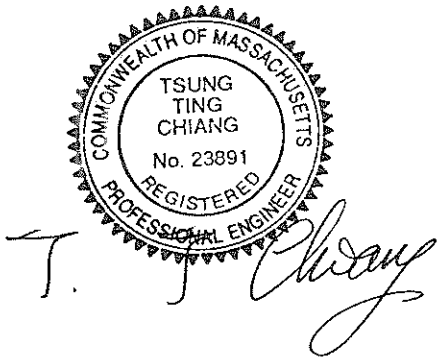
Town of Southborough, Massachusetts

Department of Public Works

REVISED REPORT ON

WATER DISTRIBUTION SYSTEM ANALYSIS



March 16, 1998

Prepared by
H_2O Engineering Consulting Associates, Inc.

H_2O ENGINEERING CONSULTING ASSOCIATES, INC.
水利工程顧問
223-C MIDDLESEX TURNPIKE ◇ BURLINGTON, MA 01803
781-270-6611 (TELEPHONE) H2OENG@TIAC.NET (E-MAIL) 781-270-6828 (FAX)

March 16, 1998

Mr. John W. Boland, Director
Department of Public Works
Town of Southborough
147 Cordaville Road
Southborough, MA 01772

Gentlemen:

In accordance with our agreement, H_2O Engineering Consulting Associates, Inc., is pleased to submit the following report on the results of our study of the Town of Southborough Water Systems with recommendations for improvements to the existing system and future system expansion. The purpose of this report is to update Southborough's Water Works System Master Plan and to establish the present and future water needs for domestic, commercial and fire flow usage and also to recommend the improvements required to provide proper water service through the year 2020.

The general scope of this report includes the following:

1. Update the Town's Water System Map.

2. Evaluate the Town's water need through the year 2020.

3. Determination to meet the projected demand of necessary reinforcement and improvement of storage and distribution system as well as the pump stations.

4. Update a master plan for the Town's Water Distribution System with major recommendations.

5. Recommend phases of construction.

6. Estimates of construction costs.

The following is a brief summary of the information presented in this report:

SUMMARY

Existing Facilities

The Town of Southborough obtains its supply entirely from the MWRA under a contract. The present contract only allows Southborough to pump a maximum of 2.0 million gallons of water per day. The distribution system consists of water mains ranging in size form 2 inches to 16 inches in diameter. The Town's three storage facilities have a total capacity of about 2.0 MG, but the usable storage is less than 1.2 MG with the system separated into two pressure zones. The two pump stations have a total capacity of about 2,000 gpm. The existing system can meet the maximum demand with inadequate pressure at certain high-ground areas. The system is not adequate to meet the required fire flow at some areas due to the lack of sufficient storage and transmission mains.

Future Water Needs

In 1997, the maximum daily demand surpassed the 2.0 MGD allowable maximum pumping rate under the MWRA contract. The water consumption of the Town of Southborough increased by 38.7% from year 1990 to year 1997. It is estimated that the Town's maximum daily water consumption in the year 2005 will be about 2.83 MG and in the year 2020, the figure will increase to about 3.25 MG.

Recommendations

The recommendations presented in the report are divided into three phases. The first phase includes recommendations to improve the capabilities of the existing system and to enable the system to meet projected demands through 2005. Currently, the existing system does not have adequate storage, especially usable storage. The only meaningful storage facility is the Fiddlers Green Reservoir. If this storage facility required maintenance, the Town of Southborough would be at a big risk for fire flow and other possible emergencies such as water main breaks.

The computer simulated hydraulic study of the existing system, combined with actual flow test results, indicates that the insufficient fire flow capacity exists. Field tests indicate insufficient fire flow at Willow Street near Route 9, and at the Neary School area. However, the computer model indicates that the available fire flow could not be sustained long enough to fight the fire, even at an area where field tests have indicated there is adequate fire flow. This is due to inadequate storage available in the system. It is also noted that the existing system lacks adequate transmission mains to carry flow from the north side to the south side of the Town. To correct these problems, Phase I Recommendations include the construction of a 2.0 MG concrete tank and installation of about 800 feet of 16 inch water mains and 9,600 feet of 12 inch water mains, and 700 feet of 8 inch watermain. Minor adjustments to the existing supply mains are also recommended.

Phase II Recommendations provide for additional reinforcement of the system and the expansion of the system to meet the projected requirements of year 2010. This phase recommends that installation of 14,200 feet of 12 inch water mains and 9,100 feet of 8 inch water main to complete the transmission mains for the new tank constructed in Phase I and the Fiddlers Green Reservoir to the south side of the Town. It also completes the transmission main from the Hosmer Pumping Station to the south side of the Town. Phase II Recommendations also include the renovations of the pumping stations and increases the capacity to 1,400 gpm at Boland Pumping Station and 1200 - 1300 gpm at the Hosmer Pumping Station.

The recommendations in Phase III have objectives similar to those of Phase II and include the installation of about 1.0 MG tank in the Pine Hill area and 12 inch water mains. A 1.0 MG booster pumping station may also be required. The time table for the construction of recommended in Phase III would depend upon the development by landowners.

Of necessity, the schedule of the system expansion summarized above has assumed a particular pattern of system growth. Although this pattern seems reasonable, actual system growth may require that certain recommendations be advanced and/or deferred from one phase to another. In general, only those improvements requiring large diameter water

mains and major expenditures of money are included in the phased recommendations. However, improvements involving smaller water mains and less money are also required in each phase of the recommendations. The recommendation section of this report discusses some of those general improvements such as elimination of system "bottlenecks", looping of dead-end branches wherever possible, and general guidelines to be considered when selecting small diameter water mains.

Acknowledgements

We would like to take this opportunity to express our appreciation to the Southborough Department of Public Works, especially to Mr. John W. Boland, Mr. Donald Buzzell and Mr. Henry Valcour with their help in providing information and assistance proved invaluable in this project.

Respectfully submitted,

H_2O Engineering Consulting Associates, Inc.

By _____

Tsu-Ling Peng, M.S.

By _____

Wen-Shang Liu, M.S., P.E.

Approved By:

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

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I. INTRODUCTION

The Town of Southborough's Water Supply System Master Plan is in need for updated and revised due to recent changes put upon the system.

The Town of Southborough has experienced much fast growth in recent year than it was expected. Its water demand is growth at faster rate than population growth due to many expensive large homes have been constructed in the Town of Southborough. Those expensive household use much more water per capita than the average homes. With the fast growth and the change of demand patterns, review of the projected demand and the water supply system becomes necessary.

In addition, The construction of the Massachusetts Water Resources Authority's (MWRA) Metro West Water Supply Tunnel (MWWST) project has started. To avoid possible future impact to some private wells along the route of the MWWST, and to provide conversion of supply from Hultman Aqueduct to MWWST, MWRA has put out several contracts for installation of water main in several communities along the route of MWWST. Southborough also has benefited from MWWST project and has few new water mains been installed by MWRA. MWRA has also constructed through Town of Southborough to install about sixty (60) house service lines for providing water supply to resident within the possible impact area of the MWWST project.

These water mains installation would not only provide public water supply to some resident, who currently are using private wells, within the possible impact area, but also encourage the available land to be developed due to the water supply is available and ready to use.

With thousands feet of new water mains added to the existing system, revision of the previous recommended system improvements may be changed, therefore, re-evaluate the water supply system become necessary.

II. POPULATION

A. Past and Present

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

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

The Town's population history between 1975 and 1997 is listed in Table 1. Between 1975 and 1985 the population of Southborough has growing very slowly with no significant changes and experienced some negative growth at 1978 and 1985. 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 has increased from 6,972 to 7,768, with 11.42% increase in four years which is more than the previous decade growth. Currently, the new subdivision and new homes built in the Town indicates this fast growth will continue.

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

Table 1 - Population History for Southborough, MA

Year	Popoulation
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	6,421
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

Town of Southborough was estimated by considering only those areas of the Town considered settleable. Then, the zoning regulations which applied to each of these areas was considered to determine the maximum number of dewelings which could be built in the Town under current zoning laws.

