CDM

Town of Exeter, New Hampshire

Public Works Department Water System Evaluation Study

January 2002

Report

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January 31, 2002

Mr. Keith R. Noyes
Director of Public Works
Town of Exeter
Ten Front Street
Exeter, New Hampshire 03833

Subject: Final Water System Evaluation Study

Dear Mr. Noyes:

CDM is pleased to present this final report on our Water System Evaluation Study.

CDM is grateful for your assistance and that of your staff throughout this project. We especially thank Mrs. Victoria Del Greco, Water/Sewer Superintendent, Ms. Jennifer Royce, Town Engineer, Mr. Robert Kelly of the Water/Sewer Advisory Committee, and Mr. Tony Calderone, Chief Water Treatment Plant Operator.

This report was prepared by CDM staff under the general supervision of Mr. Edward Nazaretian, Officer-in-Charge. I served as Project Manager. Mr. Alan LeBlanc and Ms. Julie Simonton served as Project Engineers.

Very truly yours,

Jeffrey E Diercks

Jeffrey E. Diercks, P.E.
Associate
Camp Dresser & McKee Inc.

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JEFFREY
E.
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Contents

Appendices

Tables

Figures

Executive Summary

In early 2000, Town officials recognized the need for a comprehensive evaluation of the water system to provide a master plan for future system improvements. Among the factors that led to this decision were the following:

- Operational experience has demonstrated that the current water system is vulnerable in many ways. Recent concerns have included flooding problems at the water treatment plant (WTP), water main breaks that may be related to pressure surge problems, inadequate fire flows, aging piping, and a lack of redundancy of certain key system components.

- Continued development in Exeter, particularly in the water system extremities, is placing additional demand on the water system, and is exacerbating existing low-pressure concerns in some areas.

- Additional public health regulations are being developed under the Safe Drinking Water Act, and being implemented statewide by the New Hampshire Department of Environmental Services (NHDES). These regulations will require modifications in Exeter's water treatment facilities.

- The Town is considering significant wastewater system and roadway improvements, in addition to various water system improvements. Improvements associated with multiple utility systems need to be well coordinated, to take advantage of associated cost savings.

The purpose of this project has been to determine the necessary improvements in supply, treatment, and distribution facilities, thereby providing the Town a "road map" to guide water system capital investments over the next 20 years.

The project has been completed through a collaborative effort among Town officials and CDM. In early 2000, the Town established a Steering Committee to guide the project. Members of the Steering Committee were as follows:

- Keith Noyes, Director of Public Works
- Victoria Del Greco, Water/Sewer Superintendent
- Jennifer Royce, P.E., Town Engineer
- Tony Calderone, Senior WTP Operator
- Robert Kelly, P.E., representing the Water/Sewer Advisory Committee (and currently its Chairman)

The Steering Committee was responsible for consultant selection, and for monitoring the progress of the project. The Committee received biweekly status reports for the duration of the project, and also participated in several half-day workshops at key milestones in the project. Various other Town officials also participated in several of the workshops.

The major conclusions and recommendations of the six sections of the report are reviewed below.

1.0 Introduction

Section 1 of the report provides an overview of the major components of the water system. In this report section, Figure 1-1 shows the locations of these components, and Figure 1-2 illustrates how they work together as a system. The history of the water system from its 1885 inception to date is also reviewed.

2.0 Population and Water Demand

Section 2 of the report presents trends and projections for the population and water demand for the Town of Exeter.

Based on projections prepared by the New Hampshire Office of State Planning, the population of Exeter is projected to increase as follows:

Year	Population
2000	14,497
2010	16,657
2020	19,224

Table ES-1

Total Population Projection

The serviced population is of more interest for a water system study than the total population. Based on 1995 data, it was estimated that approximately 77% of the Town's population was served by the water system.

Projections of future serviced population, and water demands, were prepared for three alternative service areas. The three alternatives were as follows:

- Alternative 1 – Maintaining the existing service area
- Alternative 2 – Extending service throughout the area south of Route 101
- Alternative 3 – Extending service throughout the entire Town

Because the differences among the alternatives proved to be relatively small, it was decided to adopt the most conservative approach (Alternative 3) for water demand projections. The resulting projections for the planning horizon year of 2020 were as follows:

Demand Condition	Demand (million gallons per day)
Average Day	1.92
Maximum Day	3.26
Peak Hour	5.38

Table ES-2

Water Demand Projections

3.0 Water Supply Sources

Section 3 of the report presents the review of Exeter's water supply sources. Locations of the sources are shown in the report on Figure 1-1.

