Water System Capital Efficiency Plan^{TM}
Fairhaven, Massachusetts

COMMONWEALTH OF MASSACHUSETTS
PATRICK S.
O'NEALE
CIVIL
No. 35117
REGISTERED
PROFESSIONAL ENGINEER

Prepared by

TATA & HOWARD
Water and Wastewater Consultants

June 2011

TABLE OF CONTENTS

Letter of Transmittal

Section	Description	Page
1	**Executive Summary**	
	1.1 General	1
	1.2 The Three Circle Approach	1
2	**Existing Water System**	
	2.1 Distribution System	3
	2.2 Water Supply Sources	3
	2.3 Water Storage Facilities	6
	2.4 Mattapoisett River Valley Water District Water Treatment Facility	7
	2.5 Previous System Studies	7
3	**Water Supply Evaluation**	
	3.1 General	8
	3.2 Water System Demands	8
	3.3 Adequacy of Existing Water Supply Sources	10
	3.4 Adequacy of Existing Water Storage Facilities	12
4	**Hydraulic Evaluation**	
	4.1 General	14
	4.2 Evaluation Criteria	14
	4.3 Hydraulically Deficient Areas	15
5	**Critical Component Assessment**	
	5.1 General	19
	5.2 Evaluation Criteria	19
	5.3 Critical Components	19
6	**Asset Management Considerations**	
	6.1 General	22
	6.2 Data Collection	22
	6.3 Evaluation Criteria	22
	6.4 Asset Management Areas of Concern	34

TABLE OF CONTENTS (continued)

Section	Description	Page
7	**Recommendations and Conclusions**	
	7.1 General	35
	7.2 General Recommendations	35
	7.3 Prioritization of Improvements	36

LIST OF FIGURES

Figure	Description	Page
2-1	**Water Main Size Distribution**	4
2-2	**Water Main Material Distribution**	5
3-1	**Historic and Projected Populations**	9
6-1	**Water Main Installation Years**	27
6-2	**Water main Material**	28
6-3	**Water Main Diameter**	30
6-4	**Areas with History of Breaks**	31
6-5	**Areas with Water Quality Concerns**	32
6-6	**Potentially Corrosive Soils**	33

LIST OF TABLES

Table	Description	Page
3-1	Authorized Withdrawal Volumes of Existing Sources	11
4-1	Water Main Replacements	18
5-1	Critical Areas	20
6-1	Asset Management Grading System	24
6-2	Pipe Material by Installation Year	25
7-1	Prioritization of Improvements – Phase I	43
7-2	Estimated Improvement Cost – Phase I	44
7-3	Prioritization of Improvements – Phase II	45
7-4	Estimated Improvement Cost – Phase II	46
7-5	Prioritization of Improvements – Phase IIIa	47
7-6	Estimated Improvement Cost – Phase IIIa	48
7-7	Prioritization of Improvements and Estimated Improvements Costs – Phase IIIb	49

Appendices

Appendix	Description
A	**Water Distribution System Map**
B	**Link Map and Hydraulic Model Pipe Database Table**
C	**Hydraulic Improvements Map**
D	**Critical Components Map**
E	**Asset Management Rating Map**
F	**Three Circles Integration Map**
G	**Improvements Maps**

SECTION 1 – Executive Summary

1.1 General

Tata & Howard, Inc. was retained by the Town of Fairhaven to complete a Capital Efficiency Plan™ for the Fairhaven water distribution system. The purpose of the study is to identify areas of the water distribution system in need of rehabilitation, repair or replacement, and prioritize improvements to make the most efficient use of the Town's capital budget. The study evaluates the existing water infrastructure including water transmission and distribution piping and appurtenances. In addition, water supply and storage needs are evaluated and prioritized. In addition, water supply and storage needs are evaluated and prioritized. This study provides a methodology, ranking, and prioritization of proposed projects as well as the associated construction costs.

1.2 The Three Circle Approach

The Capital Efficiency Plan™ evaluated the water distribution system using our Three Circle Approach that includes the following evaluation criteria:

- System hydraulic evaluation,
- Critical component assessment,
- Asset management considerations.

Each circle represents a unique set of evaluation criteria for each water system component. From each set of criteria, system deficiencies are identified. System deficiencies from each component are then compared. A deficiency falling into more than one circle is generally given higher priority. Using the Three Circle Approach, we are able to identify problem areas and recommend improvements that provide the most benefit to the system. In addition, the Three Circle Approach allows identification of situations where an improvement in one circle will eliminate a deficiency in another circle. By integrating all three sets of criteria, the infrastructure improvement decision making process and overall Capital Efficiency is optimized.

Tasks in this study consisted of the following:

- Evaluated water supply needs based on existing and projected demands and existing source capacity,
- Assessed water storage needs based on existing and future demands and fire flow requirements,
- Updated the existing water distribution system model to include infrastructure improvements since the completion of the Water System Capital Improvements Plan prepared by Tata & Howard in 2002,
- Conducted a one day workshop with the operations and management staff to review operations and maintenance practices, break history, and other pertinent information,
- Reviewed previously completed reports and available data pertaining to the condition of the existing system,
- Incorporated applicable pipe information into the hydraulic model,

- Reviewed recommended hydraulic improvements from the Water System Capital Improvements Plan, as well as potential improvements resulting from asset management and critical component considerations,
- Created a pipe rating system to identify areas needing rehabilitation or replacement. The rating system was used to create a prioritized plan of recommended improvements. This portion of the study considers buried infrastructure only.

Based on the Three Circle Approach, a prioritized list of improvements was compiled. Improvements were separated into three phases. Phase I represents the most needed improvements based on hydraulic needs, location in the distribution system and the condition of the water main. In general, these include water mains that fall into all three of the three circles, strengthen the transmission grid, eliminate potential asset management concerns, provide redundancy, or were identified as a priority by the Town.

The Phase I water main improvements include replacement of all vinyl lined asbestos cement water mains in the system, replacement of the water mains on Spring Street and Huttleston Avenue, and the installation of new water mains on Gelette Road and Shaw Road. The total estimated costs for Phase I improvements is approximately $4,160,000.

Phase II Improvements generally include areas that fall into two circles. These improvements generally benefit a localized area. Phase II Improvement include replacement of mains on Main Street, McGann Terrace, Narragansett Boulevard, Farmfield Street, Gellette Road, Old Fort Road, Raymond Street and Weeden Road and the installation of a new parallel water main on Sconticut Neck Road from South Camel Street to approximately 1,100 feet south of Silver Shell Grant Drive. The total estimated cost for Phase II Improvements is approximately $3,880,000.

Phase III Improvements generally include water mains that fall into only one circle. Phase III Improvements are divided into two sections (Phase IIIa and IIIb). Phase IIIa improvements include any remaining hydraulic improvements and water mains with high asset management scores. Phase IIIb Improvements include water mains that have high asset management scores and should be replaced when funding becomes available or roads are scheduled to be paved.

Phase IIIa Improvements include the installation of mains on Casco Street, Hopkins Street and Maitland Street and replacement of mains on Golf Street, Bridge Street, Adams Street, Pleasant Street, Laurel Street, Center Street, Green Street, Brook Drive, Jeannette Street and Kane Street. The estimated cost for Phase IIIa Improvements is $3,025,000. The Phase IIIb Improvements are discussed further in Section 7. The total estimated cost for Phase IIIb Improvements is approximately $7,250,000.

SECTION 2 – Existing Water System

2.1 Distribution System

The Town of Fairhaven's distribution system consists of approximately 100 miles of water mains ranging in size from two to sixteen inches in diameter. Figure No. 2-1 shows a breakdown of the water main size distribution of the existing water system. Approximately 50 percent of the water main is 6-inch diameter pipe. These mains are constructed of various materials including cement lined ductile iron (DI), cast iron (CI), polyvinyl chloride (PVC) and asbestos cement (AC) as shown in Figure No. 2-2. It is noteworthy, that the majority of the system is AC (39 percent) and unlined cast iron (22 percent). A Water Distribution System Map is included in Appendix A.

The Town's distribution system services elevations ranging from approximately 5 feet to 80 feet above mean sea level (MSL). Buzzard's Bay borders the southern and western boundaries of Town, while the Towns of Acushnet and Mattapoisett border the northern and eastern boundaries. There are four active groundwater supply sources.

2.2 Water Supply Sources

The Town of Fairhaven has four supply sources; the Tinkham Lane Well, and Wolf Island Road Wells No. 1, 2, and 3. The Tinkham Lane Well is the Town's primary water supply source.

Wolf Island Road Wells

The Town of Fairhaven operates three gravel packed wells located in the northwest portion of Mattapoisett off Wolf Island Road. Operation of the Wolf Island Road Wells is limited to 18 hours per day, unless Massachusetts Department of Environmental Protection (MassDEP) approval is obtained under emergency conditions. Because of the operating limitation, the total combined withdrawal volume from the three wells is 0.76 million gallons per day (mgd).

Well No. 1 is located approximately 100 feet south of Wolf Island Road, west of Branch Brook. The well is a 24-inch by 18-inch gravel packed well constructed in September 1982 to a depth of 67.5 feet. MassDEP permitted maximum pumping rate for this well is 275 gallons per minute (gpm). Well No. 1 has the highest yield of the three wells located at this site.

Well No. 2 is located approximately 140 feet north of Wolf Island Road, east of Branch Brook. The well is a 24-inch by 18-inch gravel packed well constructed in September 1982 to a total depth of 59 feet. The MassDEP permitted maximum pumping rate for this well is 180 gpm.

Well No. 3 is located approximately 640 feet south of Wolf Island Road, west of Branch Brook. This site was identified in 1979 and constructed in the spring of 1981. The well is a 36-inch by 24-inch gravel packed well constructed to a depth of 66.5 feet. The MassDEP permitted maximum pumping rate for this well is 245 gpm.

