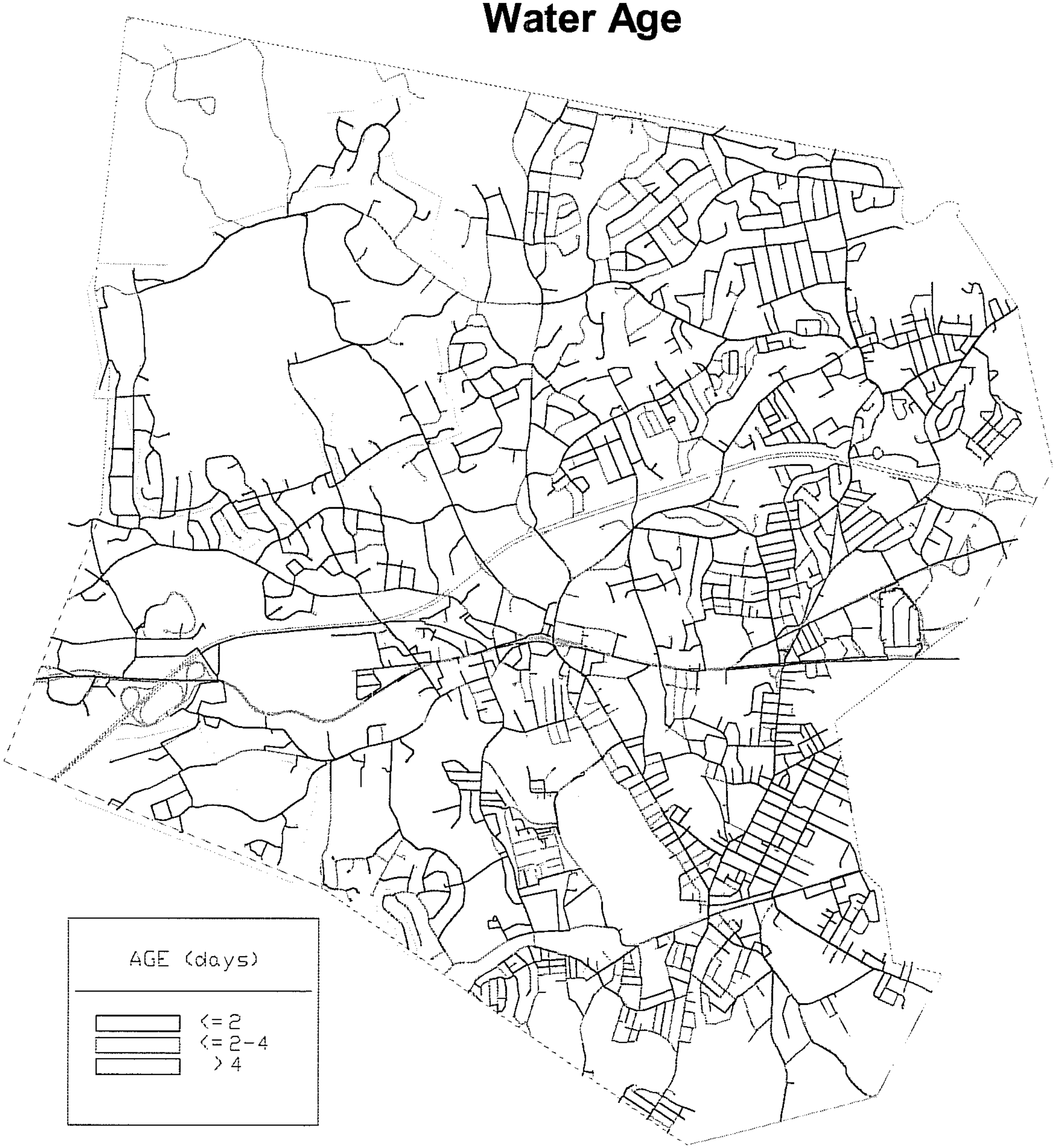


TABLE 11-7
UNRESOLVED WATER MODEL ISSUES

SUSPECTED CLOSED VALVES

FIRE FLOW TEST #	HAVE PLOTS?	INTERSECTION(S)	COMMENT
-	-	BALDWIN @ APPLE D'OR	*SOUTH VALVE CLOSED, ALREADY KNOWN*
-	-	GUILD @ BRACKETT	*NORTHWEST VALVE BROKEN SHUT, ALREADY KNOWN*
PA2	NO	ROCK @ VOSE	OR VALVE(S) CLOSED IN AREA
PA4	NO	VALVE CLOSED/PROBLEM BETWEEN PERSHING & WILSON ON WAVERLEY	OR VALVE(S) CLOSED IN AREA
2	YES	LINDA @ BROOK	OR VALVE(S) CLOSED IN AREA
3	YES	PINEWOOD @ DORIS	OR VALVE(S) CLOSED ON 12" ON PINEWOOD OR IN AREA
5	YES	TEMI @ POTTER	OR VALVE(S) CLOSED IN AREA
6	YES	COTTAGE @ SCHOOL	OR VALVE(S) CLOSED IN AREA
11	YES	VALVE CLOSED ON OLD CONN. PATH BETWEEN NEWBURY & ARLENE	OR VALVE(S) CLOSED IN AREA
22	YES	CARLING @ PHILIP	OR VALVE(S) CLOSED IN AREA
25	YES	HANNA @ CHERRY	OR VALVE(S) CLOSED IN AREA
26	YES	OAKVALE @ CORRINE	OR VALVE(S) CLOSED IN AREA
27	YES	EATON @ EISENHOWER	OR VALVE(S) CLOSED IN AREA
29	YES	CLAUDETTE @ LYMAN	OR VALVE(S) CLOSED IN AREA
34	YES	OVERLOOK IN EASEMENT OR OVERLOOK @ EATON OR MARY AGNES @ EATON	OR VALVE(S) CLOSED IN AREA
35	YES	JANEBAR @ ROUNDTOP	OR VALVE(S) CLOSED IN AREA
36	YES	HEMENWAY @ IRENE	OR VALVE(S) CLOSED IN AREA
38	YES	POTTER @ SHEFFIELD OR EATON @ POTTER	OR VALVE(S) CLOSED IN AREA
41	YES	LOMAS @ FROST	OR VALVE(S) CLOSED IN AREA
52	NO	PLEASANT ST CONNECTOR, EAST OF CROSSING BLVD	OR VALVE(S) CLOSED IN AREA
53	NO	WORCESTER @ CALIFORNIA	OR VALVE(S) CLOSED IN AREA
79	NO	LORING @ IRVING	OR VALVE(S) CLOSED IN AREA
80	NO	AMERICA @ KENDALL	OR VALVE(S) CLOSED IN AREA
87	NO	HOLLIS @ WAUSHAKUM	OR VALVE(S) CLOSED IN AREA
90	NO	FAY @ OLD CENTRAL TPK	OR VALVE(S) CLOSED IN AREA
91	NO	GEORGE @ THAYER	OR VALVE(S) CLOSED IN AREA
92	NO	VALVE CLOSED ON FOUNTAIN EAST OF WINTER	OR VALVE(S) CLOSED IN AREA
102	YES	KITTREDGE @ OAKS	OR VALVE(S) CLOSED IN AREA
103	YES	CONCORD @ SEWELL	OR VALVE(S) CLOSED IN AREA
104	NO	VALVE CLOSED @ STATE OR WEST OF STATE ON MAPLE	OR VALVE(S) CLOSED IN AREA
107	NO	8"-12" CROSSOVER CLOSED	OR VALVE(S) CLOSED IN AREA
108	NO	BERRY @ NIPMUC	OR VALVE(S) CLOSED IN AREA
109	NO	WATER @ SPRING	OR VALVE(S) CLOSED IN AREA
110/111	YES	VALVE CLOSED BETWEEN BROOK & LARIVIERE ROAD	OR VALVE(S) CLOSED IN AREA

