TOWN OF

SOUTHBOROUGH

Department Public Works
Water Division

WATER DISTRIBUTION SYSTEM

STUDY REPORT

2007

Prepared by:
H_2O Engineering Consulting Associates, Inc.
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January 15, 2007

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January 15, 2007

Ms. Karen Galligan
Town of Southborough
Department of Public Works
147 Cordaville Road
Southborough, MA 01772

Dear Ms. Galligan:

In accordance with our agreement, H2O Engineering Consulting Associates Inc., is pleased to submit the attached report entitled "Water Distribution System Study Report" for the Town of Southborough, Massachusetts. This report includes the evaluation of existing system facilities, estimates of existing and projected future system requirements and recommendations relative to system improvements.

The report contains a Water System Master Plan and three Phases of recommendations for the Town to improve the existing distribution system to meet the requirements. The cost estimations for Phase I and Phase II improvements are also included in the report.

H_2O Engineering Consulting Associates, Inc. appreciates the opportunity to serve the Town of Southborough. We would to thank you for your assistance in providing data and information relative to the water system and its operation.

Very truly yours,

Edward T.T. Chiang, Ph.D., P.E.
President

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I. INTRODUCTION

The Town of Southborough's Water Supply System Master Plan needs to be updated and revised due to recent changes put upon the system.

The Town of Southborough has experienced more growth in recent years than was expected. Its water demand is growing at a faster rate than population growth. This is due to many large homes being constructed in the Town of Southborough and those households use much more water per capita than the average home. With the fast growth and the change of demand patterns, a review of the projected demand and the water supply system has become necessary.

In addition, the Massachusetts Water Resources Authority's (MWRA) Metro West Water Supply Tunnel (MWWST) project has constructed some water main extensions to an area in Southborough where the private wells may be impacted by the tunnel project. This project enables those private well users to connect to the Town of Southborough's water supply system.

These water main extensions have not only provided public water supply to some residents who currently are using private wells, but also increased the available land along the water main route to be developed because the water supply is available and ready to use.

This report includes: population, water consumption and growth trends. A Distribution System analysis by digital computer to identify system weaknesses under present demands and projected future demands is also included. The necessary system improvements have been evaluated and a program of improvements formulated, identifying the pipe reinforcements and extensions required; the storage facilities to be added and pump station expansions.

These improvements have been grouped into two categories to indicate their urgency: Phase I (immediate, includes some improvements needed by 2010) and Phase II (improvements needed by 2015).

II. POPULATION

A. Past and Present

In general, water consumption increases with population growth, but in recent years, the rate of growth of water consumption does not correspond to the rate of population growth. This is especially true in the so-called "Nine Bedroom Communities", such as the Town of Southborough.

Population growth is usually affected by the regional economic development, land available, taxes, industrial presence, transportation convenience, etc.

The Town's population history between 1975 and 2005 is listed in Table 1. Between 1975 and 1990 the population of Southborough grew very slowly with no significant changes and had experienced some negative growth in 1978 and 1990. From 1985 to 1994, the population increased steadily at about 1% annually with a short no growth period from 1989 to 1991. From 1994 to 1997, the population increased from 6,972 to 7,768, an 11.42% increase in four years which is more than the previous decade's growth. From 1997 to 2005, the population increased from 7,768 to 9,580, a 23.3% increase in less than 10-years. Currently, the new subdivisions and new homes being built in the Town indicate this fast growth is slowing down but will continue.

TABLE 1 - Past, Present and Estimated Future Population.

Year	Population
1975	6,326
1976	6,324
1977	6,377
1978	6,299
1979	6,389
1980	6,412
1981	6,421
1982	6,392
1983	6,429
1984	6,405
1985	6,334
1986	6,431
1987	6,444
1988	6,534
1989	6,636
1990	6,628
1991	6,657
1992	6,783
1993	6,893
1994	6,972
1995	7,297
1996	7,432
1997	7,768
2000	8,781
2005	9,580
2010	10,700*
2020	11,800*
2030	12,500*

*: estimated

B. Population Projection

In order to analyze the water supply system and to determine the future water consumption, the future population of the area to be served must be established for the target year. This is usually obtained by using selected mathematical techniques to analyze previous figures for population. This, however, is a very unreliable method, as the future population is a function of many unpredictable and indiscernible events.

To minimize the possibility of error, therefore, the future population for the Town of Southborough was estimated by considering only those areas of the Town considered buildable. Then, the zoning regulations which applied to each of these areas were considered to determine the maximum number of dwellings which could be built in the Town under current zoning laws.

It is a well known fact that communities surrounding large metropolitan areas always grow with the large metropolitan, especially for those so-called "Nine Bedroom Communities". As less land becomes available, the growth rate slows down until the area has met its "saturated" or "ultimate" density. When this density will occur in Southborough is impossible to predict; however, the year 2030 is used in this report.

The Town of Southborough is located between two major large metropolitan areas, Boston and Worcester; with interstate 495 and the Massachusetts Turnpike passing through the Town. With their excellent public services and school system, and land available, the Town of Southborough has experienced steady growth through out the Nineties even when other surrounding communities' growth had slowed down due to the Massachusetts economical downturn during the late Eighties and early Nineties.

The saturation population for Southborough was estimated to be approximately 12,500. It was further assumed that this figure will be reached shortly after the year 2030. Table 1 shows the Town's population history, and projected population. Currently, the Town of Southborough does not have a public sewer system. If public sewer were available, the population could increase when currently un-buildable land would become buildable.

III. EXISTING SOURCES OF SUPPLY

A. Sources of Water Supply and Pumping Facilities

At present the Town of Southborough obtains its water from the Massachusetts Water Resources Authority's Metro-West Water Supply Tunnel (MWWST) through two pump stations, the Thomas J. Boland pump station and the Arthur L Hosmer pump station (see Table 2). These two pump Stations used to obtain their supply from the Hultman Aqueduct until the completion of the MWWST. Based on the MWRA supply system, the Town of Southborough can obtain its source of supply from either the MWWST or the Hultman Aqueduct. But the quantity of water withdrawn will always be governed by a contract between the Town of Southborough and the MWRA which is renewed periodically. Currently, the two pump stations can pump 2,000 gallons per minute into the Southborough water supply piping system. The 2,000 gpm rate is higher than the allowed contract withdrawal amount (Average 1,400 gpm approximately) if the pumps were operated 24 hours per day. The following are brief description of these two pump stations.

1. The Thomas J. Boland Pump Station is located northwest of the Town, off Northborough Road. This pump station has two 50-horse power Gould pumps and has a capacity of 1,000 gallons per minute (gpm). It supplies the water for the west and southwest areas of the Town and fills the Fiddlers Green Reservoir which is located on Tara Road.

2. The Authur L. Hosmer Pump Station, built in 1977, is located in the northeast quarter of the Town. This pump station was connected to the MWRA supply system near the Shaft No.3 of the MWRA Hultman Aqueduct. A new supply line from the MWRA's MWWST has been constructed to connect to the suction line of the Hosmer pump station. It is equipped with one 60-horse power and one 40-

horse power Marthon electric pumps with a capacity of approximately 1,000 gallons per minute (gpm). This pump station serves the remaining sections of Town and fills the Clear Hill and the Oak Hill Stand Pipes.

In addition to the MWRA water source, some areas of the Town of Southborough rely on private wells. These private well users have no connection to the Town's water system; however, the Town's water system may have to be expanded to supply some of the areas if these private wells become inadequate. For this purpose, demand in some locations has been scaled up in the computer model to represent these likely future connections.

Table 2 – Existing Pumping Facilities in Southborough, MA

Pump Station	Boland	Hosmer
Location	Northborough Road	Shaft No.3, MWRA Hultman Aqueduct
Source	MWRA transmission	MWRA transmission
No. of pump	2	2
Capacity & Head	pump #1 – 550 gpm @3560 rpm, TDH 275 ft pump #2 – 550 gpm @3500 rpm, TDH 275 ft	pump #1 – 600 gpm @1750 rpm, TDH 250 ft pump #2 – 400 gpm @3500 rpm, TDH 250 ft

B. Storage Facilities

The Town of Southborough has three water storage facilities (see Table 3), the Fiddlers Green Reservoir, the Clear Hill Stand Pipe and the Oak Hill Stand Pipe. The total storage capacity of these facilities is 2 million gallons. The Fiddlers Green Reservoir has the highest overflow elevation. A physical description of the three (3) storage facilities follows.

Table 3 - Existing Storage Facilities in Southborough, MA

Name	Fiddlers Green Reservoir	Clear Hill Stand Pipe	Oak Hill Stand Pipe
Diameter (ft)	67	40	25
Height (ft)	48	42.5	75
Capacity (gallons)	1,300,000	460,000	275,000
Overflow Elev.	515.0	493.3	492.7
Base Elev.	467	451	418
High Water Elev.	511	489.5	480
High water Level Capacity (gallons)	1,192,000	362,000	264,000
Telemeter Gradient	511 ft.	486.6 ft.	487 ft.
Normal daily Min.	40 ft. 1,083,000 gallons	28.5 ft. 268,000 gallons	62 ft. 227,000 gallons

1. The Fiddlers Green Reservoir is located on Tara Road in the northwest section of the Town. It is about 7,500 feet south of the Boland Pump Station. This reservoir's overflow elevation is at 515.0 feet USGS mean sea level and has an approximate storage capacity of 1.3 million gallons. The water main connecting from the Boland Pump Station to the Tara Reservoir is a 12-inch pipe.