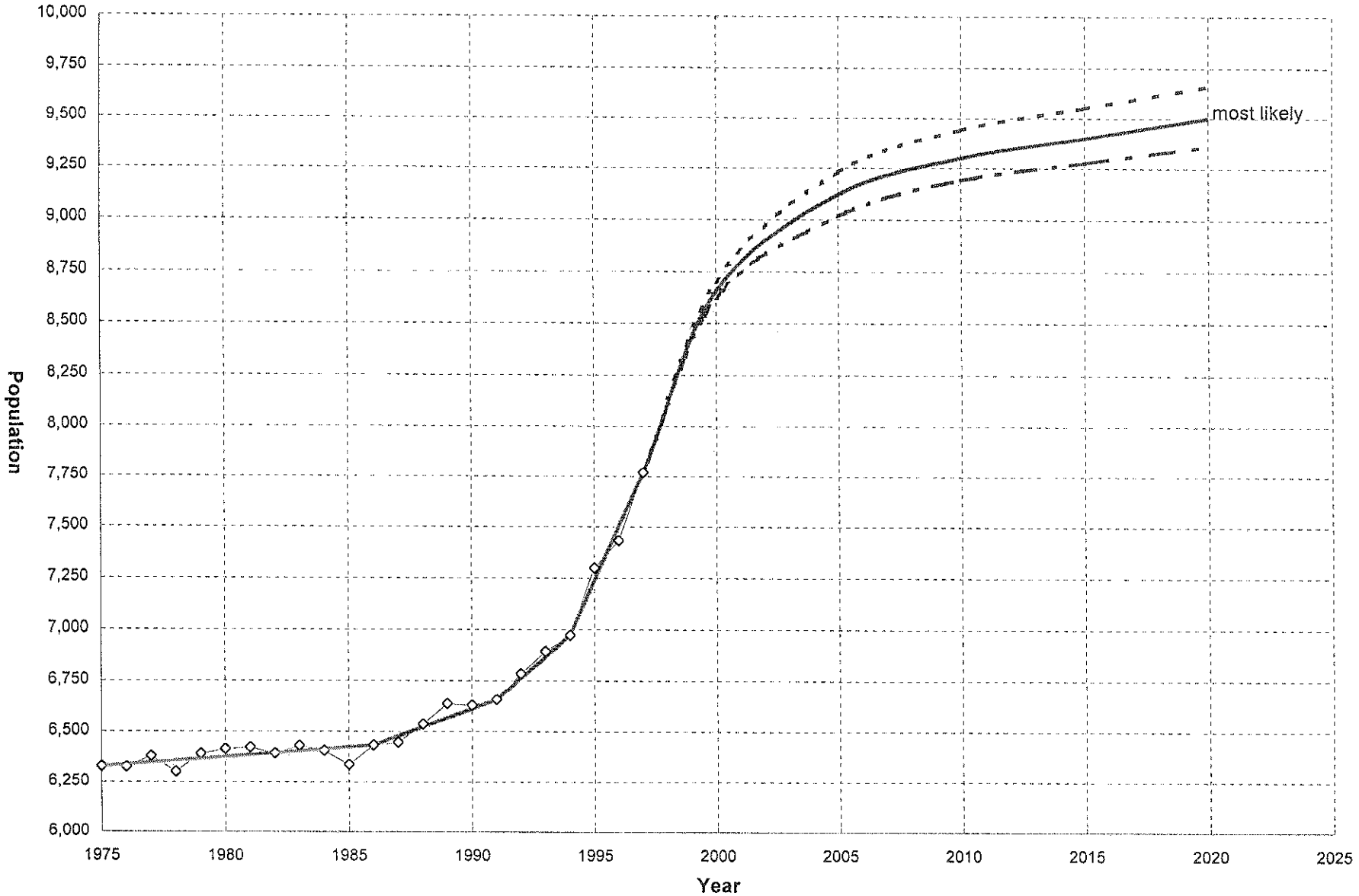
It is a well known fact that communities surrounding large metropolitan areas always growth with the large metropolitan, especially for those so-called "Nice Bedroom Communities". As less land becomes available, the growth rate slows down until the area has met its "saturated" or "ultimate" density. When this density will occur at Southborough is impossible to predict; however, the year 2020 is used in this report.

Town of Southborough located between two major large metropolitan areas, Boston and Worcester; with interstate 495 and 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 90th even when other surrounding communities' growth has been slow down due to the Massachusetts economical downturn during late 80th and early 90th.

The saturation population for Southborough was estimated to be approximately 9,500. It was further assumed that this figure will be reached shortly after the year 2020. Table 1 shows the Town's population history, and Figure 1 shows the projected population for the target year of 2020.

Currently, Town of Southborough does not have public sewer system. If public sewer were available, the population may be increased more due to some unbuildable land become buildable.

Figure 1 - Population Projection for Southborough, MA



III. EXISTING SOURCES OF SUPPLY

A. Sources of Water Supply and Pumping Facilities

At present the Town of Southborough obtains its water from Massachusetts Water Resources Authority's Hultman Aqueduct through two pump stations, the Thomas J. Boland pump station and the Arthur L Hosmer pump station (see Table 2). After the completion of the Metro West Water Supply Tunnel, which will replace the existing Hultman Aqueduct, Town of Southborough will obtain its water supply from the Metro West Water Supply Tunnel via the same two pump stations. The Hultman Aqueduct then shall be taken out of service for maintenance. Eventually, Town of Southborough could obtain its sources of supply from either or both of Metro West Water Supply Tunnel and Hultman Aqueduct. But the quantity of water withdrawn would still be governed by contract between the Town of Southborough and MWRA which is renewed periodically. Currently, the two pump stations can pump 2,000 gallons per minute into Southborough water supply piping system. The 2,000 gpm rate is higher than the contracted amount of withdrawn (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 located on Tara Road area.

2. The Authur L. Hosmer Pump Station, built in 1977, is located northeast of the Town. This pump station connects to Shaft No.3 of the MWRA

Hultman Aqueduct. 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 Clear Hill and the Oak Hill Stand Pipes.

In addition to the MWRA water source, some areas of 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 expand to supply some of the areas if these private wells become inadequate. For this purpose, some locations have been scaled up the demand in the computer model to represent these likely future connection.

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 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 followings:

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 Maintained Avail.	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 on Tara Road in the northwest section of the Town. It is about 7,500 feet south of the Boland Pump Station. This reservoir has overflow elevation at 515.0 feet USGS mean sea level and an approximate storage capacity of 1.3 million gallons. All water mains connecting from the Boland Pump Station to the Tara Reservoir are 12-inch pipes.

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 USGS mean sea level and the 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 watermains on Central Street and Oak Hill Road. This watermain which fills the Oak Hill Stand Pipe was upgraded to a 12 inch main at the end of 1993, except for a section of old 8 inch pipe from Boston Road to Learned Street and under the railroad. The Oak Hill Stand Pipe's capacity is about 0.28 million gallons with an overflow at 492.7 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 60 miles of pipeline in the system. The sizes range from 6 to 12 inch in diameter, except a short section of 16 inch from MWRA Hultman Aqueduct shaft No.3 to Hosmer Pump Station, and pipe materials include unlined cast iron, cement-lined cast iron, 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. In the north section the water is introduced into the system in the north and flows south.

1. The northern section, north of Route 9, includes Southborough's downtown area which includes more than half 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 due to the ground elevation too high to be served by the system.

3. The southern section, south of the 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. It appears that Route 90 becomes a bottleneck in servicing the southern section of the Town.

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 be replaced, besides the cost, it is difficult to obtain the permits required to install these new pipes. There were many dead ends found in the system, and most of them are difficult to eliminate.

In 1997, MWRA through the Department of Public Works of Town of Southborough has 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 at present.

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 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 MWRA's. Therefore, the total water demand in this system is based on the total metered water volume from the Town's pump station. The historical records of the monthly volumes of water pumped out from MWRA's aqueduct for the last eight years has listed and shown in Table 4 and Figure 2.

B. Water Demand

1. Domestic Demand

In general, for the so-called Bedroom Community, the domestic demand for water is the major portion of the community's demand and it has been increasing at faster rate than the rate of population growth since the 60th. This demand has been primarily caused by the ever increasing use of such water operated appliances as automatic dishwashing machine, garbage

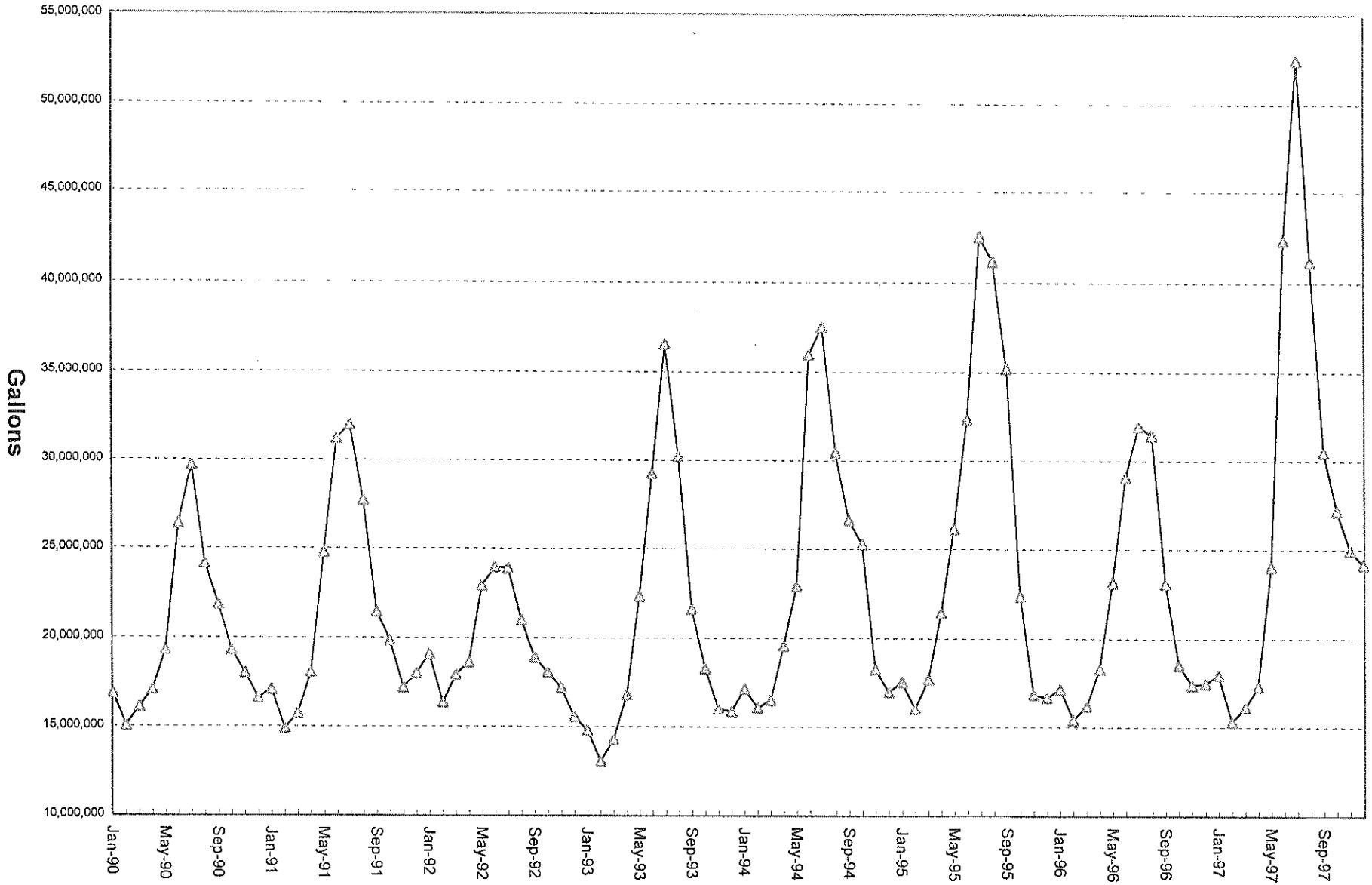
Table 4 - Historical Record of Monthly Volume of Water Pumped Out From MWRA