QUESTIONABLE AREAS

PA2	NO	CONANT AREA	MODEL ESTIMATES MORE FLOW THAN FIELD CONDITIONS
PA5	NO	WAVERLEY AREA	MODEL ESTIMATES MORE FLOW THAN FIELD CONDITIONS
9	YES	LACLEDE AREA	MODEL ESTIMATES MORE FLOW THAN FIELD CONDITIONS
12	YES	LEGGATT MCCALL AREA	MODEL ESTIMATES MORE FLOW THAN FIELD CONDITIONS
18	YES	RT. 9 AREA	MODEL ESTIMATES MORE FLOW THAN FIELD CONDITIONS
19	YES	RT. 9 AREA	MODEL ESTIMATES MORE FLOW THAN FIELD CONDITIONS
27	YES	EATON RD. WEST AREA	MODEL ESTIMATES MORE FLOW THAN FIELD CONDITIONS
37	YES	POTTER AREA	MODEL ESTIMATES MORE FLOW THAN FIELD CONDITIONS
38	YES	POTTER AREA	MODEL ESTIMATES MORE FLOW THAN FIELD CONDITIONS
48	YES	RALEIGH AREA	MODEL ESTIMATES MORE FLOW THAN FIELD CONDITIONS
64	NO	OAKCREST AREA	MODEL ESTIMATES MORE FLOW THAN FIELD CONDITIONS
81	NO	SECOND AREA	MODEL ESTIMATES MORE FLOW THAN FIELD CONDITIONS
82	NO	ALEXANDER AREA	MODEL ESTIMATES MORE FLOW THAN FIELD CONDITIONS
83	NO	CYPRESS AREA	MODEL ESTIMATES MORE FLOW THAN FIELD CONDITIONS
87	NO	DRAPER AREA	MODEL ESTIMATES MORE FLOW THAN FIELD CONDITIONS
99	YES	BRIGHAM AREA	MODEL ESTIMATES MORE FLOW THAN FIELD CONDITIONS
107	NO	DUDLEY AREA	MODEL ESTIMATES MORE FLOW THAN FIELD CONDITIONS

stations. The chloramines residuals are assessed a decay rate. The model then calculates what town areas lack adequate chloramine residuals. These results can also be used to estimate the formation of disinfection byproducts based on the age of water throughout the system.

11.11 Model Results

Figure 11-6 shows pressure contours on an average summer day. The contours indicate the water pressure for most of the town is above 50 psi. Not surprisingly, the lower pressure areas are concentrated around the storage tanks because they are at higher elevations.

Maximum day fire flow results indicate there are a few areas where the water system can not supply 1,000 gpm (gallons-per-minute) for fire protection as shown in **Figure 11-7.** This diagram includes the William J. Heights area, which will be receiving a new booster station with a high service pump, and "The Mountain" and Staples Road areas, which both have private fire pumps.

Water levels in the storage tanks were analyzed for an average day scenario and a maximum day scenario over a one month period. This analysis was made to determine if storage quantities and pump station capacities are adequate. Each scenario assumes that either the average day or maximum day occurs for a full, one-week period. **Figure 11-8** shows water tank levels during a one-week period of average day demand. **Figure 11-9** shows water levels during a one-week period of maximum day demand. It is important to note the Beebe tanks never completely fill during a maximum-day scenario.

Pump station flows were analyzed to determine the adequacy of the pumps in each station to meet all flow conditions and pump efficiency. **Figure 11-10** shows pump station flows during a one-week period of average day demand. **Figure 11-11** shows pump station flows during a one-week period of maximum-day demand. It is important to note that in the Grove Street pump station one pump runs continuously for about 50 hours at the average day demand level. One pump runs constantly and the lag pump runs for 20 hour periods during the maximum day demand level.

11.12 Storage Analysis

In general, major advantages of providing storage within a distribution system are:

1. Dampen hourly demand fluctuations at pumping stations.
2. Help meet required fire flow thereby reducing pumping station capacity requirements.
3. Provide emergency water in case of pipeline breaks, mechanical failures or power failures.
4. Equalize pressure throughout the system.
5. Allow for off-peak pumping to reduce electrical costs.

Figure 11-6

TOWN OF FRAMINGHAM, MA
AVERAGE DAY PRESSURE CONTOURS

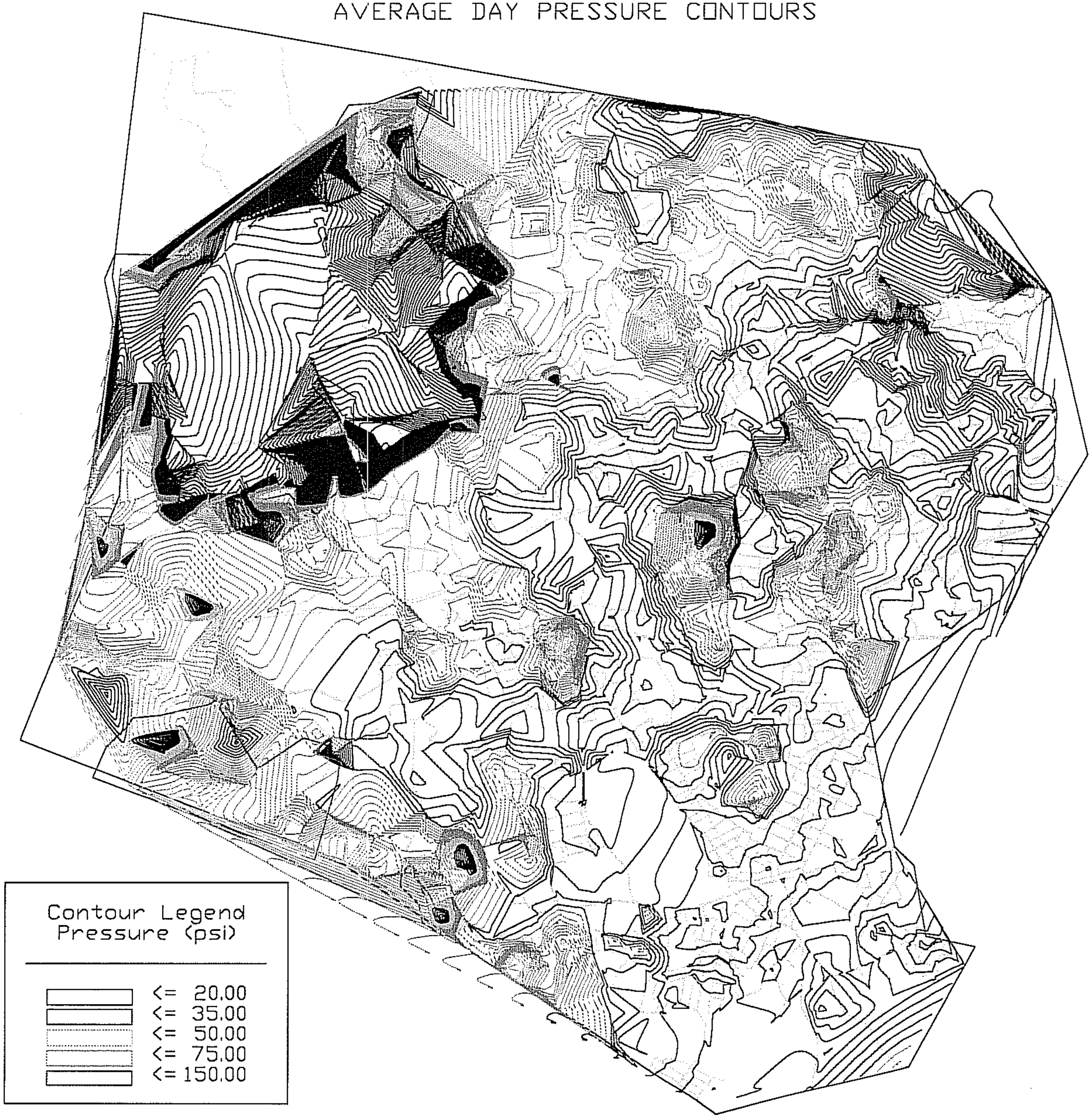


Figure 11-7

TOWN OF FRAMINGHAM, MA
AVAILABLE FIRE FLOW < 1000 GPM

Figure 11-8 TANK LEVELS (AVG DAY)