2. The Clear Hill Stand Pipe, located about 4,700 feet northwest of Hosmer Pump Station, is connected to the pump station by 10-inch and 12-inch pipes. Its overflow elevation is 493.3 ft. USGS mean sea level and its storage capacity is about 0.46 million gallons.

3. The Oak Hill Stand Pipe is located about 8,000 feet south of Hosmer Pump Station. This stand pipe is filled by the Hosmer Pump Station through the water mains on Central Street and Oak Hill Road. The water main which fills the Oak Hill Stand Pipe was upgraded to a 12-inch main at the end of 1993, except for a section of the old 8-inch pipe from Boston Road to Learned Street and a piece under the railroad. The Oak Hill Stand Pipe's capacity is about 0.28 million gallons with an overflow at 492.7 ft USGS mean sea level. Due to its limited storage capacity, this stand pipe will only help the water demand in the local area.

Prior to 1990, the water distribution system had a small elevated tank at Atwood Street. This tank had a storage capacity of 150,000 gallons. The Water Division removed this tank in 1990 because it was not cost effective to maintain such an old, small elevated tank.

C. Distribution System

Southborough's water distribution system has more than 62 miles of pipeline in the system. Pipe sizes range from 6 to 12 inches in diameter, except for a short section of 16-inch from the MWRA Hultman Aqueduct shaft No.3 to Hosmer Pump Station. Pipe materials include unlined cast iron, cement-lined cast iron, cement-lined ductile iron, and asbestos-cement. Geographically the Southborough distribution system can be separated into three sections by using Route 9 and Route 90 as dividers; north, middle and south. Both the Boland and Hosmer Pump Stations are located in the north and raise the system pressure in that section. The water is introduced into the system in the north section and flows south.

1. The northern section, north of Route 9, includes Southborough's downtown area and includes more than half of the service area of the Town. Although the Sudbury Reservoir occupies approximately 1/5 of the area in this section, it has the highest demand in the distribution system. The Boland and Hosmer Pumping Stations and the Clear Hill Stand Pipe are all located in this area; therefore, the

water service to this northern section is adequate.

2. The middle section includes the area between Route 9 and Route 90. It has two high ground areas, e.g., Fair View Hill on the west and Oak Hill on the east. The low area is a valley in the vicinity of Cordaville Road. The Oak Hill Stand Pipe feeds the easterly high point. The Fiddlers Green Reservoir feeds the westerly high point. The water pressure and volume of flow in this section of the Town are marginally adequate. The service pressure for some of the high ground areas is low even when the system pressure reaches its maximum. This is because the ground elevation is too high to be served by the system.

3. The southern section, south of Route 90, is the furthest area from the storage facilities and pump stations. The Town's distribution system map indicates only three 8-inch water mains cross Route 90 and continuing to the south, until recently when a 12-inch main was installed from Walnut Drive to Oregon Road. It appears that Route 90 becomes a bottleneck in servicing the southern section of the Town. Fortunately, this section of the Town does not have high ground, therefore its' domestic water supply is adequate but, the large fire flow needed at the Finn School area is not adequate.

The Town of Southborough has more than its share of main highways, railroads, large storage reservoirs and aqueducts crossing through the Town. It is difficult and costly to manage a complex water supply network like this. Some of the problems in this system include undersized pipes running under railroads, Massachusetts Turnpike (Route 90), Route 9 and crossing a water body and aqueduct. Because of their location, the pipes referenced here are costly to replace, besides the cost, it is difficult to obtain the permits required to install these new pipes. There are many dead ends in the system, and most of them are difficult to eliminate.

In 1997, the MWRA through the Department of Public Works of the Town of Southborough installed water mains along Sears Road, Valley Road, Bigelow Road, Pinehill Road, Johnson Road and Main Street. Most of these areas' residents are using private wells.

IV. WATER REQUIREMENT

A. General

In order to predict the future water supply needs of a community it is necessary to take into account the trends in the use of water as well as the character of the community itself.

Water demand is the sum of water consumed by customers and lost through the water distribution system, such as fire protection, hydrant flushing and testing, and leakage. In a non-industrial community there are two major types of metered water consumers; domestic and commercial. Within a community, the domestic use of water will vary depending on lot size, water cost, family income and the adequacy of the distribution system. The amount of water consumed by commercial users is dependent upon the type of business.

The Town of Southborough's water source is metered from the MWRA. Therefore, the total water demand in this system is based on the total metered water volume from the Town's pump stations. The historical records of the yearly volumes of water pumped out from MWRA's aqueduct are shown in Figure 1.

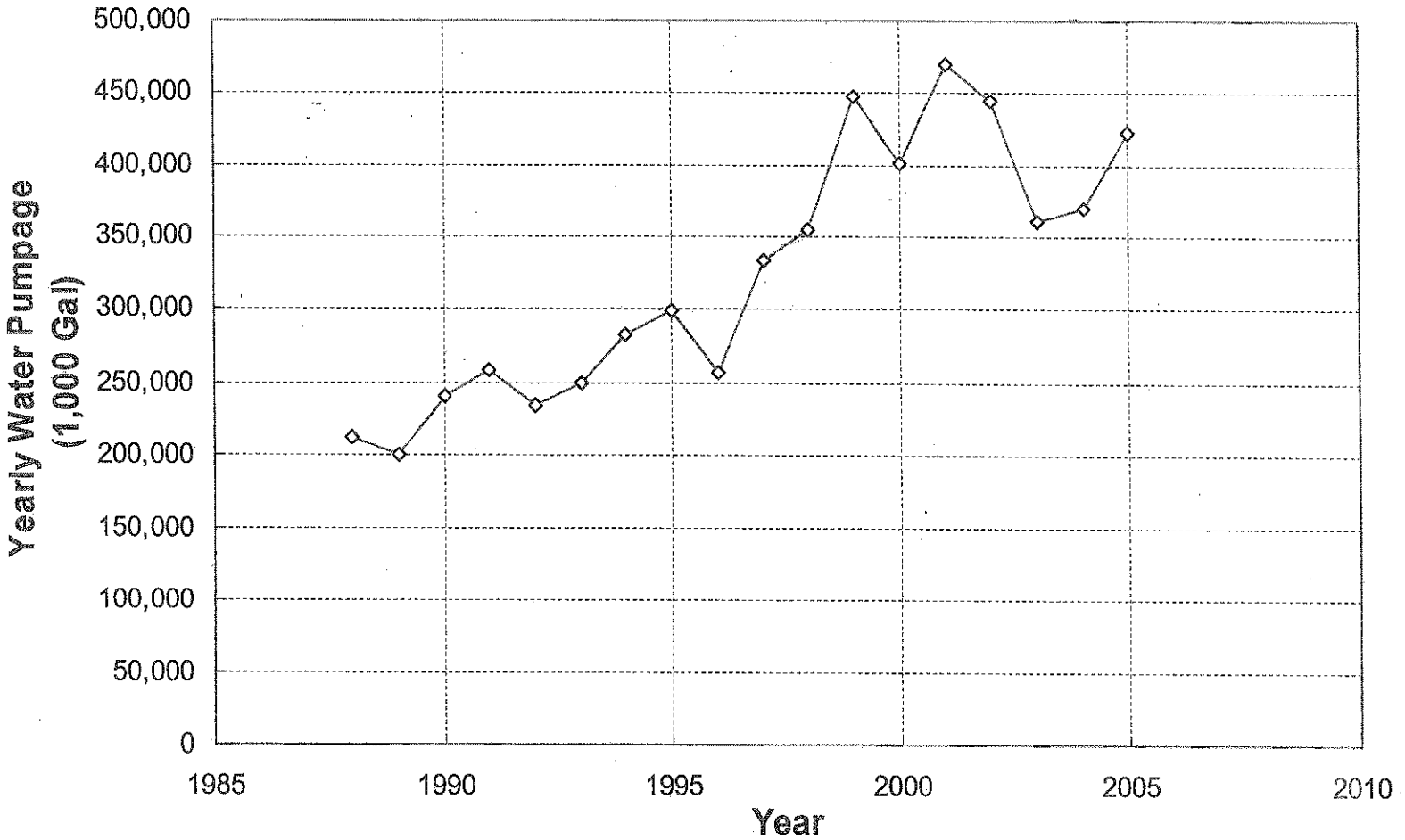
B. Water Demand

Presently the Town of Southborough accommodates very few industrial and commercial properties in addition to its residential water consumers. The Southborough Water Department records indicate that the total annual pumpage has generally increased over the years Figure 2 shows the past, present and future annual pumpage.