The Town's water supply sources are as follows:

Supply Source	Percent of Total Production (1997-2000)
Surface Water System (Water Treatment Plant) • Exeter Reservoir • Exeter River Pumping Station • Skinner Springs (in Stratham)	89%
Lary Lane Well	11%
Total	**100%**

Table ES-3

Exeter Water Supply Sources

CDM's literature search indicated that no quantitative study of the safe yield of the surface water system has ever been performed. Based on generalized area-runoff relationships, the safe yield may be approximately 6 million gallons per day (mgd). There is, however, a dam on the Exeter River in Brentwood which controls 60% of the water supply watershed. If the dam were not releasing water during low-flow conditions, then the safe yield may be approximately 2.6 mgd.

Not all of this water may necessarily be available for water supply withdrawal by Exeter, however. A number of other water uses exist, such as irrigation withdrawals, leakage or releases at the Great Dam and the dam near the WTP, and more. Quantitative information about current or future status of these uses is not available in all cases.

Nevertheless, the available information and recent operating history indicate that the available yields from the surface water system is considered adequate for Exeter's needs during the planning period of this report, provided that the dam in Brentwood does not constrain river flows during low-flow periods and that releases at the Great Dam are minor.

The Exeter River Pumping Station is in need of major renovations. The presence of only one pump and lack of standby power gives this station no redundancy, leaving the Town to rely on the Exeter Reservoir (and its poorer warm-weather water quality) when the River Pumping Station fails.

Exeter Reservoir

The Lary Lane Well was redeveloped during the course of this study, for the first time since 1977. Long-term well yields are expected to be in the 0.3-0.5 mgd range, assuming the well is redeveloped as needed. Issues related to the concentration of arsenic in this well water are of concern to Exeter as EPA has recently announced a new, stricter standard for arsenic in drinking water. This is discussed further below in Section 4.

The Exeter River Pumping Station

Exeter at one time operated two other wells located near the Exeter River Pumping Station. The Gilman Park Well and Stadium Well have not been utilized in many years. Available data regarding well yield are limited, but suggest that the total yield of the three groundwater supplies (including the Lary Lane Well) may be approximately 1.5 mgd or less. The two former wells could possibly be restored to active use in the form of satellite wells which would convey raw water to the WTP.

4.0 Water Quality and Treatment

Section 4 presents a detailed analysis of the existing water treatment plant. Waterworks facilities at the site were first developed in 1886, and the plant was last upgraded in 1993-94. Numerous deficiencies in plant equipment and reliability are documented.

Primary concerns that need to be addressed at the WTP are as follows:

- ***The WTP is vulnerable to flooding***, as demonstrated for example during Hurricane Edna in September 1954, and the October 1996 flood which forced plant shutdown for over a week. Internal flooding has also occurred due to mechanical problems. It should be noted that, even with the recent culvert improvements in Portsmouth Avenue, the WTP is still within the 100-year floodplain.

The WTP is in close proximity to the existing dam and spillway

- ***Aging equipment and facilities*** present increasing operational difficulties and cost as time goes by. Some aspects of the WTP performance are considered marginal at best; the clarification process and the chlorine contact chamber are two of the most deficient processes within the plant, as increasing water demand is already pushing these facilities to their limit. Further, out of every gallon of raw water entering the WTP, about one quart is lost as wastewater. This is a very high percentage, caused primarily by the clarification process, and affects not only the WTP but also the Town's wastewater system.

Flooding inundated the plant as a result of Hurricane Edna on September 11, 1954

- ***New public health regulations*** are being developed under the Safe Drinking Water Act (SDWA), and will force changes in WTP processes and equipment. The most immediate new regulation relates to disinfection by-products, which will be regulated more strictly starting at the end of 2001. Exeter will not be able to meet the new standards with the current facilities. Several other major regulatory initiatives are also underway, as described in Section 4.

Section 4 presents an assessment of two alternative means of addressing these concerns:

- Undertake a major rehabilitation of the existing plant. This would include process upgrades, construction of major flood protection works, a new clearwell, and many other facilities. It would be necessary to preserve normal operation of the WTP during the project.

The flood of October 20, 1996 rendered the plant inoperable for eight days.

- Construct a new WTP at a nearby site. A preliminary siting review indicates the Exeter Sportsman's Club site may be suitable. This site is owned by the Town and is adjacent to the Exeter Reservoir. Figure 4-6 in Section 4 illustrates the site. The existing plant would remain in normal service until the new WTP was ready.

After consideration of technical, institutional, and economic issues, and after several collaborative workshops, CDM and the Town have concluded that Alternative 2, a new Water Treatment Plant, is recommended.