	P.S. Boland	P.S. Hosmer	Total (gallon)
Jan-90	16,323,000	558,000	16,881,000
Feb-90	15,018,000	27,000	15,045,000
Mar-90	15,889,000	216,000	16,105,000
Apr-90	16,996,000	89,000	17,085,000
May-90	13,075,000	6,228,000	19,303,000
Jun-90	22,464,000	3,915,000	26,379,000
Jul-90	27,023,000	2,694,000	29,717,000
Aug-90	21,225,000	2,909,000	24,134,000
Sep-90	20,083,000	1,767,000	21,850,000
Oct-90	17,393,000	1,915,000	19,308,000
Nov-90	15,064,000	2,966,000	18,030,000
Dec-90	7,207,000	9,416,000	16,623,000
Jan-91	9,907,000	7,204,000	17,111,000
Feb-91	9,312,000	5,587,000	14,899,000
Mar-91	3,388,000	12,349,000	15,737,000
Apr-91	10,550,000	7,510,000	18,060,000
May-91	14,269,000	10,508,000	24,777,000
Jun-91	20,802,000	10,411,000	31,213,000
Jul-91	21,967,000	10,028,000	31,995,000
Aug-91	22,027,000	5,660,000	27,687,000
Sep-91	11,523,000	9,922,000	21,445,000
Oct-91	9,912,000	9,954,000	19,866,000
Nov-91	10,114,000	7,105,000	17,219,000
Dec-91	11,069,000	6,931,000	18,000,000
Jan-92	13,490,000	5,590,000	19,080,000
Feb-92	6,706,000	9,650,000	16,356,000
Mar-92	9,464,000	8,459,000	17,923,000
Apr-92	10,034,000	8,594,000	18,628,000
May-92	11,679,000	11,232,000	22,911,000
Jun-92	12,901,000	11,053,000	23,954,000
Jul-92	16,783,000	7,106,000	23,889,000
Aug-92	11,793,000	9,188,000	20,981,000
Sep-92	10,866,000	8,024,000	18,890,000
Oct-92	9,161,000	8,898,000	18,059,000
Nov-92	9,506,000	7,703,000	17,209,000
Dec-92	8,754,000	6,800,000	15,554,000
Jan-93	8,286,000	6,480,000	14,766,000
Feb-93	8,443,000	4,592,000	13,035,000
Mar-93	8,465,000	5,795,000	14,260,000
Apr-93	10,433,000	6,359,000	16,792,000
May-93	11,526,000	10,800,000	22,326,000
Jun-93	16,319,000	12,914,000	29,233,000
Jul-93	28,202,000	8,352,000	36,554,000
Aug-93	23,807,000	6,422,000	30,229,000
Sep-93	13,691,000	7,920,000	21,611,000
Oct-93	11,116,000	7,175,000	18,291,000
Nov-93	10,101,000	5,896,000	15,997,000
Dec-93	8,591,000	7,270,000	15,861,000

Table 4 - Historical Record of Monthly Volume of Water Pumped Out From MWRA

	P.S. Boland	P.S. Hosmer	Total (gallon)
Jan-94	9,708,000	7,441,000	17,149,000
Feb-94	8,290,000	7,774,000	16,064,000
Mar-94	8,687,000	7,827,000	16,514,000
Apr-94	11,039,000	8,519,000	19,558,000
May-94	11,929,000	10,957,000	22,886,000
Jun-94	23,819,000	12,157,000	35,976,000
Jul-94	28,549,000	8,957,000	37,506,000
Aug-94	24,156,000	6,285,000	30,441,000
Sep-94	22,646,000	3,950,000	26,596,000
Oct-94	na	na	25,265,000
Nov-94	na	na	18,263,000
Dec-94	na	na	16,981,000
Jan-95	na	na	17,551,000
Feb-95	na	na	16,027,000
Mar-95	na	na	17,682,000
Apr-95	na	na	21,416,000
May-95	na	na	26,136,000
Jun-95	na	na	32,364,000
Jul-95	na	na	42,564,000
Aug-95	na	na	41,185,000
Sep-95	na	na	35,224,000
Oct-95	na	na	22,351,000
Nov-95	na	na	16,833,000
Dec-95	na	na	16,665,000
Jan-96	na	na	17,152,000
Feb-96	na	na	15,405,000
Mar-96	na	na	16,178,000
Apr-96	na	na	18,288,000
May-96	na	na	23,134,000
Jun-96	na	na	29,038,000
Jul-96	na	na	31,959,000
Aug-96	na	na	31,454,000
Sep-96	na	na	23,045,000
Oct-96	na	na	18,510,000
Nov-96	na	na	17,376,000
Dec-96	na	na	17,467,000
Jan-97	na	na	17,940,000
Feb-97	na	na	15,307,000
Mar-97	na	na	16,090,000
Apr-97	na	na	17,310,000
May-97	na	na	24,021,000
Jun-97	na	na	42,369,000
Jul-97	na	na	52,508,000
Aug-97	na	na	41,175,000
Sep-97	na	na	30,491,000
Oct-97	na	na	27,155,000
Nov-97	na	na	24,928,000
Dec-97	na	na	24,119,000

Figure 2 - Monthly Pumpage from MWRA Aqueducts, Town of Southborough, MA



disposal units and automatic lawn sprinklers, as well as backyard swimming pool. High value residential areas are inclined to be in areas of large lots with large grass areas with home having more water using appliances.

Domestic water consumption is the major water demand in the Town of Southborough. In recent year, this consumption has steady increased faster than the rate of population increase. From 1990 through 1997, the total population increased 17.2% but the average daily water consumption has increased by 38.7%. In Southborough, some of the new homes constructed in recent year are on private wells, otherwise the domestic demand would increase much faster.

2. 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 large shopping malls and major water consumed industry. Most commercials and industry in Southborough are neighborhood commercials and office type industry. Therefore, water consumption for those areas are not separated out from the total water demand.

3. 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 5) having increased from 99 gallons per capita per day (gpcd) in 1990 to nearly 118 gpcd at 1997. It should be pointed out that some of the new homes are

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

using private well water. If all new homes are using public water supply, the rate of water demand will increase at much faster rate.

4. 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 6 indicated that the ratio of the maximum daily demand to the average daily demand of Town of Southborough varied from 1.97 to 2.91 during 1990 through 1997. This variation is due to the variation of rainfall and temperature of each year, as well as the use of lawn sprinklers.

C. Past Water Consumption

Table 6 also shows the history of the 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 year, home constructed in Southborough are large and expensive type. Therefore, water consumption has been increased rapidly, especially the maximum daily demand. Due to the location of the Town of Southborough, the land cost in the future would be very expensive, therefore, any home construction in the future would be high priced type. With the possibility of some of the homes currently on private wells may change to public water supply, the water consumption trend will continue grow faster than the population growth in the Town of Southborough.