Average Day Demand

The 2005 average daily water consumption for the Town of Southborough was 1.15 million gallons per day (MGD). The average daily water consumption has increase from 0.57 MGD in 1988 to 0.96MGD in 1998, a 68.4% increase in 10 years. It increased to

Figure 1
Historical Yearly Water Pumpage for Southborough, MA



1.29 MGD in 2001, another 34.4% increase. Since 2001 this consumption has been reduced to 1.15 MGD in 2005. From 1988 to 2005 the average water consumption has more than doubled. Figure 2. shows the past, present and projected future average water consumption. The daily water consumption can be separated into domestic water consumption and commercial and industrial consumption

Domestic Demand

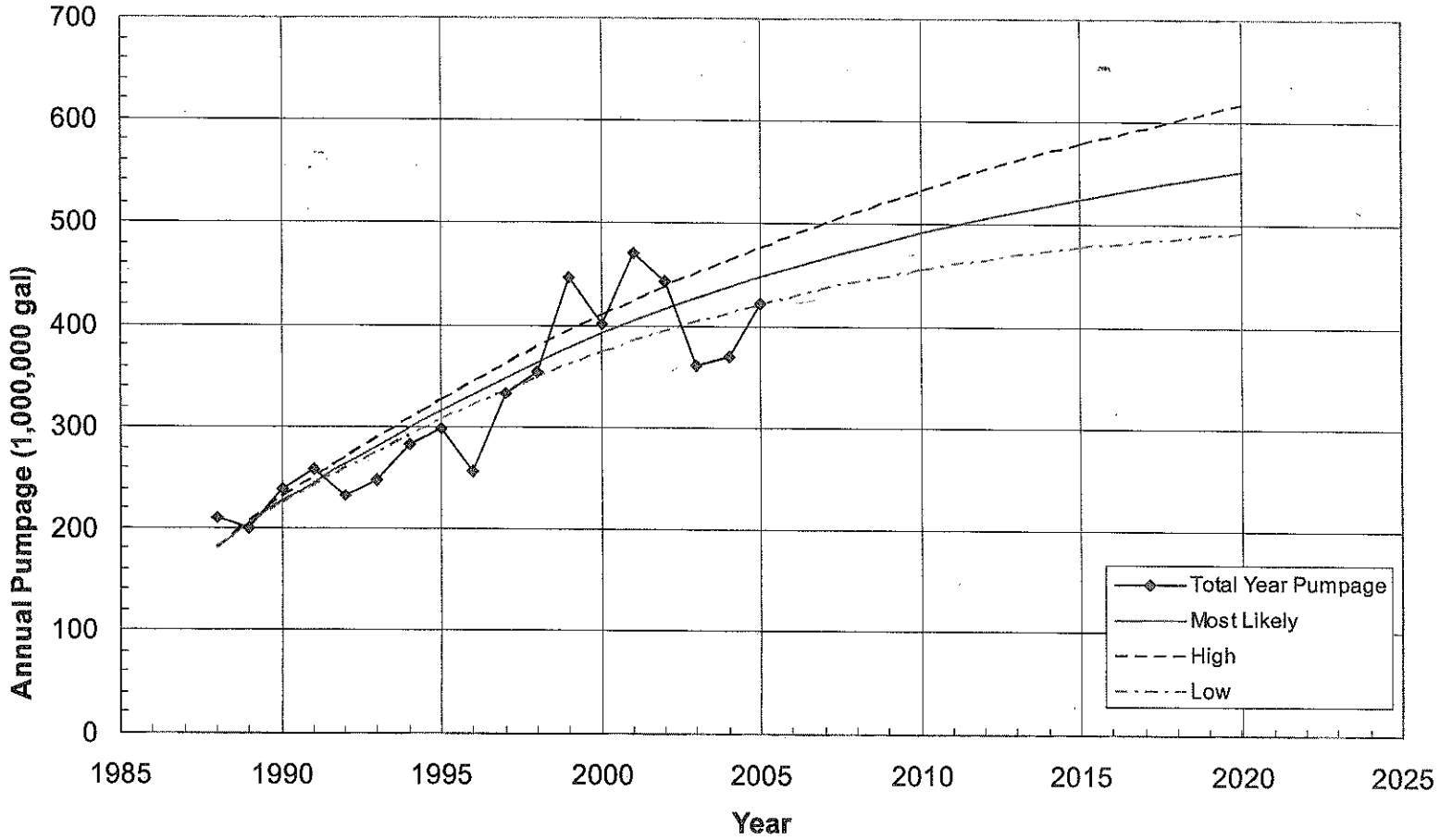
In general, for the so-called Bedroom Communities, the domestic demand for water is the major portion of the community's demand and it has been increasing at a faster rate than the rate of population growth since the Sixties. This demand has been primarily caused by the ever increasing use of such water operated appliances as automatic dishwashing machine, garbage disposal units and automatic lawn sprinklers, as well as backyard swimming pools. High value residential areas are inclined to be in areas of large lots with large grass areas with houses having more water using appliances. However, this trend of water consumption increasing faster than the population increases has been changing in recent years due to the conservation measures and the reduction of irrigation use.

Domestic water consumption is the major water demand in the Town of Southborough. In the nineties, this consumption had steadily increased faster than the rate of population. From 1990 through 1997, the total population increased 17.2% but the average daily water consumption had increased by 38.7%. In Southborough, some of the new homes constructed in recent years are on private wells, otherwise the domestic demand would increase much faster. From 1997 through 2001, the average daily water consumption increased by 42.4%. From 2001 the Southborough water consumption decreased from 1.29 MGD to 0.99 MGD (2003), but has since increased back to 1.15 MGD in 2005. With the fast population growth of the Town of Southborough, even if the per capita consumption does not increase the total water demand will be increased.

Commercial and Industrial Demand

It is extremely difficult to estimate the water requirements for future industrial and commercial areas in the Town of Southborough. Currently, Southborough does not have

Figure 2
Annual Pumpage Projection for Southborough, MA



large shopping malls and major water consuming industry. Most of the commercial and industry businesses in Southborough are neighborhood commercial and office type industry. Therefore, water consumption for those areas has not been separated out from the total water demand. Based on a recent document, the proposed EMC Complex will obtain their water supply from the Town of Westborough and private wells. Otherwise it would become a major industrial demand.

Per Capita Consumption

The Per Capita Consumption is the average daily consumption divided by the total population. Southborough Water Department records show that the total water demand increases at a rate faster than the increase in population, the per capita consumption in Southborough (Table 4) having increased from 99 gallons per capita per day (gpcd) in 1990 to nearly 118 gpcd in 1997 and to 125 gpcd in 2000. This per capita consumption leveled off after the year 2000 and slowly reduced to 120 gpcd in 2005. This may be due to conservation or that some new connections to the Southborough system have their own well for lawn and garden irrigation and that some of the new homes are using private well water. If all new homes were using the public water supply, the Per Capita Consumption of water will be higher.

Table 4 - Per Capita Consumption

Year	GPCD
1990	100
1991	106
1992	109
1993	111
1994	112
1995	113
1996	114
1997	114
2000	124
2005	120

Maximum Demand

Another factor requiring consideration during demand analysis is that of seasonal fluctuations in consumption rates. During the summer months, the demand placed on the Southborough water system is far greater than that at any other period of the year. Since this increased consumption occurs annually, the system design has to be able to provide this higher demand.

Table 5 indicated that the ratio of the maximum daily demand to the average daily demand of Town of Southborough varied from 2.03 to 2.74 during 1990 through 2005. This variation is due to the variation of rainfall and temperature of each year, as well as the use of lawn sprinklers.

Table 5 - Water Usage Per Person Per Day for Southborough, MA

Year	Pumpage (gal)	Population	gpcd
1990	240,460,000	6628	99.40
1991	258,009,000	6657	106.19
1992	233,434,000	6783	94.29
1993	248,955,000	6893	98.95
1994	285,858,000	6972	112.33
1995	305,998,000	7297	114.89
1996	259,010,000	7432	95.48
1997	333,413,000	7768	117.59

C. Past Water Consumption

Figure 3 and Figure 4 show the history and the estimated maximum daily demand and the maximum weekly demand. The numbers clearly show that the demands are increasing yearly. The increases are not only due to an increase of the population, but also an increase in the per capita consumption. In recent years, homes constructed in Southborough are the large and expensive type. Therefore, water consumption has increased rapidly, especially the maximum daily demand. Due to the location of the Town of Southborough, land cost in the future could be very expensive; therefore, any home construction in the future would be a highly priced type. With the possibility that some of the homes currently on private wells may change to the public water supply, the water consumption trend will continue to grow faster than the population growth in the Town of Southborough.

D. Estimated Future Demand

One consideration in determining the adequacy of a water system involves the comparison of the maximum daily consumption with the available supply sources and the system carrying capacity. Therefore, to estimate the maximum daily consumption is necessary.

It is very difficult to estimate accurately the average daily water demand, and it is more difficult to estimate accurately the maximum daily demand. This is because the maximum daily demand is dependant on the weather much more than other factors. To reduce the magnitude of error, therefore, the population projection, per capita consumption projection and the water consumption trend all have to be considered.

After analyzing the past data of populations, per capita consumption, water consumption trends and the ratio of maximum daily consumption to the average demand, the trend curves for the maximum daily demand is established.

Figure 3 shows that the maximum daily demand in the eighteen year history was 3,005,000 gallons per day in August 2, 1999. The projected maximum daily demand for the year of 2020 is about 3,750,000 gallons per day. The increase is about 25%. Figure 5 shows the history and projected average daily demand. The largest daily demand is 1.29 million gallons per day in 2001. The projected average daily demand for the year of 2020 is about 1.51 million gallons per day. The increase is about 13%. These projected demands will be applied in the computer model of the distribution system to determine recommended future system improvements.

It should be pointed out that future demand depends on many variables, such as zoning, land availability, public sewer availability and economic development. It should also be noted that any change to the above variables will affect the projected demands especially if a public sewer system were available. Therefore, upgrading the model periodically is recommended.