Figure No. 2-1
Water Main Diameter Distribution

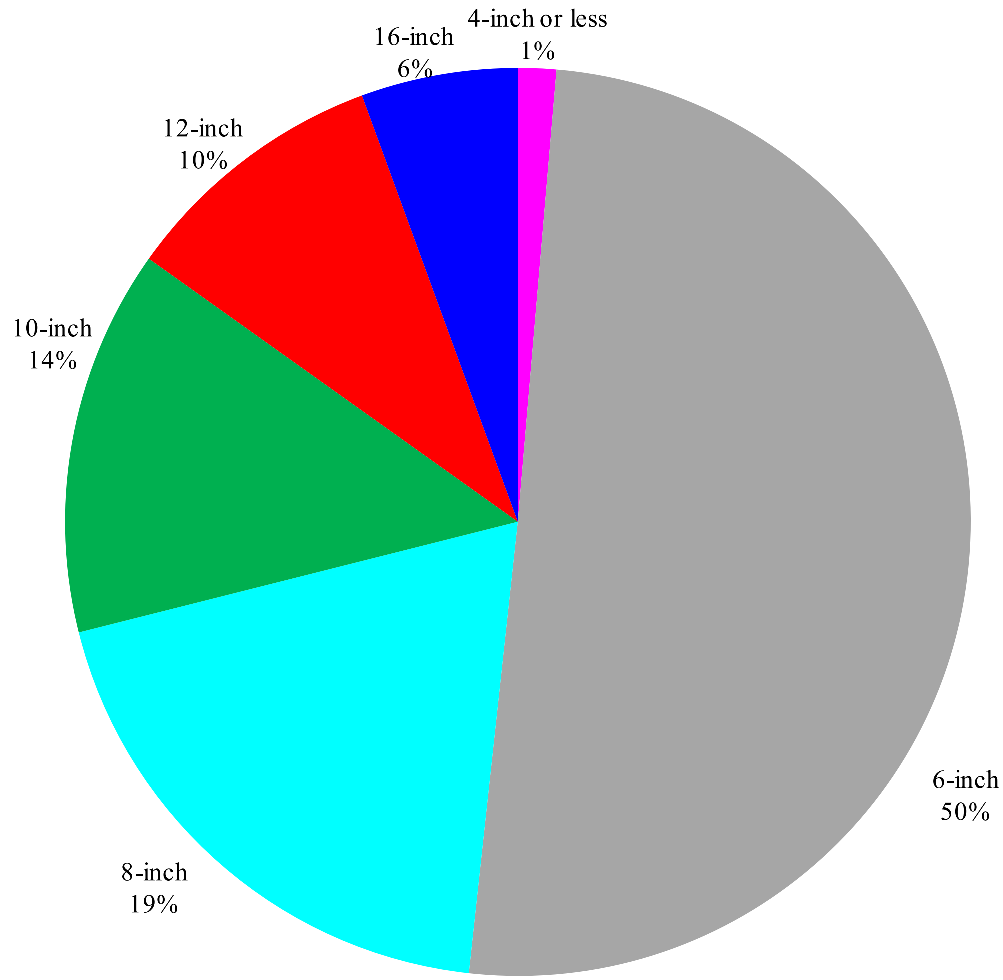
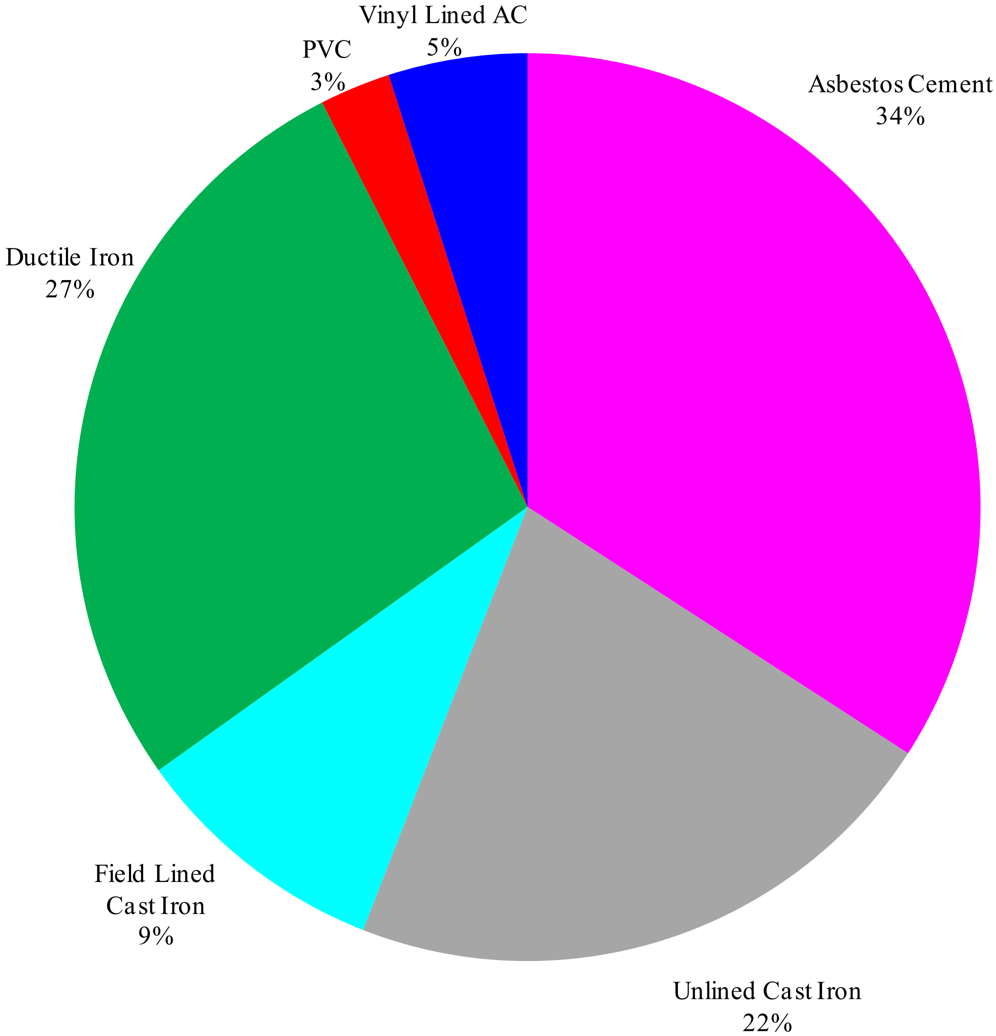


Figure No. 2-2
Water Main Material Distribution



All Wolf Island Road Wells are treated at the Mattapoisett River Valley Water District Water Treatment Facility located on Tinkham Lane in Mattapoisett.

Tinkham Lane Well

The Tinkham Lane Well is a 48-inch by 36-inch gravel packed well located at the end of Tinkham Lane, south of the Wolf Island Road wells in Mattapoisett. The well was constructed in 1985 to a depth of approximately 97 feet.

The Tinkham Lane Well has a safe yield of approximately 9.0 mgd. However, the maximum daily permitted withdrawal volume is limited to 1.73 mgd. The Tinkham Lane Well is also treated at the Mattapoisett River Valley Water District Water Treatment Facility.

Emergency Interconnections

In addition to supply sources, the Town of Fairhaven has two emergency interconnections with the City of New Bedford and two interconnections with the Town of Mattapoisett. In the 2004 Vulnerability Assessment, the water main from the Town's wells was identified as a Single Point Failure. Therefore, the Town's emergency interconnections are critical components in the distribution system to reduce the vulnerability in supply. The two 12-inch diameter interconnections to New Bedford are located on Howland Road and Bridge Street. The hydraulic grade line (HGL) elevation in New Bedford is approximately 216 feet. In order to receive water from New Bedford, the Town would have adjust the existing operating level in the Boston Hill Tank.

There is a 6-inch diameter interconnection with Mattapoisett located on River Road and an 8-inch diameter interconnection located on Tinkham Lane. The Town of Mattapoisett has a HGL of approximately 177 feet. Although Fairhaven operates at a HGL of approximately 180 feet, the Town can drop tank levels by three feet, under emergency conditions, to accept water from Mattapoisett. The existing interconnection with Mattapoisett on River Road should be evaluated for capacity, main size, and ownership on both sides of the Town line to best utilize the interconnection.

2.3 Water Storage Facilities

The Town of Fairhaven operates two water storage facilities: the Boston Hill Tank and the Sconticut Neck Tank. The Boston Hill Tank was constructed in 1975 and has a storage capacity of 2.0 million gallons (mg), a diameter of 51 feet and a height of 134.5 feet. The tank was originally constructed at an overflow elevation of 216 feet MSL to match the HGL in New Bedford. It was the intent of the Town of Fairhaven to purchase water from New Bedford; however, this option was never pursued. Therefore, in order to provide adequate water distribution system pressures, the tank is operated at 180 feet, thereby reducing the overall storage capacity to 1.5 mg.

The Sconticut Neck Tank was constructed in 1986 off Sconticut Neck Road between Briarcliff Road and Jerusalem Road. The tank has a capacity of 1.5 mg. The tank is 136.5 feet tall, 44 feet in diameter and has an overflow elevation of 180 feet.

2.4 Mattapoisett River Valley Water District Water Treatment Facility

The Mattapoisett River Valley Water District Water Treatment Facility was completed in 2008 to treat the Mattapoisett, Marion and Fairhaven water supply sources. The 6.0 mgd water treatment facility uses ozonation followed by ultrafiltration for iron and manganese removal. The arrangement among the communities allows for proportionate sharing of the treated capacity, with costs allocated according to use.

2.5 Previous System Studies

A Water System Capital Improvement Plan was completed for the Town of Fairhaven by Tata & Howard in 2002. The Plan provided recommended storage, supply and distribution system improvements to meet the existing and future needs of the system. Using the hydraulic model, capital improvements were evaluated and prioritized. These recommendations were reviewed and updated as part of the Capital Efficiency Plan™.

SECTION 3 – Water Supply Evaluation

3.1 General

In accordance with MassDEP, the supply sources of a water system must be capable of meeting existing and projected maximum day demand (MDD) conditions with all available sources online and existing and projected summer average day demand (SADD) conditions with the largest source off line. In this section, existing demand conditions were evaluated and demand projections made in previous studies were reassessed to account for potential changes in population projections based on the current economic environment. The safe yields of the supplies and permitted withdrawals of the existing supply sources were compared to current and projected future demand conditions.