Table 6 - Historical Water Demand of Southborough, MA

Year	Total Pumpage (MG)	Max. Weekly Demand		Max. Daily Demand		Ave. Daily Demand	Ratio
		Period	Volume (MG)	Period	Volume (MG)	Volume (MG)	Max.day/Ave.day
1990	240.460	7/15 - 7/21	7.98	8-Aug	1.648	0.66	2.50
1991	258.009	7/15 - 7/21	8.81	7-Jun	1.625	0.71	2.29
1992	233.434	6/8 - 6/14	6.323	29-Jun	1.382	0.64	2.16
1993	248.955	7/8 - 7/14	9.219	15-Jul	1.871	0.68	2.75
1994	222.690	6/15 - 6/21	10.265	19-Jun	1.775	0.61	2.91
1995	305.998	8/30 - 9/05	10.866	7-Jul	1.668	0.84	1.99
1996	259.010	6/12 - 6/18	8.117	7-Jul	1.397	0.71	1.97
1997	333.413	7/30 - 8/05	13.338	2-Aug	2.179	0.913	2.39

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 of 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 depending on the weather much more than average demand. 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 analyzed 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 shown the projected per capita consumption is 125 gpcd for the year 2020 based on the assumption that due to the increasing cost of water, many homes with private well and lawn sprinklers system may choose to use private well for lawn irrigation. If all private well would not be used, the per capita consumption may reach 135 gpcd at 2020.

Figure 4 shown the maximum monthly demand in the eight years history was 52,508,000 gallons on August 1997. The projected maximum monthly demand for the year 2005 is about 75,000,000 gallons per month. The increase is about 42.8%. Figure 5 shown the maximum daily demand in the eight years history was 2,179,000 gallons per day in August 2, 1997. The projected maximum daily demand for the year of 2005 is about 2,800,000 gallons per day. The increase is about 28.5%. Figure 6 shown the average daily demand in the eight years history