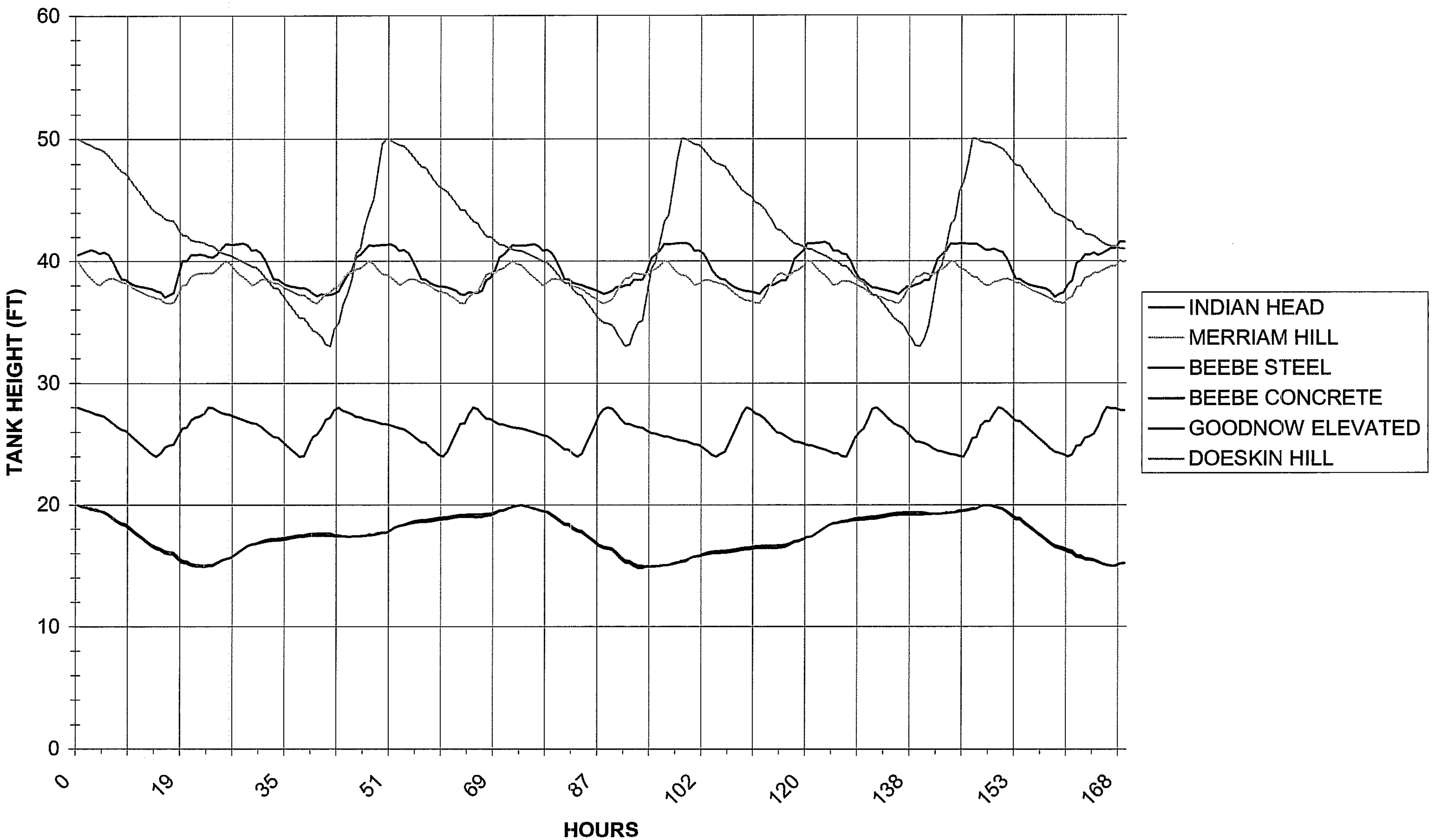


Figure 11-9 TANK LEVELS (MAX DAY)

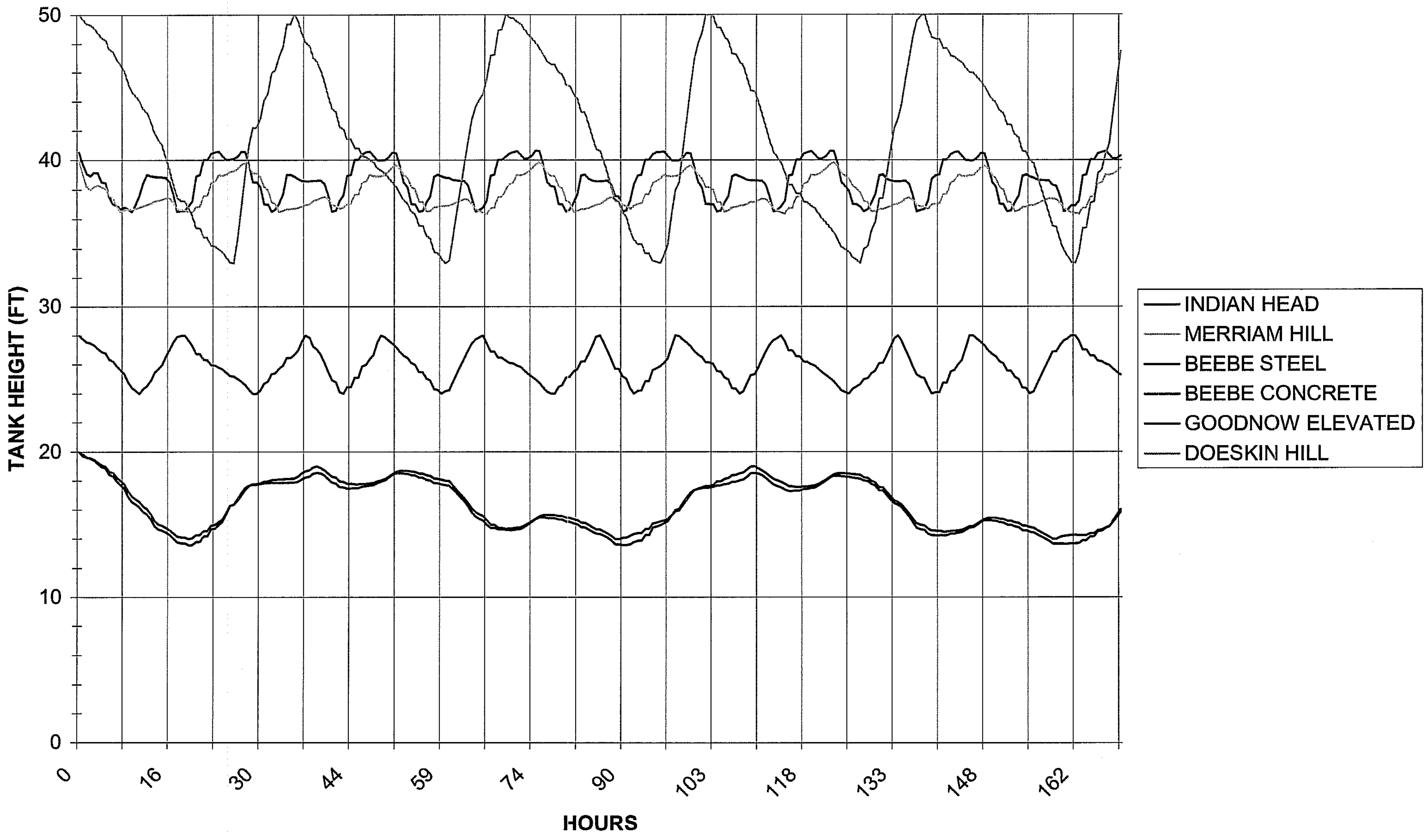


Figure 11-10 PUMP STATION FLOWS (AVG DAY)