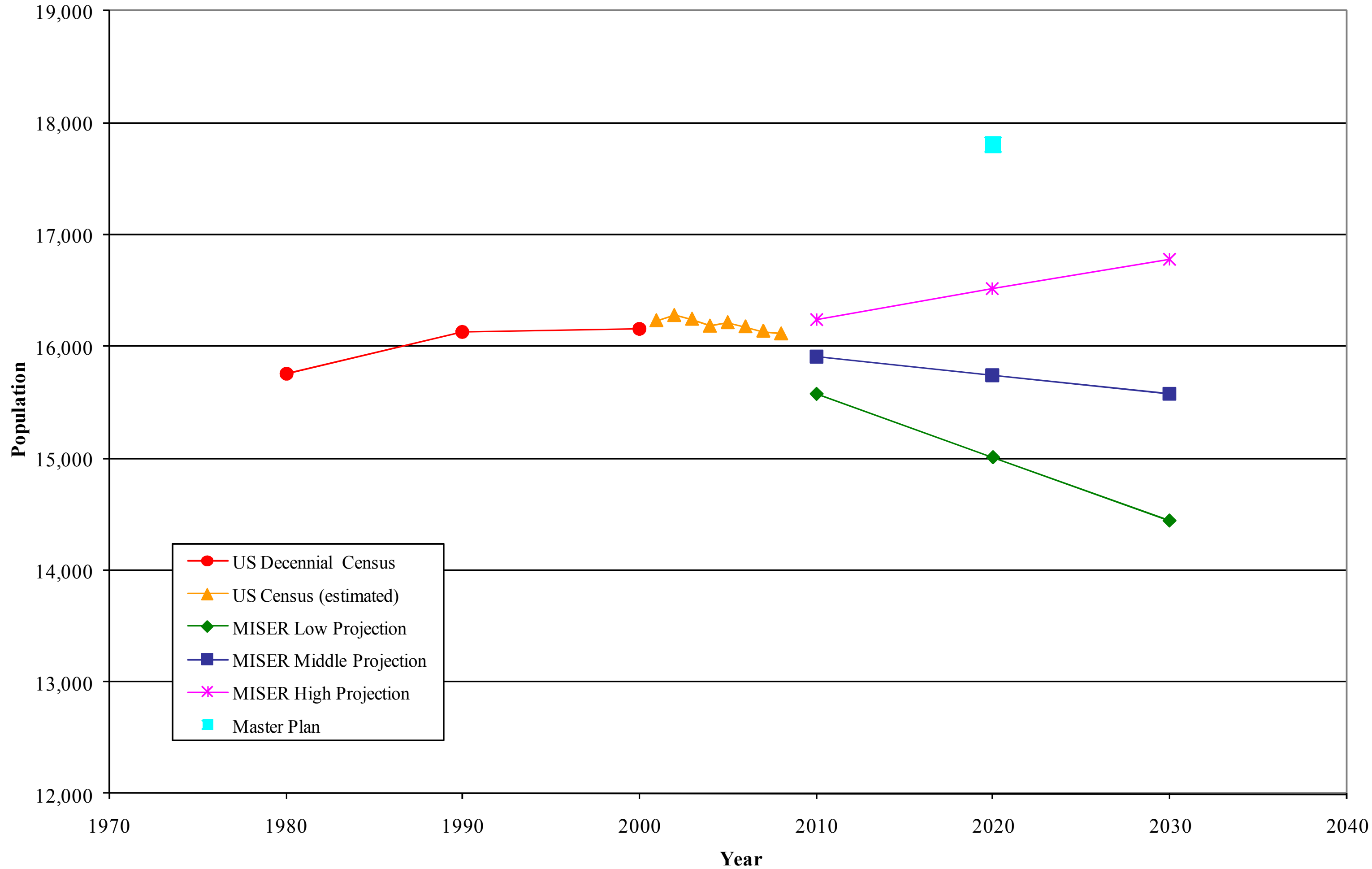
3.2 Water System Demands

Demand projections through 2020 were completed by Tata & Howard in the 2002 Water System Capital Improvements Plan. The demand projections, in this report, were based on a 2020 projected population of 17,803 as presented in the Town's Master Plan. The 2002 population projections did not anticipate the recent economic downturn, and prior to the recession the Town's growth rate did not increase as originally projected. Based on the US Census estimated populations, the Town's population has remained steady between 2000 and 2008. Figure No. 3-1 depicts the historic population and the 2020 population projected in the Town's Master Plan. Population projections for the Town of Fairhaven were obtained from the Massachusetts Institute for Social and Economic Research (MISER). MISER's high, middle and low projections are through 2020; therefore, the populations were interpolated through 2030 as shown in Figure No. 3-1. The MISER middle and low projection data result in the population decreasing over time, while the MISER high projection is increasing but at a lower rate than the Master Plan projections. Based on the information provided, the MISER high projection is more consistent with current population trends, and was therefore used in this study. The estimated 2030 population based on the MISER high projection is approximately16,800 which was used to estimate future demand projections.

Based on the 2002 study, the number of non-residential service connections was anticipated to increase at a rate of five connections per year. This number was based on growth data presented in the Master Plan. The number of non-residential service connections was 146 in the year 2000 and estimated at 246 by the year 2020. Based on the Town's Annual Statistical Reports (ASRs), the number of non-residential service connections has ranged between 135 and 153 between 2004 and 2008. Based on the limited non-residential growth since 2000 it was assumed that non-residential use in the design year 2030. The average non-residential water use between 2004 and 2008 was 64.0 mg.

The Massachusetts Department of Conservation and Recreation (DCR) follow specific guidelines when projecting the water usage for communities in conjunction with the MassDEP Water Management Act (WMA). These guidelines incorporate trends in the use of water conservation devices in homes and industry, and emphasize the importance of monitoring the distribution system through water audits and leak detection surveys to reduce unaccounted-for

Figure 3-1
Historic and Projected Populations



water. It is important to note that the DCR has a key role in the water management approval process. Water demand projections require approval by DCR before MassDEP will approve development of new water supply source or authorize the withdrawal of additional volume from existing sources.

Based on recent developments, the Massachusetts Water Resource Commission (MWRC) has adopted new Water Management Standards for all registered and permitted withdrawals. The policy includes performance standards and conditions for all registered and permitted public water suppliers in the following areas:

- Maximum residential consumption of 65 gallons per capita per day (rgpcd),
- Maximum of 10 percent unaccounted-for water,

The following criteria were used to develop the ADD for the design year 2030:

- Residential consumption of 65 gallons per capita per day (rgpcd),
- Year 2030 service population of 16,800,
- Non-residential consumption of approximately 64.0 mgy,
- Maximum of 10 percent unaccounted for water.

Based on these criteria, the estimated ADD for the design year 2030 is approximately 1.41 mgd.

MassDEP guidelines recommend that a system consider a projected SADD. The current SADD is estimated by averaging the three maximum demand months for the past five years. The SADD peaking factor is determined by dividing the SADD by the annual ADD for each of the past five years. The peaking factors are averaged to estimate the future summer peaking factor. Based on 2004 through 2008 monthly demand data, the summer peaking factor is 1.19. Based on a projected 2030 ADD of 1.41 mgd, the estimated future SADD is 1.67 mgd.

The projected 2030 MDD is estimated using the current MDD/ADD ratio. The MDD/ADD ratio provides a relationship between the two demands which can be used to estimate future demands. The MDD ranged from 1.74 mgd to 2.07 mgd from 2004 to 2008. Upon comparison of the MDD to the ADD, the ratios range from 1.35 to 1.63. In order to be conservative, the highest historical peaking factor was used to estimate future MDD. The resulting projected MDD for year 2030 is estimated at 2.29 mgd.

3.3 Adequacy of Existing Water Supply Sources

In 1987, the Water Management Act (WMA) program was implemented by MassDEP to regulate withdrawal of water from the state's watershed basins. Under this program, all new sources withdrawing more than 100,000 gpd and existing sources exceeding their registered withdrawal volume by 100,000 gpd are required to obtain a withdrawal permit under the WMA. When first implemented, the registered withdrawal volume for a public water system was based on that system's historical pumping rate of the water supply source(s) between 1981 and 1985. However, permits can be renewed and amended as system demands increase and additional supply sources are utilized. The WMA program considers the need for the withdrawal, the impact of the withdrawal on other hydraulically connected water suppliers, the environmental impacts of the withdrawal, and the water available in the river basin or subbasin (the basin safe yield) prior to issuing a permit. It is important to note that the basin safe yield is different from the safe yield of a supply. In accordance with the WMA permit, the basin safe yield is the total volume of water available that can be safely withdrawn from a river basin or sub basin without depleting the basin's supply. In other words, the volume removed from the basin must not exceed the volume replenished through natural resources. The safe yield of a well is the volume of water that can be safely withdrawn from the well under the most severe pumping and recharge conditions that can be realistically anticipated.

The current Fairhaven system is comprised of four groundwater supply sources. Table No. 3-1 provides the MassDEP authorized withdrawal rates for each of Fairhaven's supply sources. The total approved withdrawal rate from existing sources is approximately 2.49 mgd. The ADD, SADD and MDD in 2008 were 1.2, 1.49 and 1.98 mgd, respectively. The projected ADD, SADD and MDD for the year 2030 are 1.41 mgd, 1.67 mgd and 2.29 mgd, respectively.

Table No. 3-1
Authorized Withdrawal Volumes of Existing Sources*

Source Name	MassDEP Approved Withdrawal Rate (mgd)
Wolf Island Road No. 1	0.40
Wolf Island Road No. 2	0.26
Wolf Island Road No. 3	0.35
Tinkham Lane Well	1.73
Total	**2.49**

* Total approved volume per day from the combined Wolf Island Road Wells is 0.76 mgd.
* The Wolf Island Road Wells operation is limited to 18 hours per day maximum, unless MassDEP approval is obtained under emergency conditions.

MassDEP guidelines recommend that a system have adequate supply to meet the projected MDD with all sources online and the projected SADD with the largest source offline. The system's total combined yield of the active supply sources is approximately 2.49 mgd, when compared to the projected 2030 MDD; a surplus of 0.20 mgd is estimated. The Tinkham Lane Well is the largest source based on sustainable yield therefore the available pumping rate with the largest source is off-line is 0.76 mgd. Compared to the projected 2030 SADD, a deficit of 0.91 mgd is estimated. The Town of Fairhaven is able to receive water from the Mattapoisett River Valley Water District through the Town of Mattapoisett during a supply deficit.

3.4 Adequacy of Existing Storage Facilities

Distribution storage is provided to meet peak consumer demands such as peak hour demands and to provide a reserve for fire fighting. Storage also serves to provide an emergency supply in case of temporary breakdown of pumping facilities, or for pressure regulation during periods of fluctuating demand.

There are three components that are considered when evaluating storage requirements. These components include equalization, fire flow requirements, and emergency storage.

Equalization storage provides water from the tanks during peak hourly demands in the system. Typically, this quantity is a percentage of the maximum day demands. The percentages can range from fifteen to twenty-five percent, with fifteen percent used for a large system, twenty percent for a medium sized system and twenty five percent used for a small system. A system is considered small if it has less than 3,300 customers, while a system is considered large if it has more than 50,000 customers. The Fairhaven system is considered a medium sized system. As a result, twenty percent of maximum day demand was used for the equalization storage calculations.

1. Equalization

- Medium sized system = 20 percent of the Maximum Day Demand
- Maximum Day Demand in year 2008 = 1.98 mgd
- Estimated Maximum Day Demand in year 2030 = 2.29 mgd

- Equalization (2008) = 0.20 x 1.98 = 0.40 mg
- Equalization (2030) = 0.20 x 2.29 = 0.46 mg

The fire flow storage component is based on the basic fire flow requirement multiplied by the required duration of the flow. This basic fire flow is defined as a fire flow indicative of the quantities needed for handling fires in important districts, and usually serves to mitigate some of the higher specific fire flows. For the Fairhaven system, a basic fire flow of 2,250 gpm for duration of two hours is used for the storage evaluation.

2. Basic Fire Flow Requirement

- Representative fire flow = 2,250 gpm
- Duration of 2 hours or 120 minutes

- Basic Fire Flow Requirement = 2,250 x 120 = 0.27 mg

The emergency storage component is typically equivalent to one ADD. However, if there is emergency power available at the source(s) and the supply is sufficient to meet the ADD or there are emergency connections with surrounding communities, the emergency storage component can be waived. There is emergency power available at the sources of supply, therefore, the emergency storage component was not included in the storage capacity calculations.

3. Emergency - Waived

The total required storage for any given year is the equalization component plus the basic fire flow requirement. Therefore, the current (year 2008) and projected (year 2030) total required storage is presented below:

- Total Required Storage (2008) = 0.40 + 0.27 = 0.67 mg.
- Total Required Storage (2030) = 0.46 + 0.27 = 0.73 mg.

Under existing and projected ADD, MDD and peak hour demands, a minimum pressure of 35 psi should be maintained throughout the distribution system. A minimum pressure of 20 psi should be maintained during a fire flow situation. In the Fairhaven system, the highest customer is at an elevation of approximately 80 feet. In order to maintain a pressure of 20 psi , the tank levels can drop to approximately 126 feet. Based on this scenario, the total available storage is 1.43 mg. Therefore, there is currently enough storage in the system to provide the total required storage through the design year 2030.

SECTION 4 – Hydraulic Evaluation

4.1 General

In the 2002 Water System Capital Improvements Plan, Tata & Howard, Inc. used a hydraulic model to evaluate the Fairhaven water distribution system and as a basis for recommending water distribution system improvements. At the time of the study, a hydraulic computer model of the distribution system was created. The model has since been upgraded to InfoWater software from Innovyze®. The model allows the user to conduct hydraulic simulations. As part of the capital improvements plan, the hydraulic model was verified under steady state conditions based on fire flow testing and information pertaining to the sources and storage facilities. The computer model is represented by the node, pipe, tank and pump information provided in Appendix B. A link map of the water distribution system is provided in Appendix B.