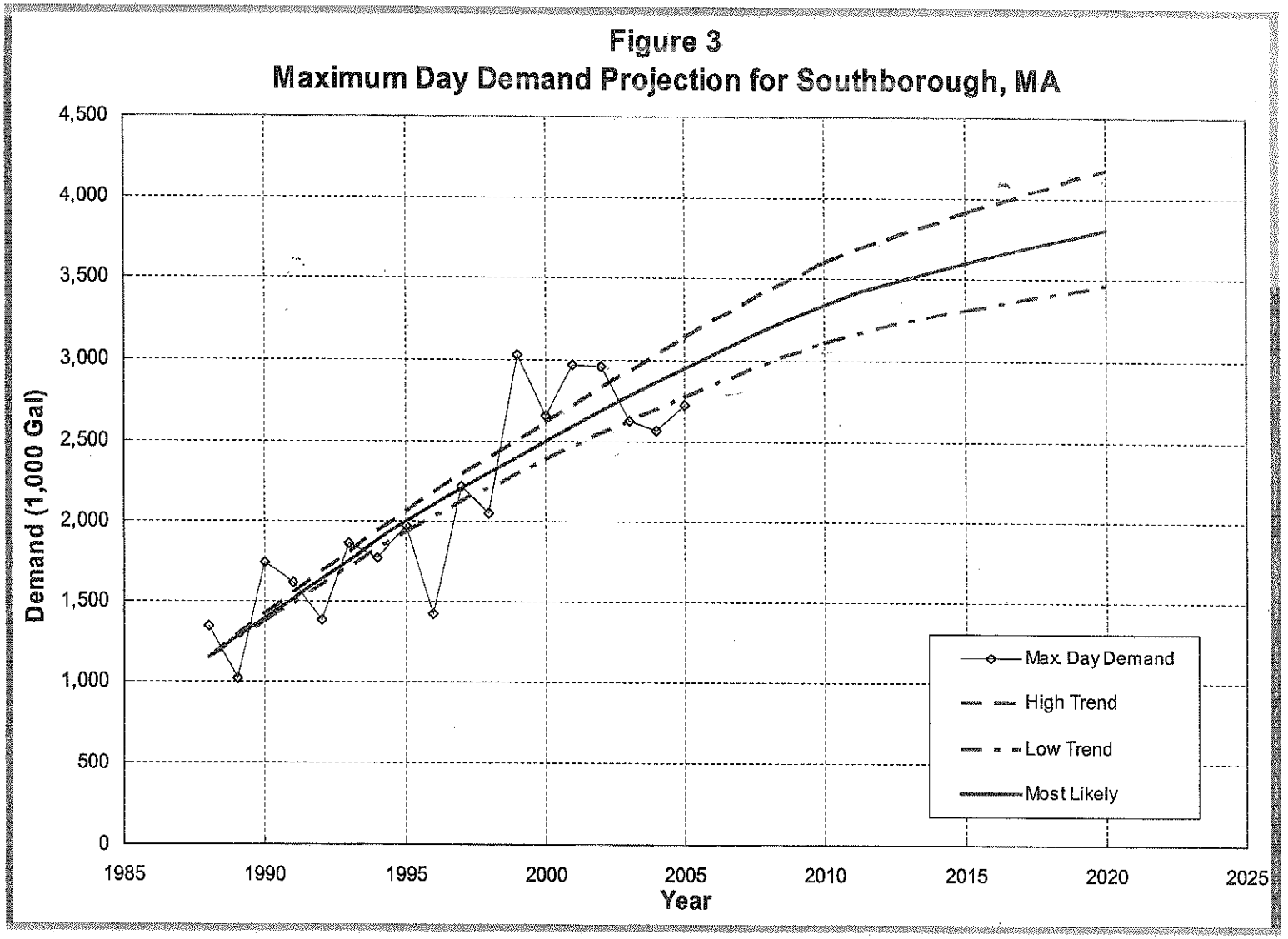


Figure 3
Maximum Day Demand Projection for Southborough, MA
Demand (1,000 Gal)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year
Max. Day Demand
High Trend
Low Trend
Most Likely

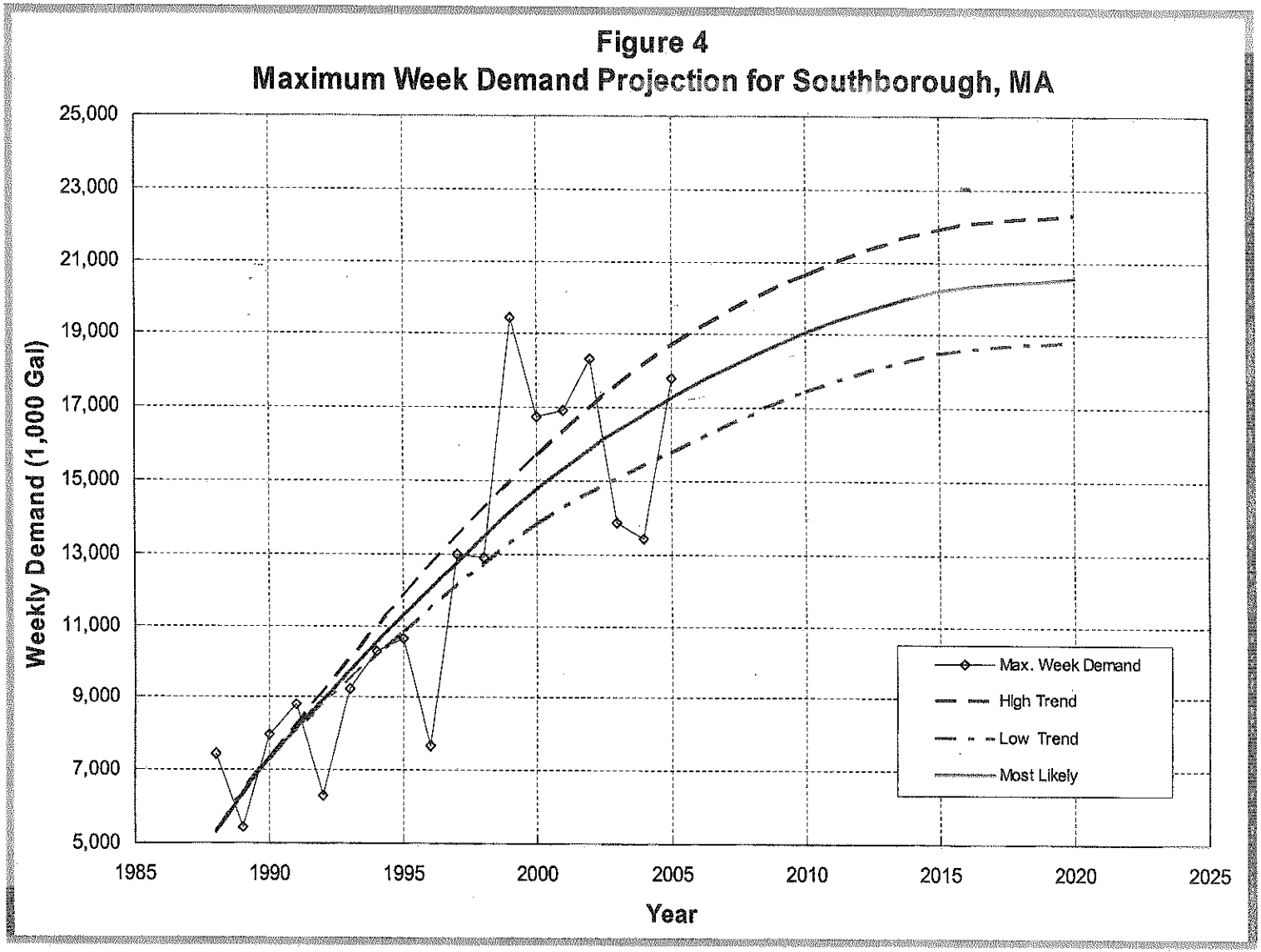


Figure 4
Maximum Week Demand Projection for Southborough, MA
Weekly Demand (1,000 Gal)
25,000
23,000
21,000
19,000
17,000
15,000
13,000
11,000
9,000
7,000
5,000
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year
Max. Week Demand
High Trend
Low Trend
Most Likely

E. Fire Flow Demand

The Insurance Service Office (ISO), formerly called the Fire Underwriter, has adopted new standards for determining required fire flow and duration. These new standards call for increased available flow rates with shorter duration as compared to the old standards. Therefore, the total required usable system storage is approximately the same, but the distribution system carrying capacity must be greater.

Based on the building density, size and building materials, the typical single family residential areas of the Town would require no more than 1,000 gallons per minute (gpm) fire flow. Areas where multi-family dwellings, schools, shopping malls and industries are located would need fire flow of about 2,500 to 3,500 gpm.

In March 1990, the ISO conducted several fire flow tests within the Town of Southborough and set the fire flow requirement. Table 6 shows the test results. Four locations (Tests 4, 5, 8 & 10) found the test flow under the required flow. All other locations had acceptable test flow.

The ISO flow testing showed the maximum available fire flow around the Parkerville Road area was about 3,000 gallons per minute in steady state (see Table 6 - Hydrant Flow Data Summary Table, Test No. 12 & No. 11). At the time of the test, the Atwood Elevated Tank was still in service. It should be noted that the fire flow test was done in a very short time period. With the limited storage capacity of the Atwood Elevated Tank, the fire flow would empty this tank in less than one hour. The system model's fire flow is 3,500 gallons per minute for three hours continuously and reduced to half the required fire flow for the next three hours. This demand is much higher than the existing system can provide and creates a critical condition for the existing system.