Figure 3 - GCPD Projection for Southborough, MA

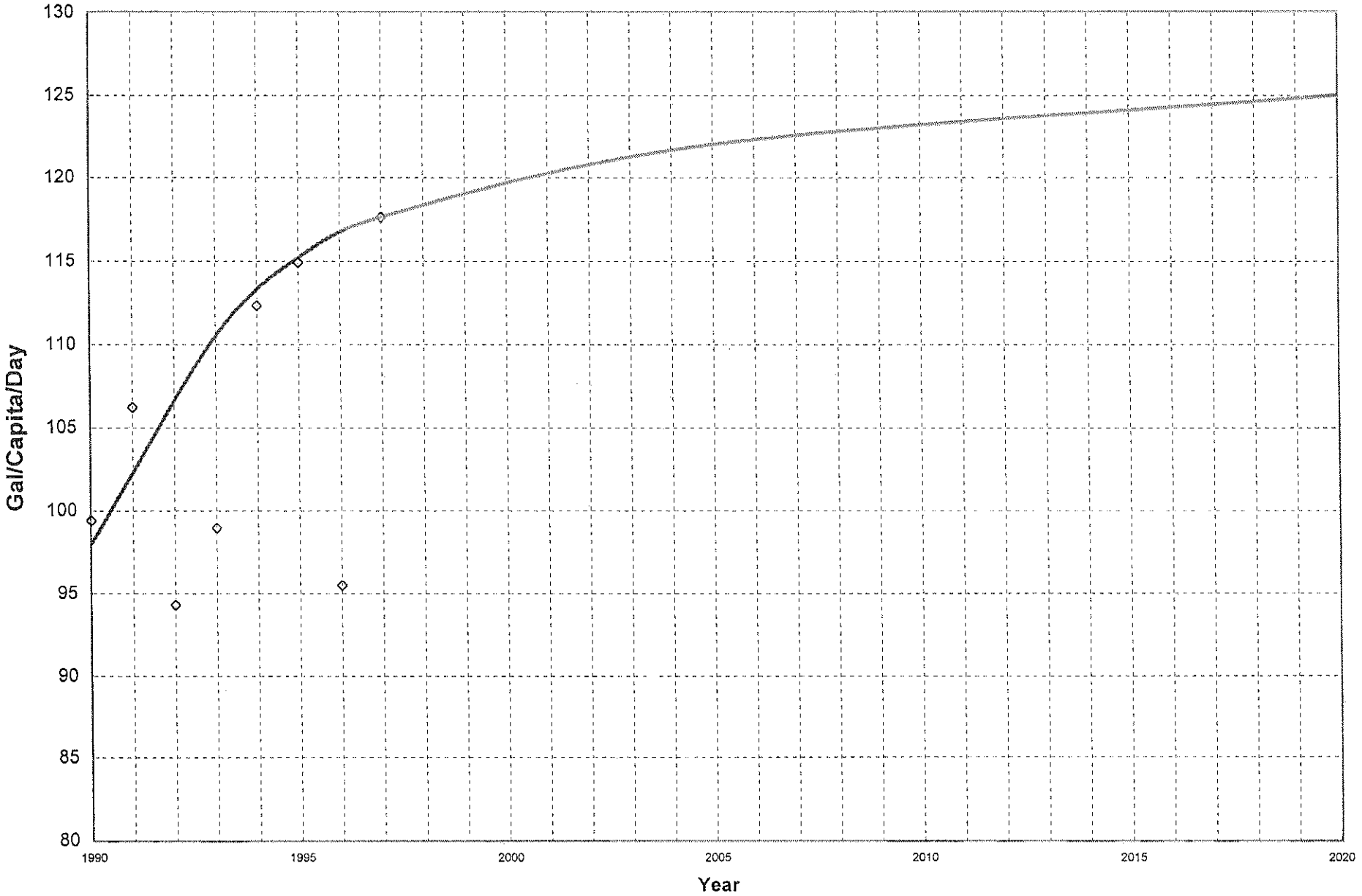


Figure 4

Maximum Monthly Demand Projection for Southborough, MA

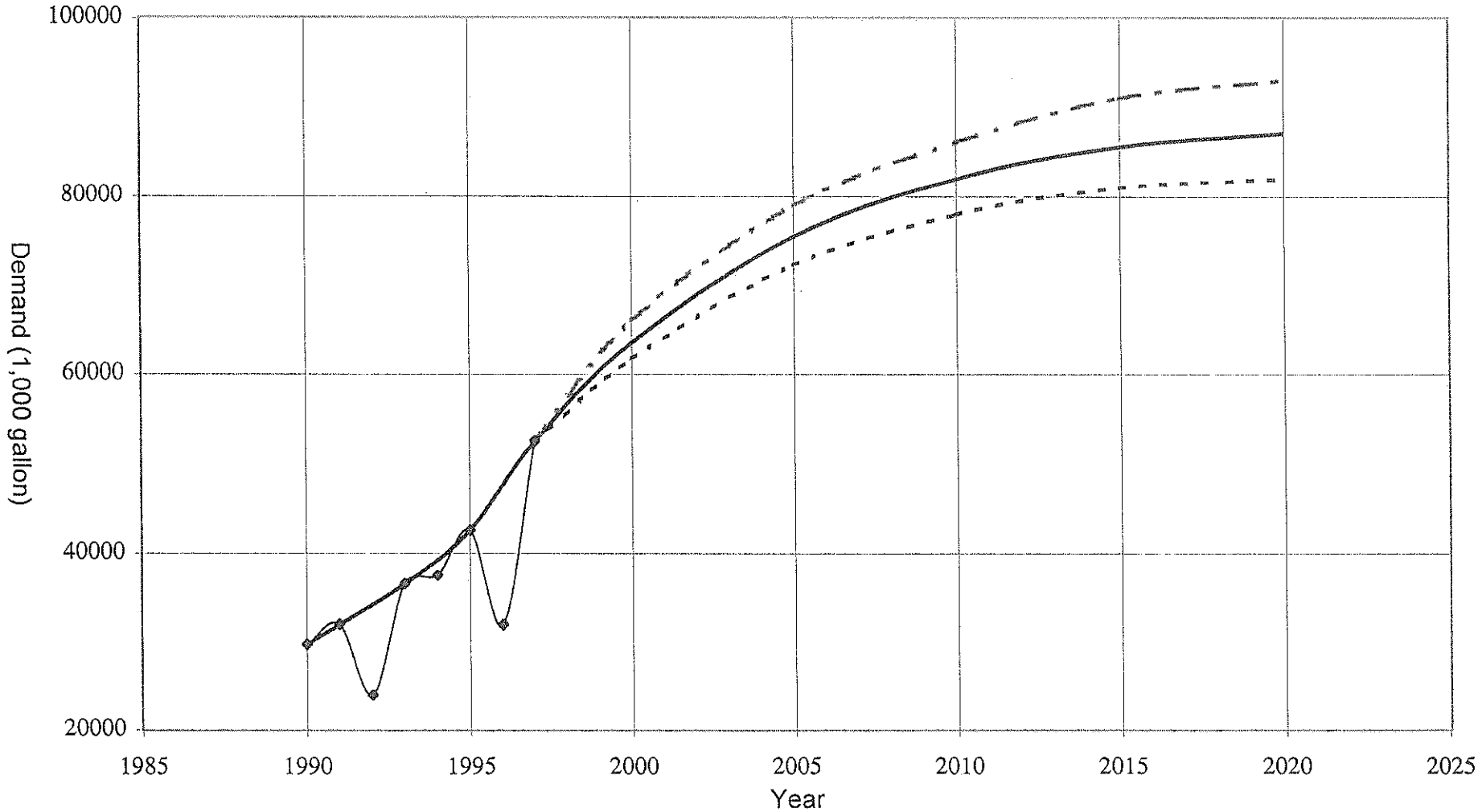


Figure 5
Maximum Daily Demand Projection for Southborough, MA

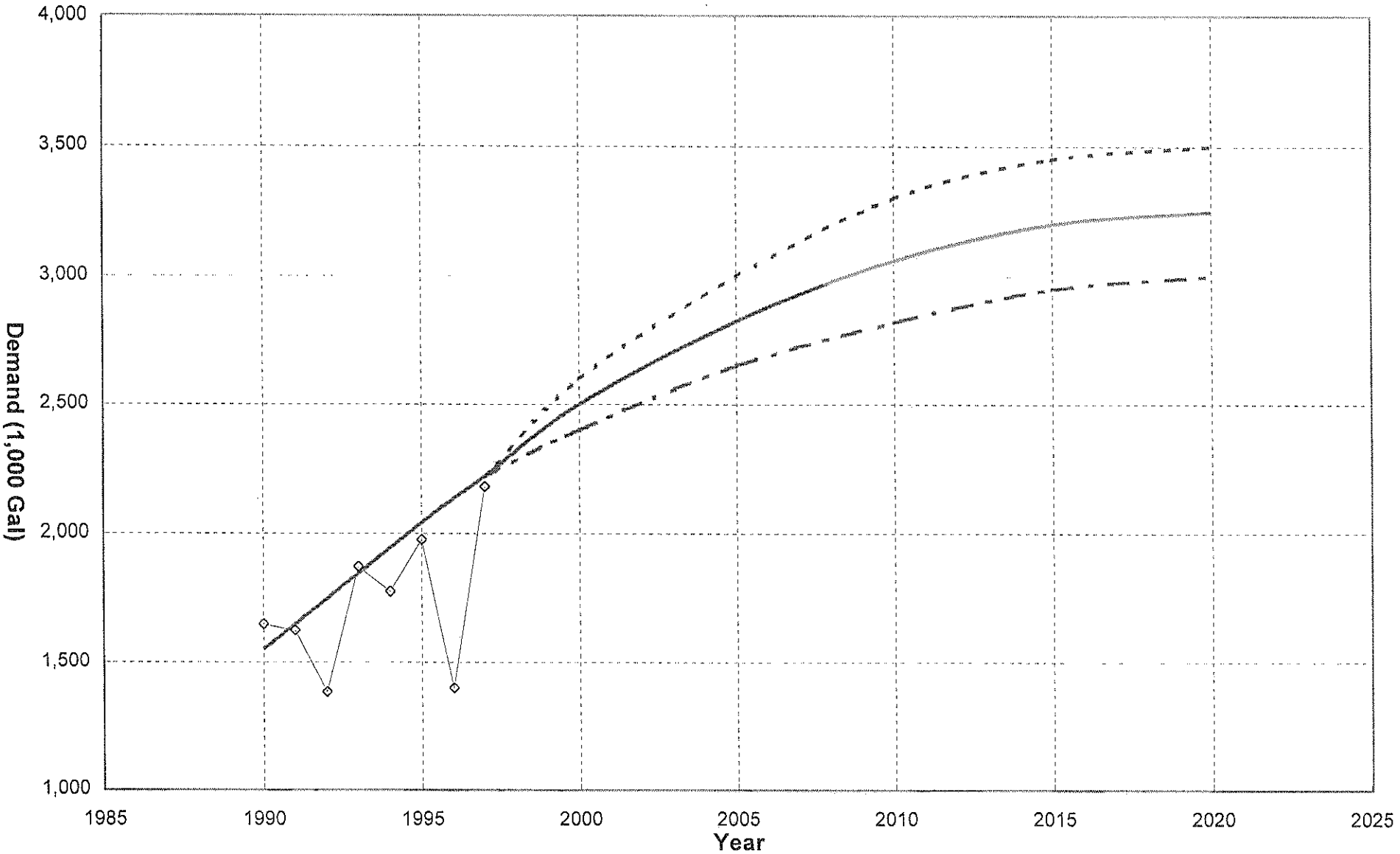
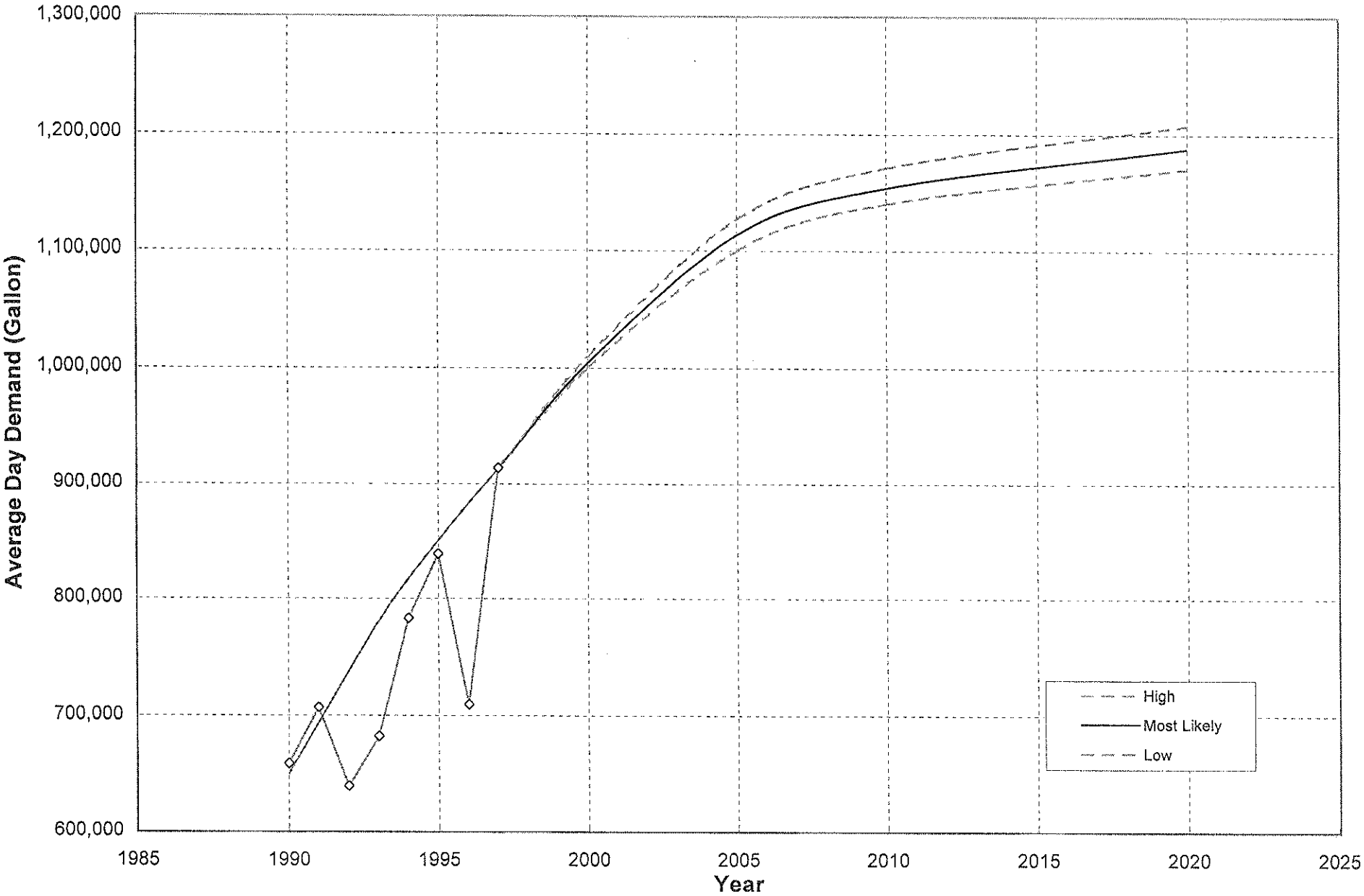


Figure 6
Average Daily Demand Projection for Southborough, MA



was 913,460 gallons per day in 1997. The projected average daily demand for the year of 2005 is about 1,112,000 gallons per day. The increase is about 21.7%. These projected demands will be applied in the computer model of the distribution system to determine recommended the future system improvements.

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

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 7 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

Table 7

ISO COMMERCIAL RISK SERVICES, INC.

HYDRANT FLOW DATA SUMMARY

City Southborough State MA Zip 01772 Witnessed by A. Lagadinos Date 3-9-90

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	5 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

Parkerville Road area was about 3,000 gallons per minute in steady state (see Table 7 - 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 1 hour. The system model's fire flow is 3,500 gallons per minute for 3 hours continuously and reduced to half the required fire flow for the next 3 hours. This demand is much higher than the existing system can provide and creates a critical condition for the existing system.

V. SYSTEM ANALYSIS

A. General

The purpose of a distribution system analysis is to evaluate the adequacy of the system's pipe network, storage facilities, sources supply and pumping capacities under present and projected 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 digital 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), water levels in the storage tanks were entered into the computer model.

After inputing 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 Street and Fairview Drive. The Southborough Water Supply System has been designed to serve the areas where the ground elevations are lower than elevation 400 (U.S.G.S.). Any location where the ground elevation is between 400 and 430 would experience unacceptable low pressures. Some areas locate between elevation 300 and 400 would encounter pressure problem during fire fighting if the pipe line is undersized.