As part of the Capital Efficiency Plan™, the Fairhaven model was updated to include improvements to the distribution system since 2002. Additional fire flow testing was competed on November 12 and 13, 2009. The fire flow test results and information pertaining to the sources and storage facilities were used for additional model verification. It should be noted that verification under an Extended Period Simulation (EPS) was outside the scope of work for this study. EPS verified models allow simulations over time to evaluate specific traits or trends including water age and water quality in various locations of the system, water storage tank fluctuations and pumping trends.

Once the model was verified, recommendations set forth by the Insurance Services Office (ISO) for water storage necessary for fire protection, fire flows, and peak demands were utilized in the analysis of the distribution system.

Based on Chapter 9 of the MassDEP May 2010 Guidelines for Public Water Systems, water mains providing fire protection and serving fire hydrants shall be 8-inch diameter or larger. The hydraulic recommendations in this section follow these guidelines. Any recommendation in this section for water mains less than 8-inch diameter involve looping existing dead ends in the system with small sections of water main. Additional hydrants would not be required on these sections of water main.

4.2 Evaluation Criteria

The Hydraulic Evaluation facet of the Three Circle approach evaluates the system's ability to meet varying demand conditions.

In general, a minimum pressure of 35 pounds per square inch (psi) at ground level is recommended during average day, maximum day, and peak hour demand conditions (no coincident fire flow). During fire flow conditions, a minimum pressure of 20 psi is recommended at ground level throughout the system. In order to evaluate the system's ability to meet these criteria, the following hydraulic simulations were run in the model:

Insurance Services Office (ISO) Fire Flow Recommendations

The recommended fire flow in any community is established by the ISO. The ISO determines a theoretical flow rate needed to combat a major fire at a specific location; taking into account the building structure, floor area, the building contents, and the availability of fire suppression systems. In general, the flows recommended for proper fire protection are based on maintaining a residual pressure of 20 pounds per square inch (psi). This residual pressure is considered necessary to maintain a positive pressure in the system to allow continued service to the customers and avoid negative pressures that could introduce groundwater into the system.

The estimated recommended fire flows, as determined by the ISO, were simulated on the computer model. Areas where the available fire flow did not meet the ISO recommend fire flow were considered hydraulically deficient. As part of the 2002 Water System Capital Improvement Plan, recommended improvements were developed to mitigate these deficiencies.

Additional Fire Flow Recommendations

According to the American Water Works Association (AWWA), the minimum recommended fire flow in residential areas where homes are between 31 feet and 100 feet apart is approximately 750 gpm. An estimated fire flow of 750 gpm at all nodes was simulated on the computer model. Some areas of the distribution system could not meet the minimum recommended fire flow; improvements were developed for these areas and are presented herein.

4.3 Hydraulically Deficient Areas

In general, the hydraulic recommendations presented in the 2002 plan were broken down into Priority I and II improvements relative to the water supply and distribution system. Priority I improvements were intended to meet water supply needs and mitigate ISO fire flow deficiencies. Priority II improvements identified improvements required at or near system extremities for fire flow deficiencies, as well as system looping in certain areas.

The 2002 recommended hydraulic improvements were revaluated, adjusted to account for new demand projections and completed system improvements. The following list provides a summary of the Priority I and II distribution system hydraulic improvements that are recommended as part of this study. A map of the recommended hydraulic improvements is included in Appendix C.

Priority I Recommended Improvements

1. There is a hydraulic restriction between the Boston Hill Tank and the Sconticut Neck Tank. The Sconticut Neck Tank does not contribute flow to meet demands in the center area of Town and lags when filling and draining relative to the Boston Hill Tank. This condition limits the available fire flow from the tank for demands in the center and north end of town and limits its effectiveness during maintenance of the Boston Hill tank. Additionally, in the winter when demands on Sconticut Neck and West Island are low, the drawdown and turnover in the tank is inadequate and may lead to bacterial problems. A mixing system was added to the tank to reduce stagnation but turnover should be increased. A hydraulic evaluation is recommended to evaluate potential distribution system improvements to improve the flow between the two tanks. This would include evaluation of potential

improvements to the existing 10-inch diameter water main on Sconticut Neck Road between Huttleston Avenue and the tank.

2. An estimated ISO fire flow of 1,250 gpm is recommended at the intersection of Huttleston Avenue (Route 6) and Shaw Road, and 2,500 gpm is recommended at the intersection of Huttleston Avenue and New Boston Road. To meet these flow recommendations several improvements are recommended and are presented below:

    a. A new 12-inch diameter ductile iron water main is recommended to replace the existing 10-inch diameter water main on Huttleston Avenue from Mill Road to New Boston Road.

    b. We recommend a new 8-inch diameter ductile iron main on Gellette Road and Shaw Road to connect the existing 6-inch diameter water main on Gellette Road to the existing 10-inch diameter water main on Shaw Road. This water main improvement will also eliminate two system dead ends and improve the residential fire flow on Gellette Road. Without the new water main on Gellette Road and Shaw Road, a new 8-inch water main would need to be installed to replace the existing 6-inch diameter water main on Gellette Road from Huttleston Avenue to the end of the existing water main.

    c. The 10-inch diameter water main on Huttleston Avenue between New Boston Road and Shaw Road should be cleaned and lined. Prior to implementing this improvement, we recommend that pipe coupons be taken from the 10-inch main to confirm the interior condition of the main and verify no external corrosion has taken place.

3. Estimated ISO fire flows of 1,000 gpm are recommended on Ruth Street and at the intersection of Balsam Street and Fisherman Road. These areas are located on Sconticut Neck and West Island and are serviced by a long dead-end 10-inch diameter main. In 2002, approximately 1,700 feet of 12-inch diameter water main was installed parallel to the existing 10-inch diameter main from the Sconticut Neck Tank to just south of Camel Street. We recommend installing an additional 4,100 feet of parallel 12-inch diameter water main from the existing 12-inch water main to approximately 1,100 feet south of Silver Shell Grant Drive. This improvement will provide the inherent capacity to meet the recommended fire flow, and improve the available flow on Sconticut Neck and West Island to meet the recommended residential fire flow.

4. A new 12-inch diameter ductile iron water main is recommended to replace the existing 6-inch diameter water main on Main Street from Winsor Street to Hawthorne Street. This improvement will provide the ISO recommended fire flow of 2,500 gpm at the intersection of Main Street and Hawthorne Street.

Priority II Recommended Improvements

5. A fire flow recommendation of 2,250 gpm was estimated along Main Street and at the end of Alden Road due to a number of large structures including multi-family units and a nursing

home. To increase fire protection in this area, we recommend replacing the existing 6-inch diameter water main on Main Street from Hawthorne Street to Nicholas Street with new 12-inch diameter ductile iron water main.

6. St. Josephs School is located on Spring Street. To meet an estimated recommended fire flow of 2,250 gpm at the school we recommend installing a new 8-inch diameter water main on Spring Street from Adams Street to the School.

7. The existing 6-inch diameter water main on McGann Terrace should be replaced with new 8-inch diameter water main to meet an estimated recommended fire flow of 2,250 gpm at the Green Meadows Nursing Home on McGann Terrace located off of Washington Street.

8. The existing water mains on Farmfield Street and James Street do not have the inherent capacity to provide the recommended residential fire flows. In order to meet the recommended fire flow, a new 8-inch diameter ductile iron water main is recommended on Farmfield Street from Laurel Street to the existing 6-inch diameter water main on James Street.

9. In order to provide the recommended residential fire flows to the area of Jameson Street and Brae Road, we recommend installing a new 6-inch diameter ductile iron water main on Casco Street. This improvement will loop the existing 6-inch diameter water mains on Jameson Street and Brae Road.

10. Currently, the existing 6-inch diameter water main on Hopkins Street does not connect to the 12-inch diameter water main on Howland Road. This portion of 6-inch main is serviced by a 4-inch diameter water main on Brown Street. The recommended residential fire flow cannot be met through the existing water main configuration. The 6-inch diameter water main on Hopkins Street should be extended and connected to the existing 12-inch diameter water main on Howland Road with 6-inch diameter ductile iron water main.

11. A new 6-inch diameter ductile iron water main is recommended on Maitland Street to connect the existing 6-inch diameter main on Maitland Street to the 8-inch diameter water main on Alden Road. This improvement will provide the recommended residential fire flow and eliminate a dead end.

12. The existing 6-inch diameter water main on Harvard Street currently dead ends at Golf Street. A new 6-inch diameter water main is recommended on Golf Street to connect the existing water main on Harvard Street to the existing 10-inch diameter water main on Sconticut Neck Road. This improvement will eliminate a dead end and improve residential fire flows on Harvard Street.

13. Table No. 4-1 identifies the remaining water mains that should be replaced with 8-inch diameter mains to meet the recommended residential fire flow of 750 gpm.

Table No. 4-1
Water Main Replacements

	Location	Existing Diameter
1.	Brook Drive	6-inch
2.	Jeannette Street	6-inch
3.	Kane Street	6-inch
4.	Narragansett Boulevard from Huttleston Avenue to Webster Street	6-inch
5.	Old Fort Road	4-inch
6.	Pine Grove Street	6-inch
7.	Raymond Street	6-inch
8.	Weeden Road from Huttleston Avenue to Shawmut Drive	6-inch

SECTION 5 – Critical Component Assessment

5.1 General

A critical component assessment was performed for the water distribution system to evaluate the impact of potential water main failures on the water distribution system. The critical component assessment includes identification of critical customers and areas served, critical water mains, and the need for redundant mains.

5.2 Evaluation Criteria

Critical areas served are locations in the distribution system that require continual water supply for public health, welfare or financial reasons. Examples of critical service areas include hospitals, nursing homes, schools, and business districts. All water mains within 500 feet of a critical area are considered a critical component. Because water storage tanks and sources provide water and maintain pressure to critical service areas, tanks and primary sources are also considered critical areas. Therefore, any water main within 500 feet of a water storage tank or primary source is considered a critical component.

Critical water mains are the sole transmission main from a source or tank. In addition, main transmission lines without a redundant main are considered critical. The evaluation included a visual review of the water mains leading into and out of the critical areas and the transmission grid.

5.3 Critical Components

Critical areas served, critical supply mains and redundant mains were evaluated in the Fairhaven Water System based on the criteria described above. Table No. 5-1 provides a listing of the areas that are considered critical components. A map of the critical components is included in Appendix D.

Critical Water Mains

Critical water mains include primary transmission lines as well as mains connecting water storage tanks and sources to the system. Critical mains are highlighted on the Critical Components Map found in Appendix D.

The critical water mains were identified based on a review of the distribution system model and using the model's criticality feature. The criticality feature runs simulations that "break" each pipe in the model. The model calculates if the system can still be served with adequate flow and pressures after a pipe is taken out of service. This feature can identify areas served by multiple mains, but would no longer be able to serve customers if one of the mains were taken out of service.

One critical transmission main is the 16-inch diameter water main from the MRV Water Treatment Facility. The water main is located on Tinkham Lane, Acushnet Road and New Boston Road until it connects with the system at Bridge Street. This is the only transmission main from the treatment facility into the distribution system.