At the Lary Lane Well, the principal water quality concern is arsenic. The well's arsenic levels have historically been considered safe, but EPA announced in October 2001 that it plans to set a new drinking water standard of 10 micrograms per liter. The well typically has slightly more than this. Exeter can continue utilizing the well for the time being as the new standard is not expected to take effect until 2006. Exeter should monitor the arsenic levels in the well on a monthly basis for the time being to determine any seasonal trends, and assess its ability to comply with the new standard. In 2-3 years, Exeter should determine if new treatment technologies appear more affordable, and determine the long-term status of the well.

Section 4 also addresses a number of issues and recommended short-term actions intended to assist in improving process control and other operational issues at the existing WTP.

5.0 Distribution System

Section 5 describes the development and use of a computer model of the water distribution system, to determine system deficiencies. The selection of remedial measures is also presented.

The key problems in the distribution system that need to be addressed are as follows:

- Based on experience during the field testing program, there are expected to be numerous closed or partially-closed valves in the distribution system, which should be opened to improve circulation and fire flows.

- The amount of distribution storage is inadequate for providing proper pressures and fire protection. Additional storage at a higher elevation would eliminate many of these problems.

- The piping network is unable to deliver the needed fire flows at a number of locations. The largest fire flow deficits are near the intersection of Main Street and Harvard Street, and along Lincoln and Linden Streets. Piping improvements are needed to correct the deficiencies.

- Pressures are inadequate at high-elevation areas in the eastern side of Exeter, along Hampton Road. Providing the additional, higher-elevation storage referenced above would address this deficiency.

- Undersized piping in the area between the Epping Road tank and the center of town causes this tank to respond slowly to changes in demands, restricts fire flows, and limits the operation of the WTP. Piping improvements would remedy this deficiency.

- The distribution system has an extensive amount of old, unlined cast iron pipe – about 14 miles, or 29% of the entire system. Some of these pipes are still providing adequate service, but some pipes are undersized by today's standards, and all such pipes represent potential water quality concerns. Of particular concern is the unusually-high amount of 4-inch diameter unlined cast iron pipe, about three miles. Such pipe cannot provide proper fire protection. A long-term pipe replacement program would eventually address these and other concerns.

6.0 Implementation of Primary Recommendations

Section 6 discusses implementation of the three primary recommendations of the study. Other recommendations, not addressed in this Executive Summary, are also listed in Section 6.

6.1 Water Treatment Plant

Proposed Construction of New Plant

CDM recommends that Exeter pursue construction of a new Water Treatment Plant to replace the existing facility. The new plant would be located outside the floodplain, would meet all current and anticipated drinking water standards, and would improve the aesthetic quality of Exeter's drinking water. The existing WTP would continue operating throughout the construction project, then would be decommissioned.

The estimated total project cost range is $16-20 million, in 2005 dollars. This includes the new plant, and modifications to the Exeter River Pumping Station, which delivers raw water to the plant.

The proposed project implementation schedule is shown on Figure 4-7. CDM recommends the Town pursue final site selection, treatment process selection including pilot treatment evaluations, if necessary, and preliminary design of the new WTP, during 2002. The cost range cited above would be refined during the conceptual design. Final design could then be initiated in 2003. Construction would occur in 2004-2005. The new plant would be on-line in late 2005 or early 2006. Delaying the schedule beyond this time frame is not recommended, due to the age and condition of the existing plant. The existing plant will experience increased operational problems over time, and continues to be threatened by flooding.

Financing of New Plant

At this time, only limited opportunities are available for securing external funding to assist in this project. The New Hampshire Department of Environmental Services (NHDES) provides low-interest loans through its State Revolving Loan Fund (SRF). These funds may be utilized by water purveyors to upgrade water systems, provided the improvements address compliance with the Safe Drinking Water Act (SDWA) and public health concerns. We expect the treatment plant project to be eligible for SRF assistance. The current interest rate is 4.464% for a 20-year loan.

The SRF program will also forgive 15-30% of the principal for "disadvantaged systems." The determination of a "disadvantaged system" is based on existing user costs, median community income, and projected water rate increases. We recommend Exeter determine to what degree, if any, it can qualify for such assistance.

For many years NHDES has provided a grant program for new filtration plants or filtration plant upgrades. This program provides a State grant for 20% of the construction cost. However, NHDES currently allows each municipality to utilize this program only once. Exeter already secured funding from this program for a prior water treatment plant upgrade.

CDM expects that, with the continuing development of new federal regulations affecting filtration and disinfection of surface water sources, many New Hampshire communities will face additional WTP upgrades or replacements in the next 5-10 years. We recommend that Exeter, perhaps in consultation with similarly affected communities, seek a modification to the 20% filtration grant program to allow communities to utilize the program a second time.

6.2 New Water Tank and Associated Water Mains

We recommend Exeter construct a new water storage tank to provide sufficient volume and pressure for fire protection, and to facilitate proper WTP operation. A privately owned site adjacent to the existing Epping Road tank appears to be the optimal location; other possible locations are discussed in Section 5.