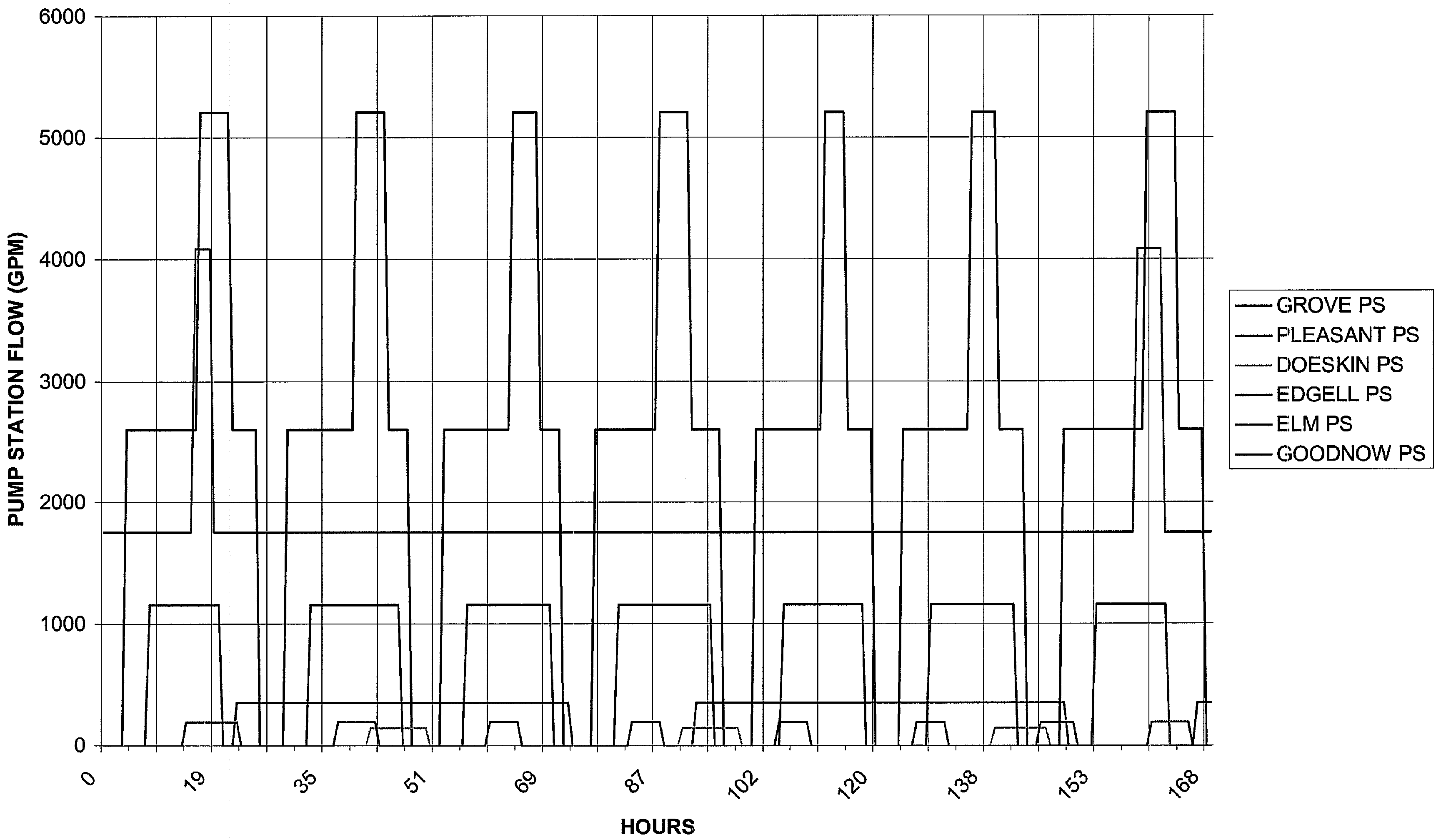
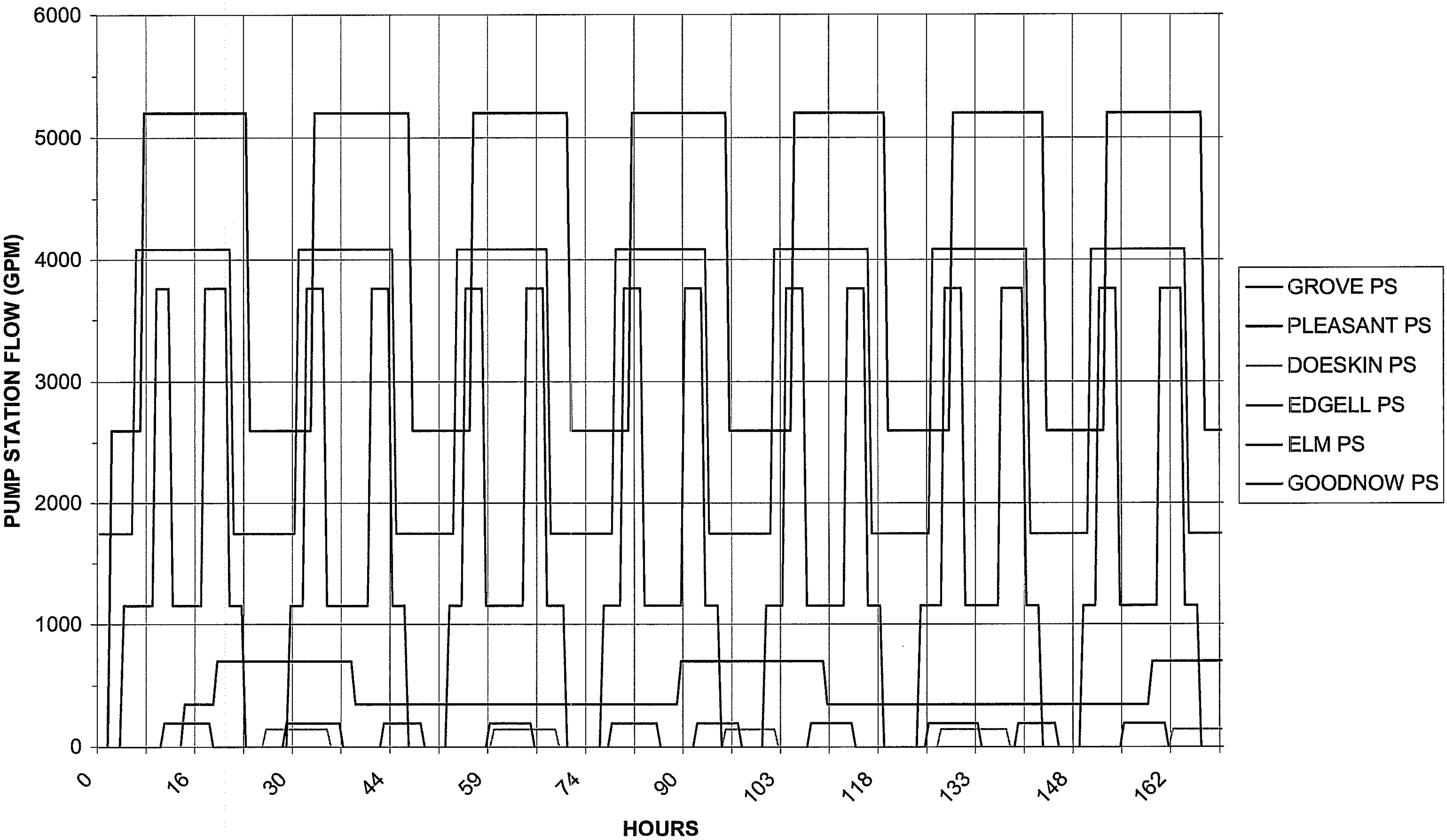


Figure 11-11 PUMP STATION FLOWS (MAX DAY)



11.12.1 Beebe Zone

Storage for the town-owned Beebe zone consists of the Beebe Steel tank and the Beebe Concrete Tank with provide a total of 1.3 million gallons of storage. The tanks stand next to one another off Edmands Road. Since supply to them comes exclusively from the Grove Street pump station, the zone is hydraulically isolated from the Town Zone. The Doeskin Hill system, which uses the Doeskin Hill tank for storage, draws from the Beebe zone. In emergency situations, it can be used to feed the Beebe system through the 6-inch pressure reducing valve on Carter Drive.