Table No. 5-1
Critical Areas

	Location	Street Address
1.	MRV Water Treatment Plant	Tinkham Lane, Mattapoisett
2.	Tinkham Lane Well	Tinkham Lane, Mattapoisett
3.	Wolf Island Wells	Wolf Island Road, Mattapoisett
4.	Boston Hill Tank	Boston Hill Road
5.	Sconticut Neck Tank	Sconticut Neck Road
6.	Interconnection with Mattapoisett	River Road, Mattapoisett
7.	Interconnection with Mattapoisett	Tinkham Lane, Mattapoisett
8.	Interconnection with New Bedford	Bridge Street
9.	Interconnection with New Bedford	Howland Road
10.	Fairhaven Police Department	146 Washington Street
11.	Fairhaven High School	12 Huttleston Avenue
12.	Hastings Middle School	30 School Street
13.	East Fairhaven School	2 New Boston Road
14.	Wood School	60 Sconticut Neck Road
15.	Rogers School	100 Pleasant Street
16.	Oxford School	347 Main Street
17.	St. Joseph School	100 Spring Street
18.	Little People's College	158 Bridge Street
19.	Little People's College	128 Sconticut Neck Road
20.	Little People's College	201 Sconticut Neck Road
21.	Montessori Preschool	357 Main Street
22.	Walnut Grove Day Care & Preschool	316 Huttleston Avenue
23.	Precious Memories Preschool	8 Webster Avenue
24.	Cozy Corner Family Child Care	59 Marguerite Street
25.	Bright Beginnings Day Care & Preschool	16 Nicholas Street
26.	Our Lady's Haven Skilled Nursing and Rehabilitative Care	71 Center Street

Table No. 5-1 (continued)
Critical Areas

	Location	Street Address
27.	Alden Court Nursing Care	389 Alden Road
28.	Community Nurse & Hospice Care	62 Center Street
29.	Oxford Terrace Nursing Home	275 Main Street
30.	Dana Court Nursing Home	180 Adams Street
31.	Green Meadows Nursing Home	McGann Terrace
32.	Fairhaven Village Nursing Home	330 Main Street
33.	Nichols House/Anthony Haven Nursing Homes	184 Main Street

The 10-inch diameter water main on Sconticut Neck Road, from the existing parallel 12-inch diameter water main just south of Camel Street to Goulart Memorial Drive, and on Goulart Memorial Drive are considered critical because they are the only water mains that serve the southerly end of Sconticut Neck and West Island.

The 10-inch diameter water main on Huttleston Avenue, from Gellette Road to Pine Grove Street, is considered critical because it is the only source of water to that portion of the system. It also provides an emergency connection to Mattapoisett.

SECTION 6 – Asset Management Considerations

6.1 General

The Fairhaven water distribution system has been in operation since the late 1800's. The existing system includes approximately 100 miles of water main varying in size and material. A number of factors including age, material, break history, soil conditions, pressure, and water quality affect the decision to replace or rehabilitate a water main. Using an Asset Management approach, each water main in the system is assigned a grade based on these factors. The grades are then used to establish a prioritized schedule for water main replacement or rehabilitation.

6.2 Data Collection

Information regarding the water main diameters was obtained from existing water distribution system maps. Information regarding pipe age, material and break history was obtained from workshops with system managers and Board of Public Works (BPW) records. Since record drawings do not exist for much of the system, water main age and material are based on the operators' field experience and best estimates.

6.3 Evaluation Criteria

To prioritize water main replacement or rehabilitation, a water main grading system has been established. The grading system uses the water main characteristics such as age, material, break history, water quality, diameter, pressure, and soil characteristics to assign point values to each pipe in the system. Each category is assigned a rating between zero and 100 with zero the most favorable and 100 the worst case within the category. Each category is then given a weighted percentage, which represents priorities within the system. It is at the Town's discretion to adjust the weight based on system performance and condition. Our recommendation is to assign a maximum of 30 percent to any one category. The rating is then multiplied by the weight. The weighted rating for each performance criteria is utilized to determine the overall rating per pipe. Those pipes with the highest grade are most in need of replacement or rehabilitation.

To establish a rating system specific to the Fairhaven water system, a workshop was held with the system manager's and operators. During the discussions, it was determined that water main age and materials are of primary concern to the BPW. The water system includes vinyl-lined asbestos cement pipe. MassDEP mandated sampling must be conducted on any dead end water main with this lining to monitor for Tetrachloroethylene (PCE), a carcinogen that can leach from the vinyl lining. The system includes five dead end polyvinyl lined AC water mains that require replacement. Therefore, polyvinyl lined AC was given the highest score in the materials category. In addition, the BPW is concerned with the age of the water mains, especially in the downtown area. A large portion of these water mains were installed prior to 1900. Therefore, water main age was given a higher overall weight in the grading system.

The BPW is also concerned with the AC pipe located on Sconticut Neck. This pipe is subject to tidal influence and has become soft or "punky" in many areas. The AC pipe in this area has also begun to experience more frequent main leaks and breaks in the past few years. In addition, cast iron or ductile iron pipes in this area are subject to corrosion in wet soils. Therefore, the corrosive soil category was given additional weight in the overall rating scale. Table No. 6-1 presents the Asset Management grading system including the ratings and category weights that resulted from discussions with the BPW.

Age/Material

The water industry in the United States followed certain trends over the last century. The installation date of a water main correlates with a specific pipe material that was used during that time period, as shown on Table No. 6-2. For example, until about the year 1958, unlined cast iron water mains were the predominant pipe material installed in water systems. Factory cement lined cast iron mains were manufactured from the late 1950's to about 1970, when pipe manufacturers switched primarily to factory cement lined ductile iron pipe.

Cast iron water mains consist of two types; pit cast and sand spun (a.k.a. centrifugally cast). Pit cast mains were generally manufactured up to the year 1930, while sand spun mains were generally manufactured between 1930 and 1976. Pit cast mains with diameters between 4-inch and 12-inch do not have a uniform wall thickness and may have "air inclusions" as a result of the manufacturing process. This reduces the overall strength of the main, which makes it more prone to leaks and breaks. Although sand spun mains have a uniform wall thickness, the overall wall thickness is thinner than the pit cast mains. The uniformity provided added strength, however, the thin wall thickness made it more susceptible to corrosion and breaks. Pit cast mains 16-inch diameter and larger have very thick pipe walls and are generally stronger than the thinner walled sand spun cast mains.

While the transition to factory cement lined cast iron mains had begun in the early 1950's, prior to the year 1958, most cast iron water mains that were manufactured were still unlined. Unlined cast iron mains increased the potential for internal corrosion. By 1958, the majority of cast iron mains manufactured had a factory cement lining. The year 1958 marked the introduction of rubber gasket joints. Prior to this date, joint material was jute (rope type material) packed in place with lead or a lead-sulfur compound, also known as "leadite" or "hydrotite". Leadite type joint materials expand at a different rate than iron due to temperature changes. This can result in longitudinal split main breaks at the pipe bell. Sulfur in the leadite can promote bacteriological corrosion that can lead to circumferential breaks of the spigot end of the pipe. Therefore, the rating score is higher for water mains manufactured before 1958.

Factory lined cast iron was manufactured and installed up until approximately 1973. Factory cement lined cast iron provided increased protection against internal corrosion. Unlined cast iron water mains make up approximately 22 percent of the Fairhaven water system. According to system records, the Fairhaven system does not have any factory lined cast iron water main. The BPW has performed field cement lining on approximately nine percent of the water system.

Between the 1930's and 1970's, the water industry also utilized asbestos cement (AC) pipe for water systems. An advantage of AC pipe is that it resists tuberculation build up, resulting in less system head loss. However, based on water quality, the structural integrity of AC mains can deteriorate over time, thereby becoming sensitive to pressure fluctuations and/or nearby construction activities. In addition, external influences such as soil type and high groundwater

Table No. 6-1
Asset Management Grading System

Weight	Performance Criteria	Rating	Weighted Rating
20%	Break History		
	Two or more breaks per 1,000 ft	100	20
	Fewer than two breaks per 1,000 ft	50	10
	No history of breaks	0	0
30%	Material		
	Vinyl Lined Asbestos Cement	100	30
	Asbestos Cement	90	27
	Unlined Cast Iron	90	27
	Field Lined Cast Iron	60	18
	Ductile Iron	0	0
	PVC	0	0
20%	Installation Date		
	Pre 1900	100	20
	1900-1919	95	19
	1920-1939	90	18
	1940-1957	80	16
	1958-1969	20	4
	1970-1979	10	2
	1980-1989	5	1
	1990-1999	2	0.4
	2000-2009	0	0
15%	Diameter		
	4-inch water main and smaller	100	15
	6-inch water main	80	12
	8-inch water main	40	6
	10-inch water main	20	3
	12-inch water main	0	0
	16-inch water main	0	0
10%	Soil		
	Potentially corrosive soil	100	10
	Gravel, sand	0	0
5%	Water Quality		
	History of water quality concerns	100	5
	No water quality concerns	0	0

Table No. 6-2
Pipe Material by Installation Year

Installation Year	Length of Water Main (feet)						
	Vinyl Lined Asbestos Cement	Asbestos Cement	Unlined Cast Iron	Field Lined Cast Iron	Ductile Iron	PVC	Grand Total
Pre 1900			34,603	18,681			**53,284**
1900-1919			31,759	12,314			**44,073**
1920-1939			6,299	5,170			**11,469**
1940-1957		17,618	39,167	850			**57,635**
1958-1969		153,169	6,455				**159,624**
1970-1979	24,823						**24,823**
1980-1989					71,976	2,871	**74,846**
1990-1999					54,311	9,830	**64,141**
2000-2009					10,533		**10,533**
Total	**24,823**	**170,787**	**109,065**	**46,243**	**136,820**	**12,701**	**500,428**
Percentage	**5%**	**34%**	**22%**	**9%**	**27%**	**3%**	**-**

can corrode AC mains, reducing the strength further. Approximately 34 percent of the Fairhaven system consists of unlined AC water mains.

For a short time, AC pipe was lined with vinyl. It was later found that the vinyl can leach PCE into drinking water and the lining was discontinued. Approximately five percent of the system is vinyl-lined AC.

Polyvinyl Chloride (PVC) pipe was first used in the United States in the early 1960's. Due to its resistance to both chemical and electrochemical corrosion, PVC pipe is not damaged by aggressive water or corrosive soils. In addition, the smooth interior of PVC pipe is resistant to tuberculation. The 1994 "Evaluation of Polyvinyl Chloride (PVC) Pipe Performance" by the AWWA Research Foundation, found that utilities have experienced minimal long term problems with PVC pipe. Generally, problems with PVC occur when the area surrounding the pipe is disturbed after installation, which can lead to main breaks.. It should be noted that PVC is a permeable material. Low molecular weight petroleum products and organic solvents can permeate PVC pipe if the contaminants are found in high concentrations in the soil surrounding the pipe. Approximately three percent of the system is PVC pipe.

Approximately 27 percent of the system is cement lined ductile iron water main. This material was introduced in the United States in the 1950's, however, was not widely used until the 1970's. According to the Ductile Iron Pipe Research Association (DIPRA), ductile iron pipe retains all of cast iron's qualities such as machinability and corrosion resistance, but also provides additional strength, toughness, and ductility. However, ductile iron pipe typically has a thinner pipe wall and may not have the same overall useful life as cast iron pipe due to external corrosion unless it is properly wrapped in polyethylene encasement.