Figure 5
Average Daily Demand Projection for Southborough, MA

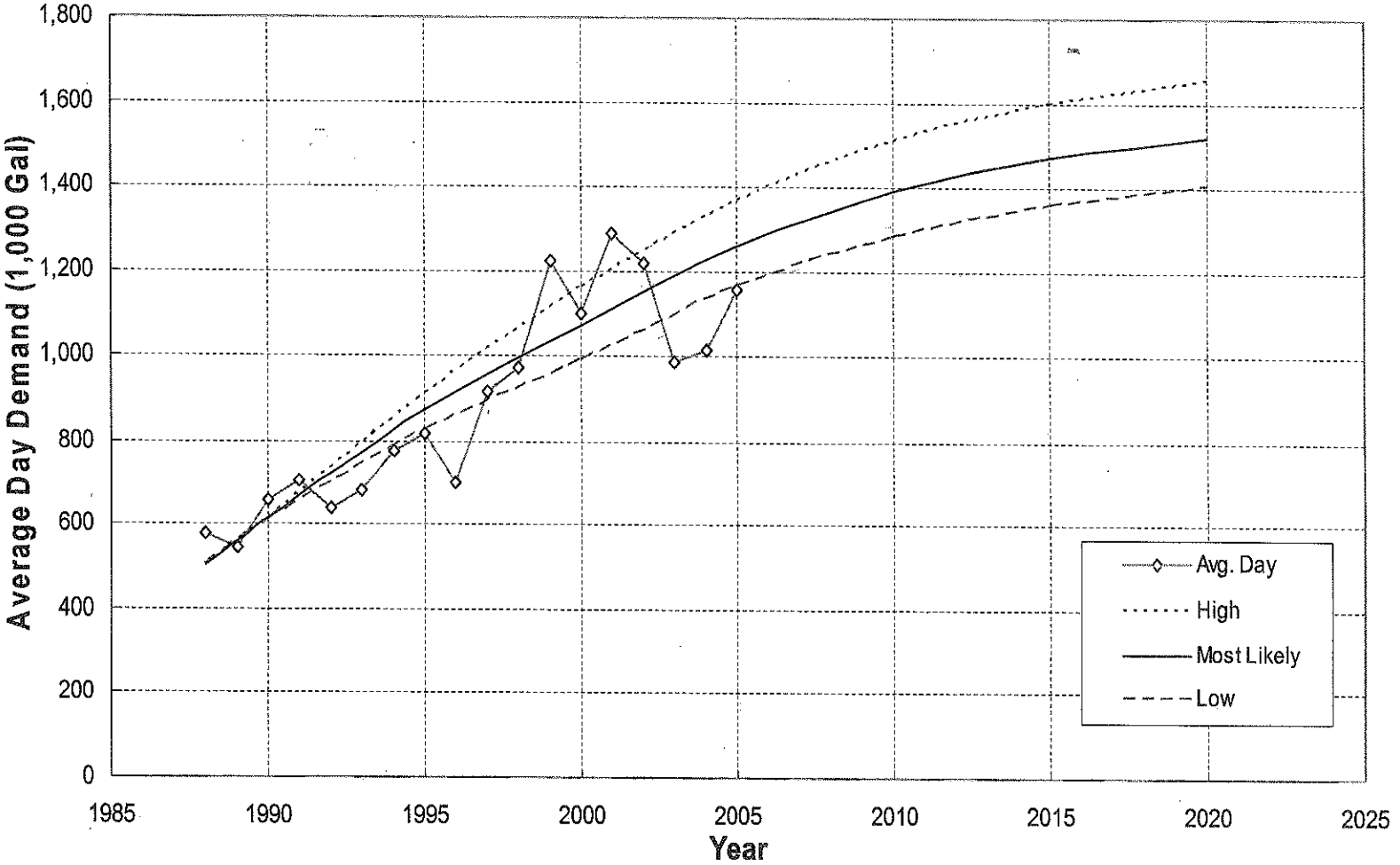


Table 7 - Hydrant Flow Data Summary for Town Of Southborough

Conducted by ISO Commercial Risk Services, Inc.

City Southborough State MA Zip 01772 Witnessed by A. Lagadinos Date 3-9-00

TEST NO.	TYPE DIST.*	TEST LOCATION	SERVICE	FLOW-GPM INDIVIDUAL HYDRANTS			FLOW-GPM TOTAL	PRESSURE PSI STATIC	PRESSURE PSI RESID.	FLOW AT 20 PSI NEEDED**	FLOW AT 20 PSI AVAIL.	REMARKS
1	Res	Presidential & Sears	Main	1140			1140	48	30	500	1400	
2	Res	6 Maple Crest Dr.	"	1570			1570	80	42	750	2000	
3	Comm	Main St. at Fay School	"	2050			2050	76	55	3000	3500	
4	Comm	150 Cordaville Rd	"	1380			1380	94	73	3000	2700	
5	Comm	Cor. Rte 9 & Willow St	"	1200			1200	90	22	3500	1200	
6	Comm	337 Turnpike Rd-Rt 9	"	2060			2060	66	55	2500	4500	
7	Res	Lynnbrook at CUL DE SAC	"	2820			2820	86	75	500	7400	
8	Comm	Neary School-Front Yard	"	1690			1690	90	34	3000	1900	
9	Comm	21 Boston Rd.	"	2150			2150	78	48	1500	3100	
10	Comm	17 Oregon Rd.	"	1280			1280	60	8	1250	1100	
11	Comm	Parkerville Rd.near Gilmore	"	1160			1160	80	62	2250	2200	
12	Res	151 Southville Rd	"	1980			1980	92	58	750	3000	
13	Comm	Southville Rd.at North St	"	1950			1950	102	50	2250	2500	
14	Comm	10 Southville Rd.	"	2220			2220	105	48	1250	2800	

THE ABOVE LISTED NEEDED FIRE FLOWS ARE FOR INSURANCE RATING PURPOSES ONLY AND ARE NOT INTENDED TO PREDICT THE MAXIMUM AMOUNT OF WATER REQUIRED FOR A LARGE SCALE FIRE CONDITION. THE AVAILABLE FLOWS ONLY INDICATE THE CONDITIONS THAT EXISTED AT THE TIME AND AT THE LOCATION WHERE TESTS WERE WITNESSED.

* Comm = Commercial; Res = Residential.

** Needed is the rate of flow for a specific duration for a full credit condition. Needed Fire Flows greater than 3,500 gpm are not considered in determining the classification of the city when using the Fire Suppression Rating Schedule.

IV. SYSTEM ANALYSIS

A. General

The purpose of a distribution system analysis is to evaluate the adequacy of the system's pipe network, storage facilities, source supply and pumping capacities under present and project future water demand conditions along with assessing the adequacy of fire protection.

The computer analysis of the existing water system and evaluation of proposed improvement in Southborough, Massachusetts, was accomplished by means of a high speed computer. The computer programs used were the Hardy Cross Method of distribution analysis and the Newton Raphson iteration technique. To put the water system on the computer, the distribution system was schematically drawn to include all water mains that transmitted significant quantities of water. Ideally, for this analysis, 6-inch diameter water mains and larger were included.

Simulating the present system by means of a mathematical model was necessary to evaluate the present and determine the proposed water distribution system. The proper boundary conditions such as the system demands, sources of supply, pipe characteristic (length, size, and "C" value), and water levels in the storage tanks were entered into the computer model.

After inputting the boundary conditions into the computer model, actual system operating data were used for the model's calibration. The distribution system model should be calibrated over a range of system operating conditions to insure that the computer model response closely matches the actual system response. Field fire flow test data including pressure, pumping flow data, and storage tank water levels were utilized in the model calibration. The model has been calibrated by using flow test data obtained through the years.

Once the water distribution system model was calibrated, the future demands were placed into the computer model to analyze the steady state condition of the system, and the requirements to meet these demands were determined from the program output.

Conditions that might develop throughout the water distribution system were analyzed by superimposing required fire flows on projected maximum system demands with elongated time. This dynamic analysis was done by assigning required pressure (20 psi) to a node at a particular location and checking for the adequacy of the flow rate along the time variation at that location. Water levels in storage facilities were adjusted along the time variation. As a result, the analysis presents the system adequacy for the specified location with the variation of the available flow along the time, and the water levels in the tanks fluctuating throughout the simulated period. This data was analyzed to determine the capacity to meet the projected future demands and was also used to recommend proposed improvements.

B. System Analysis Results

Generally, the existing system can provide a marginally adequate service to meet maximum daily demand. Some areas were found to have low service pressure due to the high ground elevation, such as Atwood Street, Harris Road, Richard Road, High Ridge Road and Fairview Drive. The Southborough Water Supply System has been designed to serve the areas where the ground elevations are lower than elevation 400 feet (ft) (U.S.G.S.). Any location where the ground elevation is between 400 ft and 430 ft will experience unacceptable low pressures. Some areas located between elevation 300 ft and 400 ft would encounter pressure problems during fire fighting if the pipe line is undersized.

The following several paragraphs discuss some of the computer results. There are many to be considered which may not be discussed in detail hereafter, but are included in the recommendations.

Fiddlers Green Reservoir, Clear Hill Standpipe, Boland Pump Station and Hosmer Pump Station are all located north of Route 9 and are capable of providing adequate service to this portion except for the high ground areas.

However, in March 1990, ISO made a flow test at the intersection of Route 9 and Willow Street and found the available flow was 1,200 gpm where 3,500 gpm is required. A previous computer model had confirmed this problem, but the problem has been solved with the installation of a 12-inch water main along Valley Road and Willow Street. But inadequate fire flow is still a problem along Route 9 between Willow Street and Oakhill Road. This is due to the old and under sized 6-inch water main along Route 9. Also water main and services lines at this area frequently have leaking problems. To correct this problem, it is necessary to replace the old main. Also, due to the heavy traffic, having a service line cross Route 9 is a problem. Therefore it would be better to have two supply lines along Route 9 to supply this section of the commercial area. However, the cost to install a new watermain on Route 9 is expensive. Therefore utilizing an easement from private land along Route 9 may be a better solution.