Storage analysis of the Beebe System indicates the existing tanks are adequate for the current population. Allowance for additional development depends on Fire Department requirements. Using a standard fire protection requirement of 1,500 gpm for a two-hour period, an additional 508 homes (total of 1,400 homes) can be safely added to the system. If a higher fire protection supply demand is required, such as 1,500 gpm for a four-hour period, an additional 283 homes (total of 1,180 homes) can be added to the system before storage becomes inadequate.

11.12.2 Goodnow Zone

Storage for the Goodnow zone consists of the Goodnow elevated tank with a capacity of 0.3 million gallons. Located off Goodnow Lane, the tank is supplied by the Town Zone.

Analysis of the Goodnow system indicates that the existing tank has an adequate capacity for the current population. Allowance for additional development depends on Fire Department requirements. Using a standard fire protection requirement of 1,500 gpm for a two-hour hour period, 12 more homes (total of 250 homes) can be safely added to the system. If a greater fire protection supply demand is required, such as 1,500 gpm for a four-hour period, no more homes should be added to the system.

11.12.3 Doeskin Hill Zone

Storage for the Doeskin Hill zone consists of the Doeskin Hill tank with a total of 0.2 million gallons of storage. Located off Brimstone Lane, the tank is supplied by the Beebe Zone.

Storage analysis of the Doeskin Hill system indicates the existing tank is adequate for the current population. Allowance for additional development depends on Fire Department requirements. Using a fire protection requirement of 1,000 gpm for a two-hour period (due to the large spacing between houses), an additional 32 homes (total of 85 homes) can be safely added to the system. It should be noted that several of these additional homes are either under construction or have been recently completed. If greater fire protection supply demand is required, no more homes should be added to the system.

11.12.4 Town Zone

Storage for the Town Zone consists of the Merriam Hill and Indian Head tanks which provide a total of 7 million gallons of storage. Supply comes from the Elm Street pump station, the Edgell Road pump station and the Pleasant Street pump station. In the near future, the zone will also be supplied by the Birch Road wells.

Storage analysis of the Town Zone is complicated due to the number of supply sources. Currently, the total approximate average day demand of 7.0 MGD equals the total storage of the zone. Typical total storage calculations, such as fire protection of 3,000 gpm for a five-hour period (for industrial/commercial fire protection demands), would yield a storage requirement of 10.8 million gallons. Since there are three independent pump stations feeding the system, fire requirements can be directly supplemented by the pump stations and emergency storage which could be reduced from a full day storage to a half-day storage. The existing storage would be adequate based on an equalization requirement of 3.07 million gallons and a reduced emergency storage of 3.5 million gallons. This assumption would mean the pump stations must be capable of pumping a combined 13 MGD at all times which is possible with only two stations on line.

11.13 Pump Capacity Analysis

The existing pump station capacities are adequate for system supply with the exception of the Grove Street pump station. The three pump stations supplying the Town Zone have adequate capacity and redundancy for future development through the next 20 years. In the near future, it is expected they will be supplemented by the Birch Road wells. In an emergency, engine driven pumps would provide enough pumping capacity during a town-wide power failure.

The Grove Street pump station does not have adequate capacity to safely supply the Beebe and Doeskin systems. Both pumps greatly exceed acceptable pump run times especially in the summer months and barely meet demand. In the event of an extended power outage in the summer months, the station will not be able to keep up with demand. The same situation is true if one of the pumps needs repairs and must be taken off line. It would also take several days for the system to fully recover from a lengthy fire demand, significant pipe break or an extended pump outage.

Section 12 – Distribution System Improvements

12.1 General

Distribution system improvements, which have been organized and prioritized in this section, are intended to be completed over a 20-year period These recommendations are based on observations of the system, information from record information, DPW input and an analysis based on the computerized hydraulic model of Framingham's water distribution system. The system was analyzed to determine its ability to provide sufficient fire flow, pressure and water quality to all town areas. The analysis considered the age and reliability of the system's individual components. Proposed rehabilitation should be combined with sewer, road and drainage projects when applicable for economy of scale. Improvements costs are represented in today's dollars with an Engineering News Record (ENR) construction cost index of 7695.1.

12.2 Pipe, Hydrant and Service Improvements

The following list details recommended improvements to pipes in Framingham's Water Distribution System:

1. Older, damaged or malfunctioning hydrants (such as Corey, Rensellear, or Darling hydrants installed prior to approximately 1950) should be replaced with new, more reliable models. A hydrant replacement program will provide better, more reliable fire protection and reduce hydrant maintenance costs.
2. Old iron or lead services should be replaced to reduce unaccounted-for water loss, provide improved customer service and reduce maintenance.
3. Closed gate valves, excepting division gates, should be opened and old or broken gate valves should be replaced. This will improve flow and circulation and provide more efficient main shutdowns in emergencies or during construction. Additionally, the opening and replacement of closed gate valves should eliminate dead ends and decrease consumption of disinfectants.
4. Major pipe loop deficiencies should be corrected by connecting dead ends. This should improve water flow and circulation and possibly reduce consumption of chloramines.
5. Water main deficiencies should be corrected by either cleaning and lining or replacing tuberculated pipes. Replacing tuberculated pipes should improve water flow, circulation and possibly decrease consumption of chloramines.
6. Unnecessary secondary mains should be removed and services and hydrants connected to those mains should be connected to larger diameter mains where applicable. These improvements will simplify the system configuration, provide less head loss due to crossovers, decrease bottlenecks at pipe intersections and improve fire protection by eliminating confusion about which main a hydrant is connected to.
7. Transmission lines should be kept in good condition to distribute water quickly and efficiently throughout the system.

8. Replace all 6-inch mains with a minimum of 8-inch mains to meet current AWWA standards.
9. Replace all asbestos cement pipes to eliminate potential asbestos contamination.
10. Update the water distribution system model on a regular basis to keep up with changes in the system.

System improvements are designated by one of three priority levels with the highest level assigned to the system's key mains. **Appendix X** indicates all of the water mains that are recommended for rehabilitation. **Table 12-1** details these recommendations.

12.3 Unidirectional Flushing Program

A unidirectional flushing program is a more effective version of a traditional flushing program. Closing valves to direct flushing water in one direction maximizes velocity through the pipes. Despite the additional labor, unidirectional flushing is desirable because it uses less water, generates higher cleaning velocities and provides chances to test distribution valves and hydrants. Flushing should always begin at the source or a tank and work outward to ensure mains are flushed with clean water.

A unidirectional flushing program is highly recommended for Framingham. Due to the relatively large size of the system, the flushing program should be divided into four or five sections of town with each section completely flushed once annually on a rotating schedule. Provisions should be made for dealing with inevitable valve and hydrant failures as well as potential pipe breaks and dirty water stirred up by the flushing program.

12.4 Pump Station Improvements

Pump station electronics should be replaced for all the pump stations except Doeskin Hill and William J. Heights. All fuel-driven engines should be removed and replaced with electric generators equipped with automatic transfer switches. This will give the town updated technology, more efficient control of pump stations and standardize pump controls throughout the system. Except for the Grove Street pumps, the current pump sizes have enough capacity to supply the town adequately for the next 20 years.

The Grove Street Pump Station needs larger pumps to fill the Beebe tanks more quickly and efficiently. Currently, the existing pumps cannot keep adequate water levels in those tanks. Instead of filling the tanks, the pumps are only able to meet demand. Fire simulations in this pressure zone show the tanks would take almost two days to refill even with both pumps running.

Based on priority, Table 12-2 recommends seven pump station rehabilitation projects and their related costs.