The following several paragraphs are discussing 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.

In the northern section, north of Route 9, Fiderlers Green Reservoir, Clear Hill Standpipe, Boland Pump Station and Hosmer Pump Station all located in this section 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. The computer model shows that the available fire flow is about 1,280 gpm at 20 psi. This low flow is due to the undersized 6-inch diameter water mains along Route 9 which restricted the flow rate. There are three approaches to improve the flow rate at this location, one is to replace the existing 6 inch diameter water main along Route 9 from Oak Hill Road to Willow Street. However, the cost to install a new watermain on Route 9 is expensive. The other approach is to install 12-inch diameter watermain from Oak Hill Drive to Brook Lane. This approach may be to install the watermain directly or in conjunction with the nearby subdivision in the future. The third approach is by replacing 6-inch watermain along Willow Street to 12-inch pipe and replacing the existing 6-inch and 8-inch pipe along Valley Road by a 12-inch pipe to take the advantage of some distance of 12 inch pipe been installed already by MWRA. Table 8 shows the computer dynamic analysis results for the available fire flow at 20 psi of pressure with different alternatives at the intersection of Route 9 and Willow Street.

Table 8 – Available Fire Flow from Dynamic Analysis for the Willow Street Improvement

Description	At the Beginning of fire flow	At the End of 3 hours of fire flow
Existing condition	1,410 gpm	1,280 gpm
Replace the 6" pipe along Route 9 w/ 12" pipe	5,300 gpm	3,100 gpm
Install 12" pipe from Oak Hill Drive to Brook Lane	4,900 gpm	2,650 gpm
Replace 6" pipe along Willow Street to 12" pipe, replace 6", 8" pipe along Valley Road to 12" pipe	5,000 gpm	3,000 gpm

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 the reasonably adequate water service. When Fiddlers Green Reservoir is being maintained at its high level, the area along Parkerville Road where the ground elevation is below 390, the distribution system can maintain adequate service. There are areas with dead end pipe 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. The water system has no problem providing maximum daily demand, but can only provide approximately 1,600 gpm of fire flow. Fire flow test conducted at the Finn School where a 3,000 gpm fire flow is needed, at the intersection of Parkerville Road and Richard Road indicates that the available fire flow on

average is less than 1,600 gpm. Computer model indicates that the high head loss is caused by the undersized pipes crossing the bottleneck at Route 90. In order to provide adequate fire flow to the Finn School area and this part of Town, the distribution system needs to be improved.

There are two improvement approaches to consider. The first approach is to provide appropriate water storage near the southern section to shorten the water transmission distance. The second approach is to replace the existing water mains with adequate size pipe. After studying and testing a number of alternatives, the best option has been determined and divided into two phases to complete this improvement. The first 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 12-inch watermain along Deerfoot Road and 16 inch watermain to the tank. The second phase is to install new 12 inch pipes from Oak Hill Road, along Walnut Drive and pass under the Mass Turnpike to connect the pipes between Oak Hill Road and Oregon Road.

There is a 12-inch pipe been installed under the Massachusetts Turnpike years ago for the purpose of delivery water from north side of Mass Turnpike to the south. This short section of 12-inch pipes, if constructed today would cost at least $500,000, will be one of major path of watermain between north and south of Mass Turnpike.

Table 9 lists the available flow with 20 psi of pressure at the Finn School from the dynamic analyses to include the first phase and second phase improvements.

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

Table 9 – Available Fire Flow from Dynamic Analysis for the Southern Portion Improvement

Description	At the Beginning of Fire Flow	At the End of 3 hours of fire flow
Existing	1,800 gpm	1,710 gpm
Construction Storage Tank & Associated Pipeline	2,870 gpm	2,690 gpm
Install Additional Pipeline at Southeast Corner	3,780 gpm	3,330 gpm

A new 12-inch water main along Central Street and Oak Hill Drive were installed in early 90th. But there is a short section of 8-inch under the railroad has not been replaced. This short section of 8-inch pipe should be replaced and the 12-inch water main should extend to Boston Road. Eventually this 12-inch water main with the pipes along Walnut Drive, under the Mass Turnpike and extend all the way to Constitution Drive area to form a transmission main from Hosmer Pump Station to supply Cordaville and Southville area.

C. Inadequate Storage Capacity

The existing storage facilities in the Town of Southborough have total capacity of about 2.0 Million Gallons (MG). But the total usable storage is less than 1.2 MG assume all three storage facilities are filled to the overflow level. This 1.2 MG usable storage just about meet the peak hourly demand, variation which usually last 3 to 3.5 hours (between 6:30 AM to 10:00 AM), and a 3 hours fire flow. But the fire fighting generally last longer than three hours. Therefore, the usable storage is not adequate. If the tank were not full at the beginning, then the

usable storage definitely is not adequate. Also, other emergency condition may occur at the same time, such as pump equipment break down, pipe line brook, etc, then the usable storage would not adequate to meet the Town's demand, specially during the summer months.

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

VI. WATER SYSTEM MASTER PLAN

A. General

Due to the several major highways, a railroad, a large water supply aqueduct and a reservoir located in the Town, with varying ground elevations throughout, 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 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 constructing costs, avoid paralleling large size mains along a street and avoiding constructing 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 to satisfy future demands concentrated on the major mains and major improvements involving large expenditures of time and money and require other 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 Hultman Aqueduct. Due to the present contract between Southborough and the MWRA expired in January, 1997, the Town of Southborough and MWRA is in the process to discuss a new contract. In accordance with the existing contract, Southborough is only allowed to pump 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. Last year, 1997, the maximum day demand did over the 2.0 MGD. It is strongly recommended when Southborough negotiate future MWRA contract requesting the 2.0 MGD limit upgrade to a higher limit, preferable 4.0 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 old 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 within next five years – after the construction of an 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 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 3.3 MGD for the year 2020. The existing gross storage is 1.97 MG, but the existing usable storage is only 0.4 MG with all storage reservoirs filled to elevation 489 (This is based on 30 psi service pressure for ground elevation 400). This is approximately 2.8 MG less than the 3.3 MG of usable required storage. With Fiddlers Green Reservoir filled to elevation 514±, the usable storage would be about 1.2 MG

which is about 2.1 MG less than the 3.3 MG required usable storage. This emphasizes the need for additional storage in Southborough.

In our previous report, H_2O Engineering Consulting Associates, Inc., recommended to change the Southborough Water Supply System into two pressure zones by creating a high pressure zone. This can be accomplished by boosting the water level in the Fiddlers Green Reservoir up to elevation 514± feet USGS. Boosting the water level in the Fiddlers Green Reservoir up to elevation 514± feet will create a higher pressure zone which requires pressure reducing valves to be installed at locations where the high-low pressure areas of the system are tied together. Currently the Water Supply Division of Southborough Department of Public Works already change the system into two pressure zone by closing some valves. This has increased the usable storage capacity within the existing system to about 1.2 million gallons.

We also recommend to construct 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 0.6 MG, but it will help the system tremendously.

D. Distribution System Improvement

The existing Southborough Water Supply System is a one pressure zone system. It's hydraulic gradients are limited by the storage facility's overflow elevations. The overflow elevations of the storage facilities, except for the Fiddlers Green Reservoir, are about 493 feet USGS. The Fiddlers Green Reservoir has an overflow at elevation 515 feet 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.

In recent year, the Southborough Water Supply Division of the Department of Public Works has operated the system as two pressure zones system by closing valves. The high

pressure zone has a hydraulic gradient controlled by the Fiddlers Green Reservoir overflow elevation of 515 feet USGS and the low pressure zone has a hydraulic gradient controlled by the other two storage tanks overflow elevation of 493 feet USGS.

Recently, MWRA local water main connection project has installed two pressure reducing valves into Southborough water system. Two additional pressure regulated valves are needed to complete the separation of the system into two pressure zones.

The Massachusetts Department of Environmental Protection (DEP) Guidelines for Public Water Systems recommends a minimum service pressure of 35 pounds per square inch (psi). Under the one pressure zone system, even when storage facilities are full, any area in the Town with the elevation higher than elevation 413 would not have the recommended minimum service pressure of 35 psi without consideration of pipe friction loses within the system. When pipeline head losses are considered, areas where the system can provide 35 psi would have a ground elevation below 400 feet USGS. However, based on USGS topo maps, areas in the Town with higher than 400 feet elevation represent approximately ten (10%) percent of the total land area, with the majority of the high areas located on the Tara Hill, Fairview Hill and Pine Hill areas.

The Fiddlers Green Reservoir has an overflow elevation of 515 feet USGS. Full utilization of the Fiddlers Green Reservoir would help to provide adequate service pressure for areas with ground elevation between 400 to 430 feet USGS. This would require separating the Southborough Water Supply System into two pressure zones. The high pressure zone would be controlled by the Fiddlers Green Reservoir and the lower pressure zone would be limited by Oak Hill and Clear Hill Storage Tanks. Pressure reducing valves must be installed at the connections between these two zone. During 1995, the two-zone system was established by closing some valves. This establishment improved the service to higher areas.