In general, the oldest water mains in the system received a high rating of 100, while the newest received a rating of zero. A significant rating decrease occurs around 1958, which represents the timeframe when factory lining was introduced. Figure No. 6-1 and 6-2 present the installation year of the water mains and the materials, respectively.

Diameter

The Fairhaven water distribution system consists of water mains ranging in diameter from two to sixteen inches. Approximately 19 percent of the system is comprised of 8-inch diameter pipes and approximately 50 percent is 6-inch diameter pipes.

In general, as the diameter of a pipe increases, the strength increases. In most cases, failure occurs in the form of ring cracks. This is primarily the result of bending forces on the pipe. Pipes that are 6-inch in diameter are more likely to deflect or bend than a larger diameter main. Pipes that are 8-inch in diameter are less likely to break from bending forces due to their increased diameter and resulting increased moment of inertia. In addition, the pipe wall thickness typically increases as the pipe diameter increases. Pipes that are 16-inches in diameter and larger have significantly thicker walls than 12-inch diameter pipe and smaller diameter water mains such that in addition to superior bending resistance, they are much more resistant to failure from pipe wall corrosion.

Figure No. 6-1 Installation year

Figure No. 6-2 Material

The rating system for the diameter of the water mains follows the concept that 4-inch diameter water mains are not as strong as 16-inch diameter water mains. Therefore, a rating of 100 was given to 4-inch diameter and smaller water mains and a rating of zero was given to the 16-inch diameter and larger water mains. Table No. 6-1 shows a significant drop in the rating score between a 6-inch diameter water main (80) and 8-inch diameter water main (40). This is due to wall thickness and field experience. An 8-inch diameter water main has proven to have nearly twice the bending strength of a 6-inch diameter water main. In general, 8-inch diameter water mains are stronger and less likely to break than 6-inch diameter pipes. Figure No. 6-3 presents the various diameter sizes throughout the distribution system.

Break History

Based on leak and break reports the Fairhaven water system experiences approximately three breaks per year on average. In relation to the total miles of water main in the system, this equates to approximately three breaks per 100 miles per year. In comparison to the national average of 25 breaks per 100 miles per year, the Fairhaven water system is in good condition. However, each water main break costs the Town time and labor. They also cause disruption to the public and water consumers. At some point, it becomes more efficient to replace the main then to continue repairing it. Based on Fairhaven's water main break records, there are several areas in the system that experience frequent breaks. These areas are given a rating of 100 while areas with no known breaks received a rating of zero. Areas with a history of breaks are highlighted on Figure No. 6-4.

Water Quality

In general, the water quality in the Fairhaven water system meets or exceeds state and federal water quality standards. However, the downtown area has the oldest water mains and has experienced water quality issues. Also, vinyl lined AC water mains have been known to leach PCE into drinking water. The dead end vinyl lined AC water mains require sampling or have a bleeder on them. These mains have the potential for water quality problems. Areas where water quality is a concern are highlighted on Figure No. 6-5. These areas are given a rating of 100, while areas without water quality concerns are assigned a rating of zero.

Soils

Water main degradation can occur both internally and externally. Factors that increase the rate of external corrosion include high groundwater, clay soils, contaminated soils, soils with low calcium carbonate, or soils with high acidity or sulphate. Wetlands areas have greater potential to cause external corrosion of water main than other soil conditions. Areas that are under the influence of ocean water also have increased corrosion potential due to the high salt content. Fairhaven also used cinders to build up some roads and cinders can cause external corrosion. Fairhaven has also experienced external corrosion in areas near the ocean as well as areas where the pipes are in clay. Clay is a low permeability soil. As a result, ground water will not drain away from the pipe readily. The additional contact with water can accelerate the rate of external corrosion of a pipe. As shown on Figure No. 6-6, much of the Fairhaven is made up of potentially corrosive soils. Areas where the water system and the potentially corrosive soils coincide are considered areas of potential exterior corrosion. There are also areas identified by the BPW where corrosion has been an issue. Water mains located in potentially corrosive soil were assigned a rating of 100, while all other locations were assigned a rating of zero.

Figure No. 6-3 – Diameter sizes

Figure No. 6-4 – Break History

Figure No. 6-5 – Water Quality

Figure No. 6-6 – Soils Map

Pressures

Plumbing code states that water heaters can be affected when pressures exceed 80 psi. Pressures above 100 psi can result in increased water use from fixtures and also increased leakage throughout the distribution system. MassDEP Guidelines and Policies for Public Water System states that normal working pressures should be approximately 60 psi and not less than 35 psi. In areas with pressures exceeding 125 psi, pressure reducing valves are recommended on the water mains. These areas are more susceptible to water main breaks. In addition, main failures in areas of higher pressures typically cause more disruption, and result in more costly repairs for damages. The Fairhaven water system generally maintains pressures ranging from 40 psi to 80 psi, within the recommended range. Therefore, pressure was not considered in the asset management grading system.

6.4 Asset Management Areas of Concern

Based on the Asset Management ratings, there are several areas of concern in the distribution system. Water mains with a total rating between zero and 32 are considered to be in good to excellent condition. Areas with a total rating between 33 and 58 are considered to be in fair to good condition, and areas with a total rating greater than 58 are considered to be in poor to fair condition. Asset Management ratings are presented graphically in Appendix E.

SECTION 7 – Recommendations and Conclusions

7.1 General

The following summarizes the findings of the study and presents a prioritized plan for recommended improvements and associated costs. The prioritization of improvements allows for constructing the necessary improvements over an extended period of time as funds allow.

Costs are based on the May 2011 Engineering News Record (ENR) construction cost index for Boston, MA of 11450.54, and include a 25 percent allowance for engineering and contingencies and costs associated with water services, hydrants and permanent and temporary trench pavement. Estimates do not include costs for land acquisition, easement or legal fees.

The capital improvement projects, considered by this study, will provide a direct benefit to the overall level of service provided to the Fairhaven customers, reduce operation and maintenance cost by reducing the frequency of water main failures and the damage they cause, as well as improve fire protection to the homeowners and businesses in the Town.

The Water Research Association's (formerly the American Water Works Research Foundation) study on "Cost of Infrastructure Failure," which was completed in 2002, found that in addition to direct costs paid by water utility ratepayers for water main failures, there are also societal costs, which are paid by the public. Examples of the direct costs include outside contractor costs, engineering costs, police assistance, fire department assistance, electrical, telephone and gas utility damage costs, landscaping restoration costs, and laboratory costs. Examples of societal costs included the cost of traffic impacts, business customer outage impacts, public health impacts (including loss of life), property damage not covered by direct costs, and the cost of reduced fire fighting capability during the failure event.

Replacement of one percent of a system each year (a 100 year replacement cycle) is a reasonable guideline based on industry experience and analysis. For the Fairhaven distribution system, this equates to approximately 5,300 linear feet of water main replacement each year as a guideline. Regular rehabilitation of water mains reduces main failures, leakage, and water quality issues. Water main rehabilitation can also provide socio-economic benefits by reducing operational costs associated with chemical and energy usage. Also, rehabilitation or replacement of water mains that are inadequately sized to provide needed fire protection improves public safety.

7.2 General Recommendations

To establish a comprehensive database of the condition of the distribution system, it is recommended that Fairhaven create a water main failure database. The database should include the location of each break and the properties of the failed main such as diameter, material, joint type, and type of lining. In addition, Fairhaven should record the type of failure such as ring crack, lateral split, hole in the pipe, "punky" AC pipe failure, or joint leak. If possible, Fairhaven should include the apparent cause of the failure such as frost load, traffic load, direct contractor damage, settlement, water hammer, external soil corrosion or stray current. This data should then be incorporated into the hydraulic model to create a Water Main Failure Map for identifying problem areas in the future. The water main failure database will aide Fairhaven in making water main replacement decisions in the future.

In addition, it is recommended that Fairhaven create a database of new or replacement water mains. The database should include water main diameter, material, lining, joint type, soil conditions, date of installation, and as-built schematic drawings. This data can be added to the existing database, created for this study, to maintain a comprehensive water main database.

Based on Chapter 9 of the MassDEP May 2010 Guidelines for Public Water Systems, water mains providing fire protection and serving fire hydrants shall be 8-inch diameter or larger. The hydraulic recommendations in this section follow these guidelines. Any recommendation in this section for water mains less than 8-inch diameter involve looping existing dead ends in the system with small sections of water main, or replacing 6-inch diameter water mains with high asset management scores with 6-inch diameter water mains in highly looped areas that meet hydraulic and fire flow recommendations.

It is recommended that prior to installation of all new ductile iron water mains, Fairhaven test the soils in the area of the new main to determine if it has high corrosion potential. If the soil is found to be potentially corrosive, Fairhaven should consider wrapping the main with polyethylene to protect against external corrosion. Wrapping is a relatively inexpensive practice that can extend the life of new ductile iron pipe. In addition, wrapping helps to protect the pipe from stray currents that may develop near the main.

The Town should perform regular scheduled maintenance programs, including hydrant flushing. The Town should implement the Comprehensive Flushing Program developed by Tata & Howard in 2007. Implementation of the flushing program will identify hydrants and valves that do not function as intended. The Town should also implement a replacement program where the indentified hydrants and valves are replaced. By replacing hydrants that are old or broken, the Town will improve fire protection in the system and eliminate potential leaks. Eliminating broken valves in the system will help improve the transmission capacity of the system.

Approximately five percent of the system is comprised of vinyl lined AC water main. This material use was discontinued due to the leaching of PCE into drinking water. The vinyl lined AC water mains that dead end must be frequently sampled and a permanent bleeder is in place on Shaw Road. Because sampling is time consuming and bleeders waste water, the BPW has indicated that replacing the remaining dead end vinyl lined water mains is a top priority.

7.3 Prioritization of Improvements

Based on the Three Circles Approach, a prioritized list of improvements was created. Improvements were separated into three phases. The Phase I and Phase II Improvements are prioritized based on hydraulic needs, location in the distribution system, and the condition of the water main. Phase I Improvements are organized into two categories, general recommendations and water distribution system improvements. In general, the Phase I Improvements include water mains that fall into all three of the circles. Phase II Improvements include water mains that fall into two of the three circles. These improvements strengthen the transmission grid, eliminate potential asset management concerns, and provide redundancy. Phase III Improvements generally include areas that fall into one circle. These improvements include the remaining hydraulic recommendations from Section 4 and areas with high asset management ratings. Phase III Improvements should be completed as funds become available and considered when reviewing road paving schedules. The hydraulically deficient areas, critical component considerations and asset management ratings are combined on one Capital Efficiency Three Circles Integration Map included in Appendix F.

It should be noted that due to the nature of this Capital Efficiency Plan™, the list of improvements is extensive. This results in a high associated cost if all of the suggested improvements were constructed. The intent of the prioritization, therefore, is to serve as a guide for implementation from the most needed to the least needed improvements based on the weighted criteria established jointly by Fairhaven and Tata & Howard. These improvements would most logically be constructed over an extended period of time.

Table No. 7-1, at the end of this section, includes a prioritized list of Phase I Improvements for the water distribution system and the hydraulic, critical component, and asset management status of each improvement. Table No. 7-2 includes the linear footage and estimated cost of each Phase I Improvement. Table No. 7-3 includes a prioritized list of Phase II Improvements and Table No. 7-4 includes the linear footage and estimated cost of each Phase II Improvement. The recommended improvements maps are included in Appendix G. It should be noted that paving schedules or highway department improvements were not evaluated as part of this study. Fairhaven may reprioritize the recommendations if paving or road work is scheduled on any of the roads recommended for water main improvements.