Table 12-2
Pump Station Improvements

PRIORITY	STATION	EST. COST
1	Grove St.	$1,400,000
2	Goodnow	$680,000
3	Elm St.	$2,100,000
4	Edgell Rd.	$2,700,000
5	Pleasant St.	$2,100,000
6	Doeskin Hill	$0
7	W. J. Heights	$0

12.5 Storage Improvements

On November 1 and 2, 2004, the five water storage tanks, excluding the new Doeskin Hill Tank, were inspected by Underwater Solutions Inc. Inspectors evaluated each tank's interior and exterior and reported on their conditions using text and photographs to back up their observations. In April 2006, water storage tanks were cleaned of sediment buildup

Recommendations to rehabilitate tanks and a prioritized list of improvements, including estimated costs, are included in **Table 12-3** identifies by importance seven projects to rehabilitate tanks and estimated costs. It is recommended that installing a mixing system in each tank would help prevent sediment buildup. A routine inspection program should be instituted as part of a preventative maintenance program. One possible plan would be to inspect one tank every year thereby allowing each tank to be inspected every five years.

Table 12-3
Water Storage Tank Improvements

PRIORITY	TANK	EST. COST
1	Goodnow	$550,000
2	Beebe Steel	$410,000
3	Merriam Hill	$1,100,000
4	Indian Head	$1,100,000
5	Beebe Conc.	$140,000
6	Doeskin	$0

The following paragraphs summarize findings of those inspection reports and include an evaluation of each zone's adequacy for future fire flow and domestic demand.

12.5.1 Goodnow Zone (300,000 Gallon Welded Steel Elevated Tank)

Physical Condition
The tank is structurally sound. The tank's exterior is almost completely uncoated resulting in moderate corrosion of all surfaces. Most of the interior surfaces reveal blistering, rust stains and surface corrosion. There is coating adhesion failure throughout the tank.

It is strongly recommended a new coating system be applied to all external surfaces in the immediate future.

Capacity
The existing tank is adequate for the current population. An additional 12 homes (total of 250 homes) can be safely added to the system depending of Fire Department Requirements.

12.5.2 Beebe Zone (300,000 Gallon Riveted Steel Tank and One-Million Gallon Concrete Tank)

Physical Condition
300,000 Gallon Riveted Steel Tank:

The tank is structurally sound. The exterior surfaces exhibit mild corrosion, moderate mildew accumulation, some vegetative growth and lots of graffiti. The finial ball vent is missing screens and there is a one-inch hole in the screen at the bottom of the overflow pipe. Corrosion, blistering and pitting can be seen where coating failures have occurred throughout the interior surfaces. There is also coating adhesion loss in some areas.

It is recommended a new coating system be applied to all interior and exterior surfaces. It is also recommended the screen at the bottom of the overflow pipe be replaced and screening be installed on the finial ball vent.

One-Million Gallon Concrete Tank:

The one-million gallon concrete tank is also structurally sound. The exterior surfaces have nonstructural shrinkage cracks in the shotcrete coating but no voids were found. Efflorescence has formed in some of the cracks and there is also some mildew accumulation. Concrete degradation known as spalling were found in the gout between some roof panel joints. A small band of light, nonstructural 1/8-inch deep scouring has been found around the interior circumference of the tank.

It is recommended that spalled grout in the panel joints be replaced.

Capacity

The existing tanks are adequate for the current population. Allowance for additional development depends on Fire Department requirements. Based on those standards, between 283 and 508 (1,180 to 1,400 total) homes can be safely added to the system.

12.5.3 Town Zone (Indian Head 3.5-Million Gallon Welded Steel Tank and Merriam Hill 3.5-Million Gallon Welded Steel Tank)

Physical Condition

Indian Head Welded Steel Tank:

The Indian head welded steel tank is structurally sound. The exterior surfaces are chalky and weathered with moderate mildew accumulation. However the coating system displays good adhesion. The roof has coating failure where the secondary coating is peeling and some surface corrosion can be seen. The roof panel is missing a two-inch diameter plug and the screen at the bottom of the overflow pipe has been dislodged. There is heavy corrosion and also steel fatigue on the vent riser tube. The screen on the vent has also been dislodged, leaving a one-inch gap. The interior surfaces have light staining, coating failure and adhesion failure where blistering and corrosion can be seen.

Both the two-inch diameter plug from the roof panel and the screen at the bottom of the overflow pipe should be replaced. It is also recommended a new coating system be applied to all interior and exterior surfaces.

Merriam Hill Welded Steel Tank:

The Merriam Hill welded steel tank is structurally sound. The exterior surfaces have very good coating adhesion with some chips creating surface corrosion. There is some mildew accumulation and graffiti on the lower portion. The secondary coating system on the ladder and cage is failing, exposing the primer. The roof has a great deal of coating system failure where cracking and blotch rusting can be seen. On the vent, a good deal of the coating system is failing, resulting in corrosion. While the interior surfaces have very good coating adhesion, there is some staining. Some corrosion can be found on and above the man-way.

It is recommended that a new coating system be applied to all interior and exterior surfaces.

Capacity

Storage analysis of the Town Zone is complicated due to the number of supply sources. Currently, the approximate average day demand of 7.0 MGD for the entire Town Zone the total storage of the zone. The existing storage volume is adequate as long as a minimum of two of the three pump stations can be immediately activated at all times to provide fire flow. Though not currently necessary, consideration should be given to building a new tank with a storage capacity of two-million gallons to reduce pump station dependency and operating costs.

12.5.4 Doeskin Hill Zone (Doeskin Hill 0.2-Million Gallon Bolted Glass Lined Steel Tank)

Physical Condition
Activated in March, 2005, the tank is in perfect condition. Routine inspection and maintenance are required for this tank.

Capacity
The existing tank is adequate for the current population. Allowance for additional development depends on Fire Department requirements. An additional 32 homes (total of 85 homes) can be safely added to the system. Please note that several of these additional homes are either under construction or have been recently completed.

12.5.5 Recommended Tank Coating

Steel tanks requiring coating will first need the current coating system to be tested for the presence of heavy metals to determine if sandblasting the old paint would be hazardous. If necessary, the tanks should be drained and cleaned with a detergent. Sharp welds and edges should be rounded off prior to sandblasting. After this, the interior and exterior should be patched or filled where needed. Interior and exterior coat should then be applied, tested and inspected. After the tank has cured, it will be flushed and disinfected. It is recommended an epoxy be used for the interior coating of the tank to comply with AWWA Standard D102-03 section 4.3. For the tank exterior it is recommended an epoxy with a polyurethane topcoat be used to comply with AWWA Standard D102-03 section 4.2. In all cases, the tank must be taken off-line throughout the entire rehabilitation process.

12.6 Supply Improvements

The activation of the Birch Road Wells in Saxonville will provide the town with additional water and may lower municipal costs since the town will be drawing less water from the MWRA-owned MetroWest Tunnel. There is a concern about blending well water with water from the MWRA tunnel since each source has a different pH. Either the well water will need to be pH-adjusted to match the MWRA water or the MWRA water will need to be pH-adjusted to meet the well water. In another approach, water from both sources could be pH-adjusted to match each other. In other communities, calcium, iron and manganese precipitation has been experienced when groundwater and surface water have been blended together.

The current MWRA agreement will not allow for sufficient supply in 2011 if the wells are not activated. Initial planning steps are currently being taken to bring the wells online.

12.7 Operational Improvements

Storage tanks should be operated with a greater variety in water depth and a mixing system to improve water quality and rapid pump cycling. This change would also reduce maintenance requirements and wear on the pumps. A unidirectional flushing program should be performed throughout town to clear the buildup of loose materials in water mains and also help locate closed or broken valves. Pressure-reducing valves should be installed to replace some division gates between higher- and lower-pressure zones. At a minimum, the division gates should be marked or locked out to prevent accidental operation.

Maintenance operations, especially in pipes and gate valves, should be tracked and entered into the GIS system. This will create a service history and allow repetitive problems to be more easily detected. When gate valves and pipe configurations are discovered in the field, they should be reported and coded into the GPS to further refine the system map and related data.

The leak detection program should be continued every other year to monitor the system for leakage. Also, the Water Conservation Plan enacted in 2004 should be enforced.

12.8 Security Improvements

A Vulnerability Assessment was prepared for Framingham's water system in December 2003. It was determined the most vulnerable assets were the town water tanks and pump stations, not including the booster pump at William J. Heights.