The two zone system will minimize the pressure problem at the Tara Hill area. Fairview Hill contains the majority of high ground and requires higher pressures. The

improvement on the Fiddlers Green Reservoir will also improve pressure on Fairview Hill but is less significant due to head loss between the two areas.

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 feet USGS.

Presently, the Pine Hill area, located North of 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 may require to construct a booster pumping station and a storage tank. Also, the pipe from 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.

When the Pine Hill area begins developing, it appears 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 prestressed 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 small storage facility will be needed for this area. There is another possible way to supply the Pine Hill area that is to obtain the right from MWRA for another supply point from MWRA water main near Pine Hill area such as Pleasant Street at Framingham and construct a small booster pump. However, we recommend that the system storage capacity and the pipe line and how to supply this area be evaluated when this area begins developing.

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 transmission mains be installed under the Mass Turnpike to serve this South Section.

There are other areas that do not have adequate fire flow rates as required by ISO due to dead ends or undersized pipes. Improvements should be made as financial conditions and time permit. For example, to improve the inadequate pressure and flow at the intersection of Route 9 and Willow Street, a 12" diameter pipe is needed along Route 9 to increase the existing available average fire flow from 1,350 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 other than installations along other Town roads. But, there are about 700 feet of unlined 6-inch cast iron pipe along Route 9 between Brook Lane and Pleasant Street, and about 1,200 feet of unlined 8-inch cast iron pipe along Route 9 at west of Woodland Road. This two section of unlined pipe, especially the 6-inch in diameter pipe is in poor condition, should be replaced when possible.

E. Water Quality

The quality of water from the Quabbin and Wachusett Reservoirs meets 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 leaching these pipe materials into the water supply. This results in increasing the concentrations of these metals above drinking water standards. Recently, 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 contracted for the design of a water treatment plant at Shaft C area. This new plant when constructed is expected to solve the corrosion problem and other water quality problem for all MWRA communities. Therefore, we recommended that Southborough take no immediate action for corrosion control, but wait for the MWRA progress before discussing further actions.

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 contemplated 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 to carry 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" in diameter.

It is recommended that in the future, any new development should submit the following to the Town's Public Works Department for reviewing 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 number 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 elevations.

To overcome the low pressure problem on those areas with high ground elevation, it is recommended that the water system be separated into high and low service areas. The approximate boundary of the two pressure zones are shown on system map. The two zone recommendation and several other recommended system improvements will minimize the pressure problem in the high ground areas, but will not eliminate them completely. 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 410 feet USGS in the low service zone, and above elevation 430 feet USGS in the proposed 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 take immediately to improve the water system and completed by the year 2002.

Phase II improvements should be considered presently and completed by the year 2008. Both Phase I and Phase II are reinforcing the existing system and upgrade the Southborough water supply system much close to meet 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, which timing would be difficult to predict. Some items may be developed in the near future and some items may be developed in the more distant future.

The watermain along the Northboro Road should be 8 inch in diameter. Currently, the existing home is on private well. As we understand, the home owner on the street is negotiating with MWRA under the Metro West Water Supply Tunnel (MWWST) contingency plan to install this 8 inch watermain. If this watermain is not been done under the MWWST project, the 8" watermain on Northboro Road will be added to the Phase III recommendations.

Phase I

1. Separating the system into two pressure zone systems by installing pressure regulated valves at the following streets:

    a. Install a 6" diameter PRV on Mt. Vickery Road near Cordaville Road.

    b. Install an 8" diameter PRV on the proposed 12" diameter main along Parkerville Road near the Massachusetts Turnpike. The existing 8" diameter main can be shut off by connecting to the proposed new 12" diameter transmission main on both sides of the PRV.

    c. When the 8-inch water main is extended along Marlboro Road and crossing under the railroad to connect to Sears Road, a PRV should be installed near the railroad connection.

2. 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" diameter and 700 feet of 12" diameter pipe would need to be installed.

3. Install 6,200 feet of 12" diameter water main on Parkerville Road from Route 9 to Richards Road. This 12" diameter main along Parkerville Road becomes the transmission main for carrying flow to Finn School and Southville area.

4. Extends the 12-inch main recently installed at Valley Road to Willow Street and replacing the 6-inch water main along Willow Street to Route 9. The estimated length is 2,700 feet. When designing this project, the 700 feet unlined 6-inch cast iron watermain along Route 9 should also be evaluated for the possibility to replace it by an 8-inch or a 12-inch watermain.

Phase II

1. Install 1,600 feet of 8" diameter pipe on Deerfoot Road from Route 9 northerly to the intersection of Deerfoot Road and Clifford Street.

2. To fully utilize the proposed new tank, a 12" diameter pipe can be either installed by taking easement from Deerfoot Road to Fairview Drive, or from the proposed tank along easement toward Sarsen Stone Way; then, follow Sarsen Stone Way to Skylar Drive to Parkerville Road. It is difficult to estimate the length of this 12" main due to the uncertainty of the easement. The estimated cost of this line is based on taking easement along property lines from Deerfoot Road to Fairview Drive, an estimated length of 1,600 feet. The pipe length may vary a lot. It is depending on where the easement can be obtained or proposed subdivision roadway would be located.

3. Increase the capacity of Hosmer Pumping Station from the existing 1,000 gpm to 1,200 – 1,300 gpm.

4. Increase the capacity of Boland Pumping Station from the existing 1,000 gpm to 1,400 gpm.

5. Install approximately 2,000 feet of 8-inch watermain on Marlboro Road including replacing existing 6-inch watermain along Marlboro Road and crossing under the railroad to connect to Sears Road.

6. Install a 12" diameter water main from the existing 12" diameter water main at Oak Hill Drive along Walnut Drive to an existing 12" diameter water main under the Massachusetts Turnpike continue along Cart Path or an easement to Oregon Road, then along Edgewood to connect to the existing 12" diameter main at Nathan Stone Way. The route of this main may vary somewhat depending upon the possible subdivision of the land between the Massachusetts Turnpike and Oregon Road; and between Oregon Road and Edgewood Road. The estimated length would be about 8,000 feet.

7. Extends the 12-inch water main along Fisher Road northeasterly of about 3,200 ft, then, turn eastly of about 700 ft to connect to the existing 12-inch main at Presidential Drive. An 8-inch main (1,800 feet) would be adequate for the rest Fisher Road toward Marlborough. A railroad crossing is required to connect watermain to the Presidential Drive.

8. Install 3,600 feet of 8" diameter water main on Parkerville Road from Main Street to the Neary School driveway.

9. Install approximately 1,600 feet of 12" diameter main on Central Street from Boston Road to Learned Street including a 60-feet section under the Railroad track which was not previously completed.

10. Connect 8" watermain on Middle Road between Mt. Vickery Road and Route 9. The estimated length is 1,700 feet.

Phase III

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

1. Any new main, in general, in future development or extension of water mains along existing streets, a minimum of an 8" 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 bodied, which are difficult to loop should be 12" diameter water mains for adequate fire flow. Also, dead end water mains should be avoided.

2. Install approximately 4,300 feet of 12" water main along Chesnut Hill Road from Main Street to Jericho Hill Road. Because this main crossing the MWRA Pressure Aqueduct, an investigation would be required to determine the feasibility of the crossing.

3. 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 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 Pine Hill Road and Waveney Road intersection area. Also, this can be accomplished by obtaining a permit from MWRA to add an new take-out point from MWRA transmission main by tapping one 12 inch pipes to the proposed MWRA 24 inch pipe which connect the Valve Chamber off Hultman Aqueduct and Pleasant Street Pumping Station in Framingham. In this case, a booster pumping station

may need to be constructed.

The third option is to obtain an easement from the Town of Framingham to install a 12" diameter pipe along Pleasant Street and Pine Hill Road from the existing 12" 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" diameter loop with 8" diameter sub-loops. No 6" diameter pipes should be used due to the high ground elevation. A storage tank may be required if this area become fully developed.

4. A 12-inch loop transmission main should be installed from Crystal Pond Road and Coslin Drive area southly toward Gilmore Road area. For high ground area, large size watermain such as 12-inch should be used for reducing the friction loss. Since Southborough water system could not provide adequate pressure for area higher than 400 feet USGS, especially for area farther away from pumping stations and storage tanks.