Phase I Improvements – General Recommendations

1. As discussed in Section 2, the water mains from the Town's supply sources are identified as a Single Point of Failure in the 2004 Vulnerability Assessment. The emergency interconnections serve as redundant connections to reduce the vulnerability in supply. To maximize the existing interconnections, an evaluation should be completed on the existing River Road interconnection with Mattapoisett. The evaluation should include a review of the capacity, main size and ownership on both sides of the Town line.

2. As discussed in Section 4, there is a hydraulic restriction between the Boston Hill Tank and the Sconticut Neck Tank. The Sconticut Neck Tank does not contribute flow to meet demands in the main area of Town and lags when filling and draining relative to the Boston Hill Tank. A hydraulic evaluation is recommended to evaluate potential distribution system improvements to improve the flow between the two tanks. This would include evaluating potential improvements to the existing 10-inch diameter water main on Sconticut Neck Road between Huttleston Avenue and the tank. This water main has an asset management rating of 54 and is considered good to fair. This water main has experienced multiple breaks and leaks in the past few years.

Phase I Improvements – Water Distribution System

1. As discussed, the areas of the system with dead end vinyl lined asbestos cement water mains are a concern for the Town. These areas are sampled frequently or continuously flushed. The water main on Pine Grove Circle is considered hydraulically deficient due to

the inability to meet residential fire flow recommendations. Also, the water mains, except for Shaw Road, have asset management ratings of 59 or higher, which is considered fair to poor condition. It is a high priority for the Town to replace the water mains on Swift Street and Tripp Street from Center Street to the end with 6-inch diameter water main, the water mains on Akin Street, Day Street and Pine Grove Street with 8-inch diameter ductile iron water mains, and the water main on Shaw Road with a 12-inch diameter ductile iron water main. The estimated probable construction cost of each improvement are listed below:

- Akin Street – $120,000
- Day Street – $120,000
- Pine Grove Street – $200,000
- Shaw Road – $940,000
- Swift Street – $55,000
- Tripp Street – $45,000

2. As discussed in Section 4, a portion of Spring Street is considered hydraulically deficient since the water main cannot meet a recommended ISO fire flow of 2,250 gpm at Saint Joseph's School. This area is also considered critical because of the school. The asset management rating for this main 64, which is considered poor to fair. The high asset management rating can be attributed to the water main's size, material, age, and water quality issues in this area. Although only a portion of the water main on Spring Street is considered hydraulically deficient, the main should be replaced with 8-inch diameter ductile iron water main from Green Street to Huttleston Avenue due to the high asset management rating. The estimated probable construction cost for approximately 3,800 linear feet of 8-inch diameter water main is $530,000.

3. To provide the inherent capacity for the ISO recommended fire flows on Huttleston Avenue at New Boston Road and Shaw Road, we recommend the following:

   a. Replace the existing 10-inch diameter water main on Huttleston Avenue from Mill Road to the Town line with 12-inch diameter ductile iron water main.

   b. Installation of new 8-inch diameter water main on Gellette Road and Shaw Road to connect the existing 6-inch diameter and 10-inch diameter water mains.

   c. The hydraulic recommendation discussed in Section 4, was to clean and line the existing 10-inch diameter water main on Huttleston Avenue from New Boston Road to the Town line. However, we recommend the replacement of this main with new 12-inch diameter pipe. The existing main has experienced recent breaks, has the potential of external corrosion due to soil conditions, an asset management rating between 56 and 66, and is considered critical users since a portion of the main is the only main that serves the eastern end of Huttleston Avenue.

The estimated probable construction cost of approximately 8,100 linear feet of 12-inch diameter water main and 3,000 linear feet of 8-inch diameter water main is $2,150,000.

Phase II Improvements

4. As discussed in Section 4, there are ISO recommended fire flows on Ruth Street and Fisherman Road on Sconticut Neck and West Island. To improve the inherent capacity on Sconticut Neck and West Island, we recommend the installation of a parallel 12-inch diameter ductile iron water main on Sconticut Neck Road from the existing parallel water main just south of Camel Street to approximately 1,100 feet south of Silver Shell Grant Drive. The existing water main is also considered critical since it is the only supply to the southerly end of Sconticut Neck and West Island. The proposed water main will add redundancy to the transmission grid and improve the reliability of service on Sconticut Neck and West Island. The estimated probable construction cost of approximately 4,100 linear feet of 12-inch diameter water main is $770,000.

5. To provide the inherent capacity of the ISO recommended fire flow on Main Street at Hawthorne Street and to improve the inherent fire flows along the northern end of Main Street, we recommend replacing the existing 6-inch diameter water main on Main Street with 12-inch diameter ductile iron water main from Winsor Street to Nicholas Street. This main is also considered critical because of several critical users in the area including schools and nursing homes. The estimated probable construction cost of approximately 3,400 linear feet of 12-inch diameter water main is $770,000.

6. We recommend replacing the existing water main on McGann Terrace with new 8-inch diameter water main. The existing water main is considered hydraulically deficient since the water main cannot meet a recommended fire flow of 2,250 gpm at the Green Meadows Nursing Home. This area is also considered critical because of the nursing home. The asset management rating in this area is 58, which is considered to be in fair to good condition. The estimated probable construction cost of approximately 700 linear feet of 8-inch diameter water main is $100,000.

7. To improve inherent fire flows along Narragansett Boulevard, we recommend replacing the existing water main from Huttleston Avenue to Webster Avenue with 8-inch diameter ductile iron water main. This area is also considered critical due to the Precious Memories Day Care Center. The estimated probable construction cost of approximately 2,000 linear feet of 8-inch diameter water main is $280,000.

8. We recommend installing an 8-inch diameter ductile iron water main on Farmfield Street, from Fort Street to the existing 6-inch diameter water main on James Street, to replace the existing 6-inch diameter water main, eliminate dead ends and improve fire flows in this area. The existing water main on Farmfield Street has an asset management rating between 60 and 69, which is considered poor to fair condition. The original hydraulic improvement required replacement water main from Laurel Street to James Street. Due to the high asset management rating of the existing 6-inch diameter water mains, we recommend that the water main be replaced from Fort Street to James Street. There is a section of existing 8-inch diameter water main on Farmfield Street, from Green Street to Laurel Street that has an asset management rating of 54, which is considered to be in fair to good condition and would not need replacement. The estimated probable construction cost of approximately 4,000 feet of 8-inch diameter water main is $550,000.

9. As discussed in Section 4, there are areas of the system that cannot meet a recommended residential fire flow of 750 gpm due to main size. The existing 4-inch and 6-inch water mains on Old Fort Road, Raymond Street, and Weeden Street have high asset management ratings and are considered fair to poor. These mains should be replaced with 8-inch diameter ductile iron water mains. Also, if the looping of Gellette Road and Shaw Road described in Improvement No. 3 is not completed, the existing 6-inch diameter water main on Gellette Road requires replacement with 8-inch diameter ductile iron water main to meet residential fire flows. If Improvement No. 3 is completed, the existing water main on Gellette Road should be included in Phase IIIb. The linear footage and estimated costs for these water mains are presented in Table No. 7-4.

Phase III Improvements

Phase III Improvements have been divided into two sections (Phase IIIa and IIIb). Phase IIIa Improvements include recommendations that represent the remaining hydraulic improvements from Section 4 along with some water mains with high asset management ratings. Phase IIIb Improvements include the water mains that have high asset management ratings and should be replaced when funding becomes available or roads are scheduled to be paved. Table No. 7-5 includes a list of Phase IIIa Improvements and the hydraulic, critical component, and asset management status of each improvement. Table No. 7-6 includes the linear footage and estimated cost of each Phase IIIa Improvement.

Phase IIIa Improvements

10. To provide the inherent capacity to meet the recommended fire flow and eliminate two dead ends in the system, a new 6-inch diameter water main is recommended on Casco Street between Jameson Street and Brae Road. The estimated probable construction cost of approximately 300 linear feet of 6-inch diameter water main is $35,000.

11. We recommend connecting the existing 6-inch diameter water main on Hopkins Street to the existing 12-inch diameter water main on Howland Road with 6-inch diameter ductile iron water main to improve the inherent fire flow on Hopkins Street and eliminate the dead end. The estimated probable construction cost of approximately 100 feet of 6-inch diameter water main is $15,000.

12. To provide the recommended fire flow on Maitland Street and eliminate a dead end in the system, a new 6-inch diameter water main is recommended on Maitland Street to connect the existing water main to Alden Road. The estimated probable construction cost of approximately 300 linear feet of 6-inch diameter water main is $35,000.

13. To improve the recommended fire flow on Harvard Street and eliminate a dead end, a new 6-inch diameter water main is recommended on Golf Street between Harvard Street and Sconticut Neck Road. The estimated probable construction cost of approximately 350 linear feet of 6-inch diameter water main is $40,000.

14. The water main on Bridge Street from Middle Street to Adams Street should be replaced with 8-inch diameter ductile iron water main. The existing water main has a high asset

management rating. The water main is also located in the vicinity of an interconnection with New Bedford. The water main is near a critical user, however, due to the gridded nature of this area of the distribution system, the water main is not considered critical. The estimated probable construction cost of approximately 2,000 feet of 8-inch diameter water main is $280,000.

15. The water main on Adams Street, from Spring Street to Center Street, has an asset management rating of 74 and is considered poor to fair condition. This water main should be replaced with 8-inch diameter ductile iron water main. This water main is also near the Rogers School, but is not considered critical because it is in an area with adequate water main gridding. The estimated probable construction cost of approximately 1,700 feet of 8-inch diameter water main is $240,000.

16. We recommend replacing the existing water main on Pleasant Street with 8-inch diameter ductile iron water main. This water main is considered to be in poor to fair condition due to asset management ratings ranging from 69 to 74. This water main is also near the Rogers School, but is not considered critical because it is in a gridded area. The estimated probable construction cost of approximately 4,300 feet of 8-inch diameter water main is $600,000.

17. The water main on Laurel Street, from Spring Street to Farmfield Street, should be replaced with 12-inch diameter ductile iron water main. This water main has an asset management rating ranging from 62 to 72. The water main is in the vicinity of critical users, but is not considered a critical water main due to the gridded pattern of the water mains in this area. The estimated probable construction cost of approximately 3,000 feet of 12-inch diameter water main is $570,000.

18. The water main on Center Street, from William Street to Hitch Street, has an asset management rating ranging from 65 to 74, poor to fair condition. This water main should be replaced with 8-inch diameter water main. The water main is also in the vicinity of critical users, but is not considered a critical water main due to the gridded pattern of water mains in this area. The estimated probable construction cost of approximately 2,400 feet of 8-inch diameter water main is $330,000.

19. We recommend replacing the existing water main on Green Street, from Maple Avenue to Washington Street, with 8-inch diameter ductile iron water main. The water main has an asset management rating ranging from 60 to 65. The water main is also in the vicinity of critical users, but is not considered a critical water main due to the interconnection of several water mains in this area. The estimated probable construction cost of approximately 3,200 feet of 8-inch diameter water main is $440,000.