In the middle section, the ground elevation at both the east and west areas are high. Fortunately, the west area is not far away from the Fiddlers Green Reservoir and the Boland Pump Station, and the east area has the Oak Hill Standpipe. Both areas are able to maintain a reasonably adequate water service. When Fiddlers Green Reservoir is maintained at its high level, the distribution system can maintain adequate service along Parkerville Road where the ground elevation is below 390 ft. There are areas with dead end piping that lack adequate fire fighting flow. Elimination of some dead end pipes should be considered.

The southern section, south of Route 90, is at the end of the distribution system. Because this section of the Town does not have a high ground elevation, the water system has no problem providing maximum daily demand, but can only provide approximately 1,600 gpm of fire flow. A 3,000 gpm fire flow at the Finn School is needed. At the intersection of Parkerville Road and Richards Road the indicated available fire flow on average is

less than 1,600 gpm. The computer model indicates that the high head loss is caused by the undersized pipes crossing the bottleneck at Route 90. During 2004-2005 a 12-inch water main was installed from Walnut Drive to Oregon Road by using the existing the 12-inch water main which was installed many years ago under the Massachusetts Turnpike. This water main improved the fire flow at the Finn School area to 2,200 gpm. In order to provide adequate fire flow to the Finn School area and this part of Town, the distribution system in this section of Town still needs to be improved.

For system stability and reliability, the Town needs to provide storage and improve the piping system. This work can be divided into two phases to complete the required improvement. One phase is to install a water tank on Fairview Hill near the end of Skylar Drive and also improve some pipes on Parkerville Road (between Route 9 and Richards Road). This tank shall be fed by installing a 12-inch water main along Deerfoot Road and a 16-inch water main to the tank.

This storage tank has been recommended for many years, but has not been constructed yet due to the possibility of two construction sites. One site is at Fairview Hill and the other is the Fiddlers Green Reservoir. Both sites have pros and cons, but based on the analysis, it is recommended that this storage facility be located at the Fairview Hill area.

Table 7 lists the pro and con of the two sites.

No computer analysis has been performed for the Pine Hill Area which currently does not have public water supply from Southborough. To supply water to this area, a storage tank and 12-inch loop will be required. It may also require a booster pumping station to supply the area.

A 12-inch water main along Central Street and Oak Hill Road was installed in the early Nineties. There is a short section of 8-inch pipe under the railroad that has not been replaced. This short section of 8-inch pipe should be replaced to complete the 12-inch water main along Central Street to Boston Road.

Table 7 - Pro and Con of the Two Tank Sites

Description	Fiddlers Green	Fairview Hill
Safety	Poor	Good
Hydraulic Control	Very Good	Good
System Hydraulic	Good	Very Good
Size	Limited to 1.3MG	Can construct up to 2.5MG
Construction Cost	Relatively Low	Relatively High Due to access road requirement

C. Inadequate Storage Capacity

The existing storage facilities in the Town of Southborough have a total capacity of about 2.0 Million Gallons (MG). But the total usable storage is less than 1.2 MG assuming all three storage facilities are filled to the overflow level. This 1.2 MG usable storage just about meets the peak hourly demand variation, which usually last three to three and a half hours (between 6:30 AM to 10:00 AM), and a three hour fire flow. But the fire fighting generally last longer than three hours (usually six hours). Therefore, the usable storage is not adequate. If the tank was not full at the beginning, then the usable storage definitely is not adequate. Also, another emergency condition could occur at the same time, such as pump equipment break down, pipe line break, etc., then the usable storage would not be adequate to meet the Town's demand, especially during the summer months. Generally, storage facilities should be capable of providing the additional water required for demand equalization and emergency situations such as fire flow demands, pipe line breaks, etc.

The other problem is that the Town of Southborough Water Division can not take Fiddlers Green Reservoir out of service for maintenance without a risk, as there is no storage to provide for fire flow and the maximum daily demand. Eventually, the Fiddlers Green Reservoir has to be taken out of service for painting; therefore an additional storage facility is needed.

D. Inadequate Pumping Capacity

Currently, the maximum pumping capacity of both pumping stations is 1,000 gpm but the maximum daily demand has increased to over 2,000 gpm since 1997. In the summer time, during the maximum weekly demand, the variation of demand from day to day varies very little. To make up the pump deficiency, water would have to come from storage facilities, which will make the system storage more inadequate. Increasing pumping capacity therefore is necessary. The first pump station that should be renovated to increase the pumping capacity is the Boland Pump Station. It is recommended that the pumping capacity of this pump station be increased from the current 1,000 gpm to about 1,500 gpm, and before the year 2015, the Hosmer Pump Station should be renovated to increase its capacity from the current 1,000 gpm to about 1,200 gpm.

V. WATER SYSTEM MASTER PLAN

A. General

Because there are several major highways, a railroad, a large water supply aqueduct and a reservoir located in the Town, and varying ground elevations throughout town, it is difficult and costly to develop a water supply system which would provide adequate supply at sufficient pressure to all areas in the Town of Southborough.

The recommended Master Plan in this Report intends to provide a feasible and practical development of the water distribution system considering the Town of Southborough's existing system capabilities. In general, the following criteria were considered in the Master Plan Development:

1. Maximum utilization of existing water distribution system and storage facilities.

2. Location and sizing of the reinforcing mains throughout the Town to minimize construction costs, avoid paralleling large size mains along a street and avoiding construction in "high" value streets.

The Master Plan was designed based on projections of future growth under current zoning. The Town should, however, review their demands and distribution system periodically to allow for any unusual growth patterns or demands placed on the system. Minor modifications may be required due to some unforeseen events, such as a new residential complex, a high water consumer or construction of an industrial complex in the remote areas of the system.

The design of the system is meant to satisfy future demands by concentrating on the major mains and major improvements involving large expenditures of time and money which would require more than Town labor. As for minor improvements, these will be covered under the section of general recommendations which will be discussed later in this Report.

B. Source of Supply and Pumping Facilities

The Town of Southborough's source of water supply is from the MWRA's MWWST

Tunnel which has had no problem supplying the Town of Southborough's water needs. Because the present contract between Southborough and the MWRA expired in 1997, the Town of Southborough and the MWRA are in the process of discussing a new contract. In accordance with the existing contract, Southborough is limited to pump only two million gallons per day by the MWRA. In our previous System Study Report, we predicted that the demand will grow over the 2 MGD rate in 1997. In 1997, the maximum day demand did go over the 2.0 MGD. It is strongly recommended that when Southborough negotiates a future MWRA contract the Town requests the 2.0 MGD limit be upgraded to a higher limit, preferably 4.0 MGD, which is just higher than the projected 2020 maximum daily demand of 3.8 MGD, including obtaining water from a neighboring MWRA community.

The capacity of the two existing pumping stations can adequately handle a flow rate of about 2.8 MGD. Considering the age of each pumping station, we strongly recommend the equipment in each station be thoroughly inspected, repaired and/or replaced, including chlorinators, pumps and motors as well as electrical wires and panels. The capacity and equipment of Boland pump station should be improved and expended to 3.8 MGD before 2010 – after the construction of a new storage reservoir.

C. Storage Facilities

The storage facilities within a water system are one of the most essential elements of a water supply distribution system. The purpose of water storage in a distribution system is to increase the capacity and efficiency of the water as follows:

1. Provide adequate flow for fighting fires

2. Meet maximum and peak hourly demand variations

3. Provide more uniform pressures within the system 24 hours a day

4. Provide water to meet system demands at emergency conditions such as mechanical failure, periodic maintenance of pumping facilities or water main breaks

5. Provide a safety outlet in the system to attenuate the effects of pressure surges known as water hammer

The primary purpose of storage is to provide a source of pressure and a standby supply that will result in a more balanced system pressure and in an equalization of system supply and demand. Storage "rides" on the hydraulic gradient of the distribution systems so power outages do not affect the immediate ability of the storage facilities to supply the water distribution system.

In addition, if a system had no storage, the water supply pumping facilities would have to be capable of supplying the maximum, instantaneous rate of consumption, regardless of how infrequent this rate occurred.

The required storage volume of a water supply system can be analyzed in detail based on the hourly demand variation of a maximum daily demand, and based on maximum fire protection requirements to determine the required fire flow storage. However, it is quite difficult to determine the required emergency storage which varies with the type of emergency.

It is a "rule of thumb" that a system should have, as a minimum, a usable storage equal to its maximum daily demand, especially for small systems. Many small systems have storage equal to 5 times its maximum daily demand. The Town's projected maximum daily demand is about 3.8 MGD for the year 2020. The existing gross storage is 1.97 MG, but the existing usable storage is only 1.2 MG with each storage reservoir filled to its overflow elevation (This is based on 30 psi service pressure for ground elevation 400 ft.). This is approximately 2.4 MG less than the 3.8 MG of usable required storage. This emphasizes the need for additional storage in Southborough.

We recommend constructing a new two million gallon storage facility which would provide another 1.4 million gallons of usable storage. With the above improvements, the total usable storage would be about 2.6 MGD. This total usable storage is less than the projected maximum daily demand by about 1.2 MG, but it will help the system tremendously. Some time in the future, a new storage tank could be added to the low pressure zone, or a larger tank could be constructed to replace the Clear Hill Tank and /or the Oak Hill standpipe. Mt. Vickery area has

ground elevation of about 430 ft.USGS, which may be a possible tank site but, would require a long transmission water main.

D. Distribution System Improvement

The existing Southborough Water Supply System has already been changed to a two pressure zone system. The overflow elevations of the storage facilities in the low pressure zone are about 493 ft USGS. The high pressure zone controlled by the Fiddlers Green Reservoir, its overflow elevation is about 515 ft USGS. Using the overflow elevations of the storage facilities, the required service pressure and the approximate highest service elevation in the system can be determined.