C. Cost Estimation

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

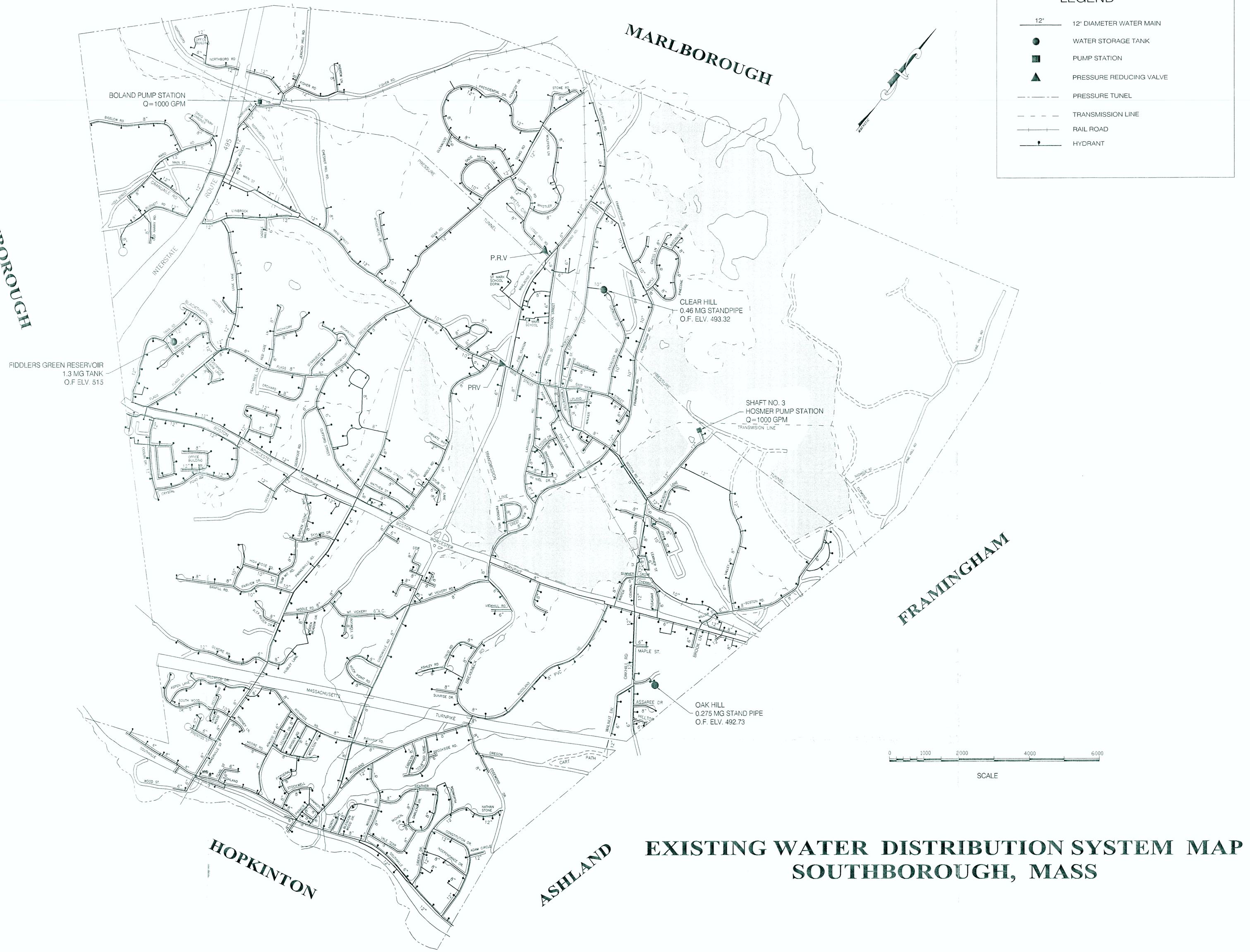
Phase I Recommendations:

1.a & b	Installing 2 PRVs		$85,000
2.a	Construct 2.0 MG New Tank		$1,070,000
	Control Valve & Site Preparation		$180,000
	16" diameter water main from reservoir to distribution system	800 ft	$70,400
	12" diameter water main on Deerfoot Rd.	700 ft	$51,800
3.	12" water main on Parkerville Rd. from Route 9 to Richard Rd.	6,200 ft	$458,800
4.	12" watermain from Valley Road to Willow Street	2,700 ft	$199,800
	Install 700 feet of 8-inch pipe along Route 9	700 ft	$46,900
		Total	***$2,162,700***

Phase II Recommendation:

1.	12" water main on Deerfoot Rd. from Rt. 9 to Clifford St. NO	1,600 ft	$118,400
2.	Increase the capacity of Hosmer P.S. from 1,000 gpm to 1,200 – 1,300 gpm, excluding standby pump NO		$120,000
3.	Increase the capacity of Boland P.S. from 1,000 gpm to 1,400 gpm, excluding standby pump NO		$120,000
4.	8" watermain on Marlboro Road and connecting to the Sears Road NO	2,000 ft	$134,000
	Install one PRV YES		$43,000
5.	12" water main along Walnut Dr., through Mass Turnpike and Cart Path to Oregon Rd YES	4,500 ft	$333,000
	12" water main along Edgewood Rd. from Oregon Rd. to Nathan Stone Way YES	3,500 ft	$259,000
6.	Extend 12" diameter water main on Fisher Rd. including a railroad crossing YES NOT NECESSARY	3,000 ft	$272,000
	Extend 8" diameter water main on ~~Fisher~~ Jericho Rd NO	1,800 ft	$120,600
7.	8" water main on Parkerville Rd. from Main St. to Neary School driveway NO	3,600 ft	$240,000
8.	12" water main on Central Street from Boston Road to Learned Street NO	1,600 ft	$118,400
9.	8" watermain on Middle Road between Mt.Vickery Road and Route 9 NO	1,700 ft	$113,900
		Total	*$1,992,300*

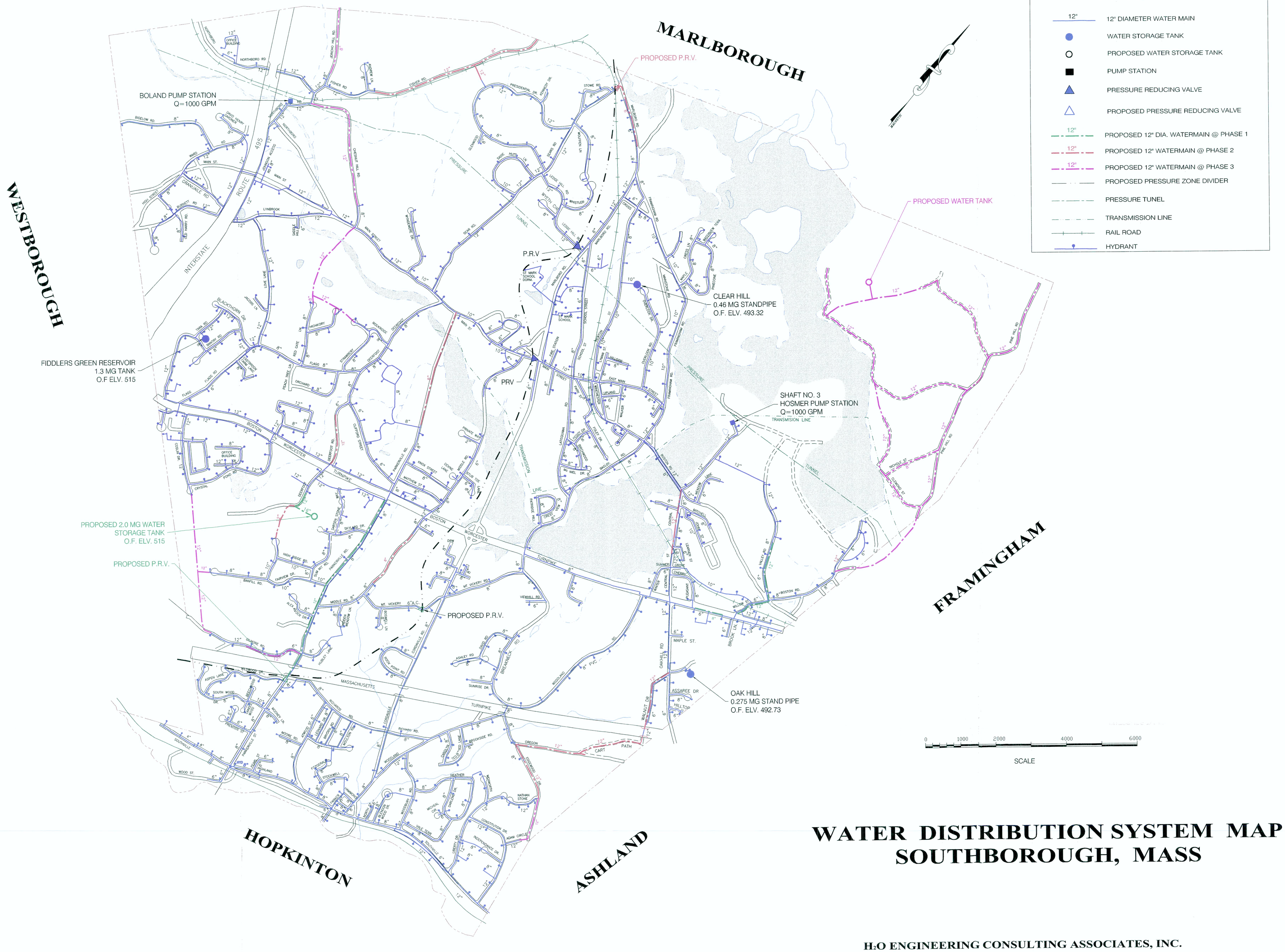
Appendix



EXISTING WATER DISTRIBUTION SYSTEM MAP SOUTHBOROUGH, MASS

H₂O ENGINEERING CONSULTING ASSOCIATES, INC.

MARCH, 1998



WATER DISTRIBUTION SYSTEM MAP
SOUTHBOROUGH, MASS

H₂O ENGINEERING CONSULTING ASSOCIATES, INC.

MARCH, 1998