20. As discussed in Section 4, there are areas of the system that cannot meet a residential fire flow of 750 gpm due to main size. These include the water mains on Brook Drive, Jeannette Street, and Kane Street. These water mains should be replaced with 8-inch diameter ductile iron water main. The linear footage and estimated costs for these water mains are presented in Table No. 7-6.

Phase IIIb Improvements

21. There are numerous water mains that are considered to be in poor to fair condition based on an asset management rating of 59 or greater. These water mains should be replaced based on available funding or paving schedules. Table No. 7-7 includes a list of Phase IIIb Improvements and the hydraulic, critical component and asset management status of each improvement and the linear footage and estimated cost of each improvement.

Table No. 7-1
Prioritization of Improvements - Phase I

Item No.	Location	From	To	Hydraulically Deficient?	Critical Area?	Asset Management Rating
1	Akin Street			No	No	59
	Day Street			No	No	59
	Pine Grove Street			Yes	No	61
	Shaw Road			No	No	50
	Swift Street			No	No	59
	Tripp Street	Center Street	End	No	No	59
2	Spring Street	Huttleston Avenue	Green Street	Yes	Yes	63-64
3a	Huttleston Avenue	Mill Road	New Boston Road	Yes	Yes	46-48
3b	Gellette Road/Shaw Road			Yes	No	-
3c	Huttleston Avenue	New Boston Road	Town Line	Yes	Yes	46-56

Table No. 7-2
Estimated Improvement Costs - Phase I

Item No.	Location	From	To	Water Main Diameter (in)	Length (LF)	Estimated Cost
1	Akin Street			8	850	$ 120.000
	Day Street			8	850	$ 120.000
	Pine Grove Street			8	1,400	$ 200.000
	Shaw Road			12	5,000	$ 940.000
	Swift Street			6	450	$ 55.000
	Tripp Street	Center Street	End	6	400	$ 45.000
2	Spring Street	Huttleston Avenue	Green Street	8	3,800	$ 530.000
3a	Huttleston Avenue	Mill Road	New Boston Road	12	4,100	$ 930.000
3b	Gellette Road/Shaw Road			8	3,000	$ 420.000
3c	Huttleston Avenue	New Boston Road	Town Line	12	4,000	$ 800.000
					Total Estimated Phase I Cost:	**$4,160,000**

Table No. 7-3
Prioritization of Improvements - Phase II

Item No.	Location	From	To	Hydraulically Deficient?	Critical Area?	Asset Management Rating
4	Sconticut Neck Road	South of Camel Street	1,100 feet south of Silver Shell Grant Drive	Yes	Yes	56
5	Main Street	Winsor Street	Nicholas Street	Yes	Yes	43-45
6	McGann Terrace			Yes	Yes	58
7	Narragansett Boulevard	Huttleston Avenue	Webster Avenue	Yes	Yes	57
8	Farmfield Street	Laurel Street	James Street	Yes	No	60-69
9	Gellette Road	Huttleston Avenue	Judson Drive	Yes	No	65
	Old Fort Road			Yes	No	71
	Raymond Street			Yes	No	75
	Weeden Road			Yes	No	65

Table No. 7-4
Estimated Improvement Costs - Phase II

Item No.	Location	From	To	Water Main Diameter (in)	Length (LF)	Estimated Cost
4	Sconticut Neck Road	South of Camel Street	1,100 feet south of Silver Shell Grant Drive	12	4,100	$ 770,000
5	Main Street	Winsor Street	Nicholas Street	12	3,400	$ 770,000
6	McGann Terrace			8	700	$ 100,000
7	Narragansett Boulevard	Huttleston Avenue	Webster Avenue	8	2,000	$ 280,000
8	Farmfield Street	Laurel Street	James Street	8	4,000	$ 550,000
9	Gellette Road	Huttleston Avenue	Judson Drive	8	2,200	$ 310,000
	Old Fort Road			8	650	$ 90,000
	Raymond Street			8	2,600	$ 360,000
	Weeden Road			8	4,700	$ 650,000
					Total Estimated Phase II Cost:	**$3,880,000**

Table No. 7-5
Prioritization of Improvements - Phase IIIa

Item No.	Location	From	To	Hydraulically Deficient?	Critical Area?	Asset Management Rating
10	Casco Street	Jameson Street	Brae Road	Yes	No	-
11	Hopkins Street	Howland Road	Existing 6-inch	Yes	No	-
12	Maitland Street	Alden Road	Existing 6-inch	Yes	No	-
13	Golf Street	Harvard Street	Sconticut Neck Road	Yes	No	-
14	Bridge Street	Adams Street	Middle Street	No	No	64-73
15	Adams Street	Center Street	Spring Street	No	No	74
16	Pleasant Street			No	No	68-74
17	Laurel Street	Farmfield Street	Spring Street	No	No	62-72
18	Center Street	William Street	Hitch Street	No	No	65-74
19	Green Street	Maple Street	Washington Street	No	No	60-65
20	Brook Drive			Yes	No	53
	Jeannette Street			Yes	No	43
	Kane Street			Yes	No	53

Table No. 7-6 Estimated Improvement Costs - Phase IIIa						
Item No.	**Location**	**From**	**To**	**Water Main Diameter (in)**	**Length (LF)**	**Estimated Cost**
10	Casco Street	Jameson Street	Brae Road	6	300	$ 35.000
11	Hopkins Street	Howland Road	Existing 6-inch	6	100	$ 15.000
12	Maitland Street	Alden Road	Existing 6-inch	6	300	$ 35.000
13	Golf Street	Harvard Street	Sconticut Neck Road	6	350	$ 40.000
14	Bridge Street	Adams Street	Middle Street	8	2,000	$ 280.000
15	Adams Street	Center Street	Spring Street	8	1,700	$ 240.000
16	Pleasant Street			8	4,300	$ 600.000
17	Laurel Street	Farmfield Street	Spring Street	12	3,000	$ 570.000
18	Center Street	William Street	Hitch Street	8	2,400	$ 330.000
19	Green Street	Maple Street	Washington Street	8	3,200	$ 440.000
20	Brook Drive			8	1,300	$ 180.000
	Jeannette Street			8	900	$ 130.000
	Kane Street			8	900	$ 130.000
Total Estimated Phase IIIa Cost:						**$3,025,000**

Table No. 7-7
Prioritization of Improvements and Estimated Improvement Costs-Phase IIIb

Item No.	Location	From	To	Asset Management Rating	Water Main Diameter (in)	Length (LF)	Estimated Cost
21	Stetson Avenue			91	6	250	$ 30,000
	Harborview Avenue			91	6	400	$ 45,000
	Chestnut Street	Union Street	Farmfield Street	84	8	1,400	$ 195,000
	Allen Street			77	6	330	$ 40,000
	Tripp Street	Washington Street	Center Street	74	8	800	$ 110,000
	Hitch Street			74	8	700	$ 100,000
	Summer Street	Center Street	Washington Street	74	6	550	$ 65,000
	Rodham Street	Adams Street	Chestnut Street	74	8	600	$ 85,000
	Chestnut Street	Spring Street	Center Street	74	8	1,350	$ 190,000
	Middle Street	Washington Street	Ferry Street	74	8	1,250	$ 180,000
	South Street	Laurel Street	Chestnut Street	74	6	300	$ 35,000
	Atlas Street			74	8	700	$ 100,000
	Holcomb Street			73	8	650	$ 90,000
	Bryant Lane	Washington Street	Sunset Lane	73	6	300	$ 35,000
	Delano Street			73	6	330	$ 40,000
	Shore Drive			73	6	250	$ 30,000
	Ivy Lane			71	6	350	$ 40,000
	Phoenix Street			71	6	500	$ 60,000
	Coe Street			71	6	350	$ 40,000
	School Street cul-de-sac			68	6	280	$ 35,000
	Elizabeth Street	Washington Street	430 feet north of Manor Drive	68	8	850	$ 120,000
	Cedar Street	Washburn Avenue	Laurel Street	68-71	8	2,300	$ 320,000
	Buist Avenue			67	6	550	$ 65,000

Table No. 7-7 (Continued)
Prioritization of Improvements and Estimated Improvement Costs-Phase IIIb

Item No.	Location	From	To	Asset Management Rating	Water Main Diameter (in)	Length (LF)	Estimated Cost
21	North Street	Main Street	100 feet west of Main Street	66	6	130	$ 15,000
	Walnut Street	Washington Street	Morse Street	65	8	1,150	$ 160,000
	William Street	Washington Street	Morse Street	65	8	1,200	$ 170,000
	Morse Street			65	6	250	$ 30,000
	Water Street			65-68	8	830	$ 120,000
	Ferry Street			65	12	380	$ 75,000
	Union Street			65-74	8	2,050	$ 290,000
	Fort Street	Morse Street	Church Street	65	6	550	$ 65,000
	Church Street			65-74	8	2,150	$ 300,000
	Akin Street	Huttleston Avenue	Dartmouth Street	65	6	350	$ 40,000
	Winona Avenue			65	8	1,050	$ 150,000
	Tecumseh Avenue			65	6	250	$ 30,000
	Whisper Lane			65	6	250	$ 30,000
	End of Sconticut Neck			65	6	450	$ 55,000
	Washington Street	Water Street	Main Street	64-68	8	380	$ 55,000
	North Green Street	Huttleston Avenue	Mayflower Street	63	8	1,850	$ 260,000
	Francis Street	Mayflower Street	Elm Avenue	63	8	680	$ 95,000
	Plymouth Avenue	North Green Street	Adams Street	63	8	730	$ 105,000
	Massasoit Avenue	Walnut Street	Adams Street	63	8	1,150	$ 160,000
	Elm Avenue	Main Street	Adams Street	63	8	1,750	$ 245,000
	Academy Avenue	Elm Avenue	Larch Avenue	63	8	600	$ 85,000
	Castle Avenue	Elm Avenue	Larch Avenue	63	8	600	$ 85,000
	Linden Avenue	Main Street	Adams Street	63	8	1,700	$ 240,000
	Larch Lane			63	8	600	$ 85,000

Table No. 7-7 (Continued)
Prioritization of Improvements and Estimated Improvement Costs-Phase IIIb

Item No.	Location	From	To	Asset Management Rating	Water Main Diameter (in)	Length (LF)	Estimated Cost
21	Francis Street	Hope Avenue	Huttleston Avenue	63	6	600	$ 70,000
	Hope Avenue			63	6	380	$ 45,000
	Bellevue Street	Huttleston Avenue	Adams Street	63	8	1,350	$ 190,000
	Cross Street			63	6	450	$ 55,000
	Dartmouth Street	Studley Street	Atkin Street	63-75	8	630	$ 90,000
	Seaview Avenue			63	8	2,250	$ 310,000
	Grandview Avenue			63	8	2,200	$ 310,000
	Widemarsh Beach Way			63-75	8	1,800	$ 250,000
	Jerusalem Road			63	8	1,700	$ 240,000
	Cherry Street	Tabor Street	Hedge Street	62	6	300	$ 35,000
	Hedge Street	Main Street	430 feet west of Adams Street	62	8	880	$ 125,000
	Ash Street			60-63	8	1,300	$ 180,000
	Cottage Street			60-63	8	1,300	$ 180,000
	Maple Street			60-69	8	800	$ 110,000
	Alden Road	Berdon Way	Plaza Way	62	8	450	$ 65,000
						Total Estimated Phase IIIb Cost:	**$7,250,000**