There are several Pressure Regulating Valves installed between the two pressure zones, so that water can flow from the high pressure zone to the low pressure zone in case that the low pressure zone is in need of water. This is the reason why it is recommended that the new storage facility be constructed in the high pressure zone, so it can benefit both pressure zones.

The Massachusetts Department of Environmental Protection (DEP) Guidelines for Public Water Systems recommend a minimum service pressure of 35 pounds per square inch (psi). In the low pressure zone system, even when the storage facilities are full, any area with a ground elevation higher than elevation 413 ft will not have the recommended minimum service pressure of 35 psi, even neglecting the pipe friction losses within the system. When pipeline head losses are considered, areas where the system can provide 35 psi would have a ground elevation below 400 ft USGS. However, the Fiddlers Green Reservoir has an overflow elevation of 515 ft USGS. When the Fiddlers Green Reservoir is full, it can help to provide adequate service pressure for areas with ground elevation between 400 to 430 ft USGS. But for areas in high pressure zones, when the ground level is higher than 430 ft USGS, it will not have adequate service pressure. The high pressure zone is controlled by the Fiddlers Green Reservoir and the lower pressure zone is

controlled by the Oak Hill Storage stand pipe and the Clear Hill Tank.

To minimize low pressure problems on the Fairview Hill area, we recommend construction of a storage facility on Fairview Hill along with related pipeline improvements. This storage facility should have a capacity of 2.0 MG with an overflow elevation 515 ft USGS.

Presently, the Pine Hill area, located north of the Sudbury Reservoir, is not being served by Southborough's Water System. To serve this area would require the installation of a long pipeline from Old Boston Road to the Pine Hill area. It will require the construction of a booster pumping station and a storage tank. Also, the pipe from the Old Boston Road line must pass through the MWRA facility below the Sudbury Reservoir. Therefore, obtaining the easement would be extremely difficult and construction economically unrealistic.

To supply water to the Pine Hill area from the Town of Southborough water s ystem will be very costly. It appears that it would be more feasible to obtain water from the Town of Framingham's high service area. Framingham's high service zone has one pumping station (Grove Street P.S.), a one million gallon pre-stressed concrete tank, along with an old 300,000 gallon steel tank which may be out of service. The supply of Framingham's high service system is limited by the Grove Street Pumping Station's one million gallon per day pumping capacity, therefore, a storage facility will be needed for this area. There is another possible way to supply the Pine Hill area and that is to obtain the right from MWRA for another supply point from the the MWRA water main near the Pine Hill area such as Pleasant Street in Framingham and construct a small booster pump and a storage tank. However, we recommend that the system storage capacity and the pipe line and how to supply this area be evaluated once this area needs the water supply. The Town of Southborough should warn those who build their house at this area that there is no fire protection and emergency water supply.

Another area that requires immediate attention is the section located south of the

Massachusetts Turnpike. Although this area has adequate domestic supply, the system can not provide adequate fire flow to areas such as the Finn School area and Parkerville Road due to the lack of transmission mains under the Massachusetts Turnpike, as previously discussed. It is recommended that once the storage tank, recommended at Fairview Hill has been constructed, a 12-inch water main be constructed from the storage tank to boost up the supply in the Parkerville Road area. This would help to increase the fire fight flow at the Finn School area. There are other areas that do not have adequate fire flow rates as required by ISO due to dead ends or undersized pipes. It is recommended that no new dead end construction should be allowed for any future developments. Improvements and elimination of the dead ends should be made as financial conditions and time permit. For example, to improve the inadequate fire flow at the intersection of Route 9 between Willow Street and Oakhill Road, a 12-inch diameter pipe is needed along Route 9 to increase the existing available average fire flow from 2,100 gpm to more than 4,000 gpm. However, the installation of a water main along Route 9 would not be permitted by the State Highway Department for at lease five years following its last resurfacing. Installation of a water main along Route 9 would be financially detrimental compared to installations along other Town roads. But, there are about 1,300 feet of unlined 6-inch cast iron pipe and 8-inch cast iron pipe along Route 9 east bound between Brook Lane and Pleasant Street, and about 1,200 feet of unlined 8-inch cast iron pipe along Route 9 east bound west of Woodland Road. These two sections of unlined pipe, especially the 6-inch in diameter pipe are in poor condition, and should be replaced when possible. Clean and lining of the 8-inch main has been considered, but due to the age of the pipe and the under-size of the pipe, clean and lining is not recommended. The buildings along Route 9 west bound, between Pleasant Street and Willow Street, should have a separate west bound supply line in order to eliminate the need for a service line under Route 9.

E. Water Quality

The quality of water from the Quabbin and Wachusett Reservoirs meet or exceed present

EPA and DEP drinking water standards except for bacteria and corrosiveness.

Because raw water quality meets most DEP and EPA drinking water standards, it is not surprising that past treatment was limited to disinfection in Southborough. Aggressive water corrodes distribution system piping and plumbing, causing leaching of pipe materials into the water supply. This results in increasing concentrations of these metals to above the drinking water standards. Recently, the MWRA has constructed a corrosion control facility at Shaft C in Marlborough. Southborough is located very close to this MWRA Corrosion Control Facility. Therefore, corrosion treatment for the Southborough Water Supply may not be required.

Also, the MWRA has constructed the water treatment plant at Shaft C area. This new plant is expected to solve the corrosion problem and other water quality problems for all MWRA communities. Therefore, we recommended that Southborough take no immediate action for corrosion control.

There are many miles of AC pipes in the water system. They should be slowly replaced by D.I. pipe, especially the dead end AC pipes which should be replaced as soon as financially feasible.

F. System Reliability

The 12-inch pipe from Boland pumping station along Northborough Road and the access road to Main Street which delivers more than half of the system supply, with a total length over 3000 feet, is not only under high pressure but also high velocity. After the Boland Pump Station is upgraded this condition will worsen. It is a vulnerable situation. Also, due to the high head losses, the pump has to pump at a higher head and waste energy. It is recommended that either a 12-inch connection pipe under the railroad from Fisher Road to Presidential Drive be installed or a 12-inch pipe along Chestnut Hill Road be installed to connect to the existing 12-inch water main at Main Street. This will not only provide reliability to the system, but also reduced the pumping head by about 3 psi.

If both pipes are installed, the pumping head can be reduced by more than 5 psi. It would save energy costs and reduce the extra pressure on the pipe line located at low ground elevation.

VII. RECOMMENDATIONS AND COST ESTIMATES

A. General Recommendations

The water system improvements discussed below are general in nature and in some cases may be performed by the Town's own labor force. The suggested improvements described below should be conducted on a continual basis and should be included in design considerations for future system growth.

Where future extension of the water distribution system is needed or when existing lines are being replaced, consideration should be given to its effect on the over all water distribution system. Extensions should be made to create looped connections and with pipe sizes large enough to carry the required domestic and fire flows for future demands.

It should become standard practice, within the Town, that all water mains serving hydrants should be a minimum of 8-inch in diameter.

An old pipe replacement program should be put in place to replace all old under sized (6-inch) pipe, especially the AC pipes. Any replacement pipe should be a minimum of 8-inch in diameter.

It is recommended that in the future, any new development should submit the following to the Town's Public Works Department for review to determine the effect on the water system:

1. Plans of subdivisions should be submitted to the Town's Department of Public Works for review and approval.

2. Record plans should be submitted to the Public Works Department for all projects affecting the water system.

3. Large projects such as condominiums, industries, etc., should be investigated with respect to fire requirements, prior to approval.

B. Specific Recommended Improvements

As a result of the computer model analysis of the Southborough Water System, it was concluded that the distribution system can adequately meet consumer demands except for a few high elevation areas with inadequate pressure, but can not satisfy required fire flow demands in many areas. Among the reasons for this are the undersized and limited numbers of transmission mains within the Town, along with many "dead-end" pipes which result in a lack of necessary reinforcing "loops" within the system. Another major problem is the low pressures existing in the sections of Southborough which are at high ground elevations.

To overcome the low pressure problem on those areas with high ground elevation, it is recommended that any building constructed in Low Pressure Zone on land with an elevation above 380 ft USGS should provide a domestic water booster pump, and that any building constructed in High Pressure Zone on land with elevation above 410 ft USGS should also provide a domestic water booster pump. This will not eliminate the inadequate pressure problem completely, but will help some domestic supply pressure issues. There are some undeveloped areas which are economically infeasible to supply at present. This condition should be considered carefully before developing those areas. Therefore, several solutions are presented to further minimize the pressure problems in high ground areas:

1. Prohibit all developments above elevation 400 ft USGS in the low service zone, and above elevation 430 ft USGS in the high service zone.

2. Request developers to construct necessary water tanks and booster systems to provide required pressure in the high elevation areas.

The above facts led to the compilation of a series of proposed improvements which have been broken into three phases. Phase I involves all measures that should be taken immediately to improve the water system and completed by the year 2010. All

recommended improvements are shown on the system map in the Appendix.

Phase II improvements should be considered promptly and completed by the year 2015. Both Phase I and Phase II reinforce the existing system and upgrade the Southborough water supply system to bring the Town much closer to meeting the existing required standards. Therefore, the work recommended in Phase I and Phase II should be completed as soon as possible. Phase III improvements would depend upon the progress of land development and economical conditions. Phase III's timing is difficult to predict. Some items may be developed in the near future and some items may be developed in the more distant future.

Phase I

1. Construction of a storage tank and associated pipes:

   Construct a 2.0 MG water storage tank at the hill between Deerfoot Road and Sarsen Stone Way and install the necessary pipeline. It is estimated that a minimum 800 feet of 16-inch diameter and 700 feet of 12-inch diameter pipe would need to be installed.