The town has employed a number of detect-and-delay measures at each of the vulnerable sites. Some of these measures include: motion detecting lights, alarms, fences, barbed wire, durable structure materials, metal doors; metal lattices on windows, inaccessible ladders and locked access to gates, doors, windows, hatches and instrumentation boxes. Other security features include agreements with residents to report suspicious activity, isolated and hard-to-access locations and improved chlorine gas transport policies.

The detect-and-delay systems listed above have not been employed at all asset sites.

To improve the effectiveness of detect-and-delay measures at each of the vulnerable town assets, the following improvements are recommended.

- Motion detector lighting where there is none.
- Electronic gate openers and card/keypad door entry systems to log individuals.
- Mailings to residents asking them to alert authorities if intruders are seen.
- Remote intrusion alarms installed inside pump stations.
- Installation of barb wire fencing where current fencing is inadequate.
- Repairs to barbed wire where needed.
- Keeping gates, windows, and doors closed and locked at tanks and pump stations.
- Install steel doors at chlorine rooms.
- Changing door and gate locks periodically at all pump stations and water tanks.
- Establishing a system to account for the location and custody of keys.
- Installation of intrusion detectors on pump station windows.

These improvements would raise the effectiveness ratings on the town's vulnerable assets.

12.9 Twenty-Year Capital Improvement Plan

Distribution system improvement recommendations are prioritized and intended to be completed over a 20-year period Recommendations presented are based on system observations, record information, DPW input, and the results of the analysis performed using the computerized hydraulic model of Framingham's water distribution system.

Recommended improvements should be combined with sewer, road and drainage projects when applicable to reduce costs. At the time of completion of this Water Master Plan, the master plans for sewer, drainage and road work were not available. Therefore, it is difficult to accurately project the costs and schedule for all water-related work out to 20 years without knowing if the work will be a small or significant component of construction contracts for other municipal infrastructure work.

Using a yearly cost amount of $3 million worth of pipe improvements, **Table 12-4** is one possible scenario detailing year-by-year improvements for a 20-year period. **Appendix Y** indicates the first five years of improvements including tanks and pump stations. Costs for improvements are in today's dollars.

Costs for water system improvements, exclusive of water storage tank and pump station improvements, is approximately $58 million over 20 years, or approximately $3 million per year. Combined with the water storage tank and pump station improvements, projected CIP costs would be as follows:

Year	Total Capital Improvement Costs
2007	$2,425,000
2008	4,720,000
2009	3,420,000
2010	6,650,000
2011	6,685,000
2012	5,410,000
2013 – 2026	$3,000,000 per year

Excluded from these capital costs are any costs associated with reactivation of the Birch Road Well Field which the Town of Framingham is addressing independently of this Water Master Plan.

Table 12-1
Framingham Water System Capital Improvement Plan

First Priority Water System Improvements

Location	Approx. Length (ft)	Existing Size (in)	New Size (in)	Description	Estimated Pipe & TW Paving Cost	Estimated Cold Plane & Overlay costs	Total Cost
Fay Road, Daytona Avenue & Weybosett Avenue	4,700	6 & 8	8	Install new 8" main	$761,400	$222,075	$983,475
Grant Street	5,000	6	8	Install new 8" main	$810,000	$236,250	$1,046,250
Water Street	10,500	8	12	Install new 12" main	$1,984,500	$496,125	$2,480,625
Cove Avenue, Lake Street, Dow Street, & Nipmuc Road	4,400	6 & 8	8	Install new 8" main & connect svcs. & hyds. to 12"	$690,000	$207,900	$897,900
Waverly Street (Winter Street to Town Line)	2,600	6	8	Install new 8" main	$421,200	$122,850	$544,050
Brigham Road	510	6 & 16	16	Connect svcs. & hydrants to 16" main	$55,080	$24,098	$79,178

Second Priority Water System Improvements

Location	Approx. Length (ft)	Existing Size (in)	New Size (in)	Description	Estimated Pipe & TW Paving Cost	Estimated Cold Plane & Overlay costs	Total Cost
Propsect Street	4,400	6 & 16	16	Connect svcs. & hydrants to 16" main	$475,200	$207,900	$683,100
Edgell Road (Water Street to Central Street)	9,300	8	12	Install new 12" main	$1,757,700	$439,425	$2,197,125
Central Street	12,200	12	12	Install new 12" main	$2,305,800	$576,450	$2,882,250
Concord Street (Hardy Street to Union Avenue)	12,800	6 & 8	8	Install new 8" main	$2,073,600	$604,800	$2,678,400
Main Street & Union Avenue (Route 9 to Concord Street)	9,100	8 & 12	8 & 12	Install new 8" & 12" main	$1,719,900	$429,975	$2,149,875
Pershing Ave.	1,000	6	8	Install new 8" main	$162,000	$47,250	$209,250
Barbieri Rd. to Whitney Ave (Under Lake Waushakum)	1,500	None	8	Directional Drill 8" Main	$600,000	$600,000	$600,000

Third Priority Water System Improvements

Location	Approx. Length (ft)	Existing Size (in)	New Size (in)	Description	Estimated Pipe & TW Paving Cost	Estimated Cold Plane & Overlay costs	Total Cost
Temple Street	3,500	6	8	Install new 8" main	$567,000	$165,375	$732,375
Pleasant Street (Mass Pike to Little Tree)	8,300	8	8	Replace 8" AC w/ new 8" main	$1,344,600	$392,175	$1,736,775
Winthrop Street (Waverly Street to Dow Street)	1,800	8 & 12	12	Connect svcs. & hydrants to 12" main	$194,400	$85,050	$279,450
Winthrop Street (Dow Street to Hollis Street)	1,600	8	8	Install new 8" main	$259,200	$75,600	$334,800
Winter Street	10,000	12	12	Install new 12" main	$1,890,000	$472,500	$2,362,500
Maple Street	3,600	12 & 14	12	Install new 12" main	$680,400	$170,100	$850,500
Pond Street, Everit Street, Lawrence Street, Essex St., Mansfield St. & Arthur St. (West of Bishop St.)	9,000	6	8	Install new 8" mains	$1,458,000	$425,250	$1,883,250
Burdette Street	830	8 & 12	12	Connect svcs. & hydrants to 12" main	$89,640	$39,218	$128,858
Dudley Rd. (South Rd. to Fountain St.)	2,100	6	8	Install new 8" main	$340,200	$99,225	$439,425

Additional Streets Requiring Rehabilitation in Conjunction with Proposed Road Reconstruction

Location	Approx. Length (ft)	Existing Size (in)	New Size (in)	Description	Estimated Pipe & TW Paving Cost	Estimated Cold Plane & Overlay costs	Total Cost
Barber Road	1,200	6	8	Install new 8" main	$194,400	$56,700	$251,100
Benson Avenue	1,010	6	8	Install new 8" main	$163,620	$47,723	$211,343
Clark Street	2,500	12 & 8	8	Install new 8" main	$405,000	$118,125	$523,125
Cochituate Road (Rt. 9 to Caldor Rd.)	4,100	6	12	Install new 12" main	$774,900	$193,725	$968,625