2. Renovate Boland Pump Station to increase its capacity to 1,500 gpm and install about 700 feet of 12-inch pipe from Fisher Road to Presidential Drive. This water main has a railroad crossing, therefore its cost would be very high. Another alternative is to install a 12-inch main along Chestnut Hill Road as described in Phase II - 3.

3. To increase the available flow to the Finn School and the Southville area, install a 12-inch water main from Deerfoot Road to Fairview Drive and install a 12-inch pipe along Parkerville Road from the intersection of Fairview Drive and Parkerville Road to Richards Road. The estimated length of this alternative route is about 5,900 feet and requires an easement from EMC Inc. The estimated length can vary because the easement route is unknown.

4. Extend the 12-inch main recently installed at Willow Street along Route 9 replacing the 6-inch and 8-inch water main along Route 9. The estimated length is 2,400 feet between the new 12-inch water main near Brook Lane and Pleasant Street. Should funding become an issue, this item can be deferred to Phase II

Phase II

1. Install 1,600 feet of 12-inch diameter pipe on Deerfoot Road from Route 9 northerly to the intersection of Deerfoot Road and Clifford Street. This includes the replacement of the 600 ft of 6-inch line.
2. Increase the capacity of Hosmer Pumping Station from the existing 1,000 gpm to 1,300 - 1,400 gpm.
3. Install a 12-inch water main along Chestnut Hill Road. The length of this main is about 5,700 feet. This main has to cross the MWRA pressure aqueduct, investigation of the aqueducts' exact location and elevation should be conducted.
4. Install approximately 1,600 feet of a 12-inch diameter main to replace the existing 8-inch main on Central Street from Boston Road to Learned Street including a 60 foot section under the Railroad track which was not previously completed.
5. Connect the 8-inch water main on Middle Road between Mt. Vickery Road and Route 9 with a 12-inch main. The estimated length is 1,700 feet.
6. Install a 12-inch main on Parkerville Road from Main Street to the Neary School driveway.
7. Connect the 8-inch main on Breakneck Hill Road between Davis Road and Viewhill Road. The estimated length is approximately 1.300 feet

Phase III

The recommendations in this phase include pipes that shall form an efficient transmission looping system for the Town of Southborough. The recommended time for the installation of many of these water mains in this phase depends upon future subdivisions. However, each subdivision is responsible for installing the proper size water mains through the subdivision to abutting lands.

1. In general, in any new main in future developments or extension of water mains along existing streets, a minimum of an 8-inch diameter water main should be installed. Any

new main without a loop and longer than 1,500 feet, such as streets which may end at wetlands, State and Interstate Highways, and water bodies, which are difficult to loop, should require a 12-inch diameter water main for adequate fire flow. Also, dead end water mains should be avoided.

2. During development of the Pine Hill area, purchasing water from the Town of Framingham's high service zone would be the most feasible supply solution. However, since Framingham's high service system supply is limited by the Grove Street Pumping Station, Framingham may not be willing to sell water to the Town of Southborough.

   Another option is to purchase water from Framingham's low service zone at the Pine Hill Road and Waveney Road intersection area. Also, this can be accomplished by obtaining a permit from MWRA to add a new take-out point from the MWRA transmission main by tapping one 12-inch pipe to the MWRA 24-inch pipe which connects the Valve Chamber off the Hultman Aqueduct and Pleasant Street Pumping Station in Framingham. In those cases, a booster pumping station will need to be constructed.

   The third option is to obtain an easement from the Town of Framingham to install a 12-inch diameter pipe along Pleasant Street and Pine Hill Road from the existing 12-inch diameter main at Boston Road in (Southborough) to the Pine Hill area. The cost for this long pipe is infeasible. Pipe size at the Pine Hill area should have a 12-inch diameter loop with 8-inch diameter sub-loops. No 6-inch diameter pipes should be used due to the high ground elevation. A storage tank is required if this area becomes fully developed.

3. A 12-inch loop transmission main should be installed from Crystal Pond Road and Coslin Drive area southerly toward the Gilmore Road area. This area is currently under the EMC proposed development which may obtain their water supply from the Town of Westborough.

4. For high ground areas, large size watermain such as a 12-inch pipe should be used for reducing the friction loss. Especially, since the Southborough water system can not provide adequate pressure for an area higher than 400 ft USGS, especially for areas

farther away from the pumping stations and storage tanks.

5. For pipe line replacement, it is recommended that the minimum pipe size should be an 8-inch diameter.

6. A 12-inch loop from Lynbrook Road to Tara Road should be installed when this area becomes developed.

C. Cost Estimation

The cost estimate for Phase I and II is based on the current cost estimation and is shown on the next two pages. This does not include the cost of land acquisition, right of way, appraisal and survey, site preparation, or new access roads, (which in some cases, the new purchase of land may be required). This is a preliminary estimate for alternative comparison only.

Phase I Recommendations:

1	Construct 2.0 MG New Tank		$1,230,000
	Control Valve & Site Work, Foundation		$460,000
	16-inch diameter water main from reservoir to distribution system with access road	800 ft	$149,000
	Install a 12-inch diameter water main on Deerfoot Rd.	700 ft	$80,000
	Sub-Total		**$1,919,000**
2.	Renovate Boland Pump Station to increase its capacity from 1,000 gpm to 1,500 gpm		$471,000
	Install 700ft of 12-inch line include Railroad crossing from Fisher Road to Presidential Drive		$145,000
	Sub-Total		**$616,000**
3.	Install a 12-inch water main from Deerfoot Rd to High Ridge Road (through EMC site) and along Parkerville Rd. from Fairview Drive to Richard Rd.	5,000 ft	$517,000
4.	Replace 6-inch diameter pipe along Route 9 with a 12-inch diameter pipe	2,400 ft	$305,000
		Total	**$3,357,000**

Phase II Recommendation:

1.	Install an 8-inch water main on Deerfoot Rd. from Rt. 9 to Clifford St.	1,600 ft	$147,000
2.	Increase the capacity of Hosmer P.S. from 1,000 gpm to 1,300 – 1,400 gpm, excluding standby pump		$287,000
3.	Install a 12-inch water main along Chestnut Hill Road	5,700 ft	$655,000
4.	Replace the existing 8-inch main on Central Street including Railroad Crossing from Boston Road to Learned Street.	1,600 ft	$338,000
5.	Connect an 8-inch diameter water main along Middle Road between Mt. Vickery Road and Route 9.	1,700 ft	$173,000
6.	Install a 12-inch water main on Pakerville Road from Main Street to the Neary School driveway.	3,600 ft	$373,000
7.	Connect the 8-inch and 6-inch water main along Breakneck Hill Road between Davis Road and Viewhill Road with an 8-inch main.	1,300 ft	$131,000
		Total	***$2,104,000***

MARLBOROUGH

WESTBOROUGH

FRAMINGHAM

ASHLAND

HOPKINTON

PHASE 1: PUMP STATION RENOVATION

PHASE 2: PUMP STATION RENOVATION

PHASE 3: PROPOSED WATER TANK O.F. ELEV. 473.±

FIDDLERS GREEN
1.3 MG TANK
O.F ELV. 515

PROPOSED WATER STORAGE TANK
OVERFLOW: ELEV. 515.0

PRIMARY EMERGENCY SOURCE HOOKUP W/ FIRE ENGINE

SECONDARY EMERGENCY SOURCE HOOKUP W/ FIRE ENGINE

SECONDARY EMERGENCY SOURCE HOOKUP W/ FIRE ENGINE

TROTTER MIDDLE SCHOOL

NEAMY SCHOOL

ST MARK SCHOOL DORM

ST MARK SCHOOL

FIRE STATION

CULVERT

TRANSMISSION LINE

TRANSMISION LINE

PRESSURE TUNNEL

TUNNEL

INTERSTATE 495

ROUTE 9

ROUTE 90

BOSTON WORCESTER TURNPIKE

MASSACHUSETTS TURNPIKE

NORTHBORO ROAD

MAIN STREET

FISHER ROAD

FRAMINGHAM ROAD

MARLBORO ROAD

PINE HILL RD

BOSTON RD

CHESTNUT HILL ROAD

DEERFOOT ROAD

PARKERVILLE RD.

CORDAVILLE RD.

MT. VICKERY RD.

BREAKNECK RD.

OAKHILL RD

WALNUT DR

OLD CART PATH

SCALE IN FEET

0 1000 2000 4000 6000

LEGEND

- 12" DIAMETER WATER MAIN
- EXISTING WATER STORAGE TANK
- PROPOSED WATER STORAGE TANK
- PUMP STATION
- PROPOSED PRESSURE REDUCING VALVE
- PRESSURE REDUCING VALVE
- PRESSURE TUNEL
- HIGH PRESSURE ZONE
- LOW PRESSURE ZONE
- TRANSMISSION LINE
- RAIL ROAD
- HYDRANT
- PROPOSED PRESSURE ZONE DIVIDER
- COMMUNITIES INTERCONNECTION
- PROPOSED 12"Ø WATERMAIN @ PHASE 1
- PROPOSED 12"Ø WATERMAIN @ PHASE 2
- PROPOSED 12"Ø WATERMAIN @ PHASE 3

PREPARED BY H_2O ENGINEERING CONSULTING ASSOCIATES, INC.

TOWN OF SOUTHBOROUGH,
MASSACHUSETTS
WATER DEPARTMENT
144 CORDAVILLE ROAD
SOUTHBOROUGH, MA 01772

TOWN OF SOUTHBOROUGH,

PROPOSED WATER DISTRIBUTION SYSTEM IMPROVEMENT

2007