Table 12-1
Framingham Water System Capital Improvement Plan

Desoto Avenue	300	6	8	Install new 8" main	$48,600	$14,175	$62,775
Edwards Street/Cestnut	1,700	6	8	Install new 8" main	$275,400	$80,325	$355,725
Evergreen Street	650	6	8	Install new 8" main	$105,300	$30,713	$136,013
Knox Avenue	300	6	8	Install new 8" main	$48,600	$14,175	$62,775
Larabee Ave.	640	6	8	Install new 8" main	$103,680	$30,240	$133,920
Learned Street	400	6	8	Install new 8" main	$64,800	$18,900	$83,700
Palmetto Avenue	700	6	8	Install new 8" main	$113,400	$33,075	$146,475
Sanger Street	600	4	8	Install new 8" main	$97,200	$28,350	$125,550
Seminole Avenue	700	8	8	Install new 8" main	$113,400	$33,075	$146,475
Sewell Street	400	6	8	Install new 8" main	$64,800	$18,900	$83,700
State Street	2,700	6 & 8	8	Install new 8" main	$437,400	$127,575	$564,975
Wilde Avenue	550	6	8	Install new 8" main	$89,100	$25,988	$115,088
Wilson Avenue	1,270	6	8	Install new 8" main	$205,740	$60,008	$265,748
Older Mains (<1928)							
Arthur St. (East of Bishop)	1,750	6 & 12	12	Connect svcs. & hydrants to 12" main	$189,000	$82,688	$271,688
Arthur St. (West of Bishop)	1,550	6	8	Install new 8" main	$251,100	$73,238	$324,338
Barbieri Rd.	390	2	8	Install new 8" main	$63,180	$18,428	$81,608
Beacon St.	4,100	8 & 16	16	Connect svcs. & hydrants to 16" main	$442,800	$193,725	$636,525
Belknap Rd. (Mill to Edgell)	3,150	6	8	Install new 8" main	$510,300	$148,838	$659,138
Concord	18,500	8	12	Install new 12" main	$3,496,500	$874,125	$4,370,625
Chestnut St. & Paper Street	562	6	8	Install new 8" main	$91,044	$26,555	$117,599
Connant Rd.	1,040	8	8	Install new 8" main	$168,480	$49,140	$217,620
Franklin St. (South end, small dead end)	220	4	8	Install new 8" main	$35,640	$10,395	$46,035
Hamilton St.	1,130	8	8	Install new 8" main	$183,060	$53,393	$236,453
Kellogg St.	1,400	6 & 8	8	Install new 8" main	$226,800	$66,150	$292,950
Maynard Rd.	3,500	6	8	Install new 8" main	$567,000	$165,375	$732,375
Meadow St./Meadow La.	2,100	6	8	Install new 8" main	$340,200	$99,225	$439,425
Mill St.	2,400	6	8	Install new 8" main	$388,800	$113,400	$502,200
Morse Rd.	1,500	6	8	Install new 8" main	$243,000	$70,875	$313,875
Myrtle St.	450	6	8	Install new 8" main	$72,900	$21,263	$94,163
Thurber St.	200	2	8	Install new 8" main	$32,400	$9,450	$41,850
Newbury St.	3,100	6 & 12	8 & 12	Install new 8" main	$502,200	$146,475	$648,675
Nipmuc Terrace (South of Nipmuc Rd.)	400	6	8	Install new 8" main	$64,800	$18,900	$83,700
Old Conn Path (Danforth to Town Line & under Mass Pike)	1,820	6	8	Install new 8" main	$294,840	$85,995	$380,835
Robertson Rd.	500	6	8	Install new 8" main	$81,000	$23,625	$104,625
Rt. 9? (needs to be simplified since no one knows what is going on there)				Unknown	Unknown	Unknown	Unknown

Table 12-1
Framingham Water System Capital Improvement Plan

Shawmut Ter.	800	6 & 12	12	Connect svcs. & hydrants to 12" main	$86,400	$37,800	$124,200
Singletary Ln.	4,500	6 & 16	8 & 16	Install new 8" main	$729,000	$212,625	$941,625
Vernon St. Loop	1,200	4, 6 & 8	8	Install new 8" main	$194,400	$56,700	$251,100
Walsh St.	800	6	8	Install new 8" main	$129,600	$37,800	$167,400
Waverley (Winthrop to Concord & Bishop to Town Line)	6,800	RECHECK				$321,300	$321,300
AC Mains							
Willis Ave.	960	6	8	Install new 8" main	$155,520	$45,360	$200,880
McAlee Ave.	1,100	6	8	Install new 8" main	$178,200	$51,975	$230,175
Nipmuc Rd.	1,630	6 & 12	12	Connect svcs. & hydrants to 12" main	$176,040	$77,018	$253,058
Cypress St	600	6	8	Install new 8" main	$97,200	$28,350	$125,550
Raymond St.	600	6	8	Install new 8" main	$97,200	$28,350	$125,550
Willis St.	960	6	8	Install new 8" main	$155,520	$45,360	$200,880
Grant St	2,900	6	8	Install new 8" main	$469,800	$137,025	$606,825
Howe St	600	6	8	Install new 8" main	$97,200	$28,350	$125,550
Grant St Ext	1,000	6	8	Install new 8" main	$162,000	$47,250	$209,250
Loop off of School St	2,250	6	8	Install new 8" main	$364,500	$106,313	$470,813
Long Ave.	1,700	8	8	Install new 8" main	$275,400	$80,325	$355,725
Singletary Ln.	4,100	6	8	Install new 8" main	$664,200	$193,725	$857,925
Old Worcester Rd	1,200	6	8	Install new 8" main	$194,400	$56,700	$251,100
Alder Ln.	650	6	8	Install new 8" main	$105,300	$30,713	$136,013
Rose Ln.	800	6	8	Install new 8" main	$129,600	$37,800	$167,400
Oak Crest Dr.	2,500	6	8	Install new 8" main	$405,000	$118,125	$523,125
Pleasant St (Waveney to Little Tree Ln.)	7,500	8	8 or 12	Install new 8" or 12" main	$1,417,500	$354,375	$1,771,875
Belknap Rd (West end to Major Hale Dr.)	1,770	8	8	Install new 8" main	$286,740	$83,633	$370,373
Grove St. (South of Belnap)	4,500	8	8	Install new 12" main	$850,500	$212,625	$1,063,125
Jean St.	1,950	6	8	Install new 8" main	$315,900	$92,138	$408,038
Park Ave.	1,600	6	8	Install new 8" main	$259,200	$75,600	$334,800
Indian Head Heights	500	16	16	Install new 16" main	$94,500	$23,625	$118,125
Joclyn Ave.	1,000	6	8	Install new 8" main	$162,000	$47,250	$209,250
School St. to Old Conn. Path to Wells	6,000	16	16	Install new 16" main	$1,134,000	$283,500	$1,417,500
Indian Head Rd. to Summer St.	6,680	16	16	Install new 16" main	$1,262,520	$315,630	$1,578,150
Looping/Redundancy							
Hemenway continue 12"	1,700	8	12	Install new 12" main	$321,300	$80,325	$401,625
Bradford Rd., Griffin Rd., Elm Field Rd., Elm St. to Overlook Drive East.	4,700	6 & 8	12	Install new 12" main	$888,300	$222,075	$1,110,375
Pinewood Dr. Easement to Swanson Rd.	600	None	12	Install new 12" main	$113,400	$28,350	$141,750

Table 12-1
Framingham Water System Capital Improvement Plan

Edgell Rd (Between Kara Ann Dr. and Harrington Rd.)	400	None	8	Install new 8" main	$64,800	$18,900	$83,700
Lomas Cir. To Cider Mill Rd.	650	None	8	Install new 8" main	$105,300	$30,713	$136,013
Crosby to Sun Valley	350	None	8	Directional Drill new 8" main	$140,000	$16,538	$156,538
Auburn St. (West Half)	350	2	8	Install new 8" main	$56,700	$16,538	$73,238
West end of Edmands close loop	1,200	None	8	Install new 8" main	$194,400	$56,700	$251,100
Worcester Rd. (Main St. to Cochituate)	2,400	8	12	Install new 12" main	$453,600	$113,400	$567,000
Fraley Dr. to Travis Dr. Easement	400	None	8	Install new 8" main	$64,800	$18,900	$83,700
Joclyn Ave.	140	None	8	Install new 8" main	$22,680	$6,615	$29,295
Wilmont Rd.	110	None	8	Install new 8" main	$17,820	$5,198	$23,018
Gibbs Valley Path to Joanne Dr. Easement	330	None	8	Install new 8" main	$53,460	$15,593	$69,053
				Totals	**$45,336,104**	**$13,319,795**	**$58,055,899**

Notes:

1 - Prices include cost for construction plus 35% for engineering and contingencies.
2 - All recommended work on water mains installed prior to 1928.
3 - Prices are planning level only.