This project would include a new 1.5-million-gallon elevated steel tank, removal of the existing Epping Road tank, addition of a tank booster station at the Hampton Road tank, and modification of the pumping units at the supply sources. In addition, about 3,800 feet of new water main in Epping Road, Cass Street and Main Street is recommended. These mains will replace old, inadequate mains, thereby improving the hydraulic connection of the tank to the rest of the water system, and also improve fire flows. The total project cost is estimated to be $4.4 million in 2005 dollars.

The new tank will significantly improve the operability of the existing and new water treatment plant. Current operation of the plant is seriously constrained by the lack of storage and by limitations in the piping network between the Epping Road tank and the center of town. It is recommended to have the new tank on-line no later than the start-up of the new water treatment plant. This would entail completing the design no later than 2004, and completing the tank construction no later than 2005.

Opportunities for external funding assistance for this project appear limited. The SRF program excludes projects related to growth or fire flow improvements. However, the SRF program does include projects involving replacement of old cast-iron main. Further, a case could be made for this project being related to the WTP project, because of the significant effects upon operability of the WTP. CDM recommends Exeter discuss these issues further with NHDES to determine the level of SRF funding that may be allowed for this project.

6.3 Long-Term Pipe Rehabilitation Program

Exeter should initiate a long-term pipe rehabilitation program to address the issue of aging, poor-condition, and undersized water mains.

The highest priorities should be areas with known fire flow deficiencies, such as the Lincoln Street School. Replacement of undersized mains (such as the three miles of inadequate 4-inch diameter pipe) and certain large-diameter, severely-corroded mains is also recommended for the early years of the program.

Such a program may require decades, to address all the mains of concern. If, for example, the Town were to attempt to address all concerns listed in Section 5 over a 20-year period, an annual appropriation of $400,000 (2001 dollars) would be needed. If Exeter were to determine that this level of funding is not achievable, we would recommend an achievable annual appropriation be set aside for this purpose. Exeter should coordinate such work with other ongoing infrastructure improvements, such as sewer, drainage, gas, or roadway work, to realize the maximum cost efficiencies.

6.4 Draft Capital Improvement Program

Figure ES-1 shows a possible sequencing of these projects. The actual schedule and amount of funding will be dependent upon the Town's upcoming deliberations and overall financial status. We understand the Town will review and modify the Capital Improvement Program based on these issues and on interrelationships with other utility programs.

Primary Projects

	2002	2003	2004	2005	2006	2007	2008	2009	2010 to 2025
1. New Water Treatment Plant	Preliminary Design $300,000	Final Design $1,700,000	Construction $18,000,000						
2. New Tank and Associated Mains			Final Design $400,000	Construction $4,000,000					
3. Long-Term Pipe Rehabilitation					Year 1 $400,000	Year 2 $400,000	Year 3 $400,000	Year 4 $400,000	Years 5-20 $400,000/year
	2002	2003	2004	2005	2006	2007	2008	2009	2010 to 2025

Notes:
1. Upper ends of report cost ranges are cited.
2. Design phase assumed to be approximately 10% of total project cost. Actual design scope and budget, and refined construction budget, to be determined after preliminary design.
3. During CIP finalization, Town should consider effects of inflation upon annual pipe rehabilitation program cost, and adjust accordingly.
4. Design phase costs include siting, permitting, preparation of construction bidding documents, etc.
5. Project costs do not include land acquisition, easements, rights-of-way, or associated legal fees.

Figure ES-1
Draft Capital Improvement Program for Primary Projects

Section 2
Water Consumption Trends and Projections

2.1 General

This section summarizes the historical production and consumption information for Exeter and describes CDM's approach for calculating projected water demands. Demand projections are essential to planning water system expansion, determining future water supply needs, and developing a water supply improvement program.

Future water consumption was estimated using historical and projected population growth, areas of expected population growth, and existing and anticipated land use. Additionally, the projected population growth and locations of growth were compared to the existing water system service boundaries. Alternative water service boundaries were developed to evaluate the impact of expanding the current water system.

2.2 Town Historical and Projected Population

2.2.1 Historical Population

Historical population data was based on estimates provided by the US Census and the New Hampshire Office of State Planning (OSP). As shown in Table 2-1, the historic growth in the Town has slowed from an average rate of 2.2% per year in the 1970s to an average of 0.7% per year between 1990-1995. However, this 0.7% figure is an average rate for the 1990s and not representative of the recent growth in Exeter. There was very little growth in the early part of the 1990s, due to the recession, and the growth rate in the later part of the decade has been closer to historic growth rates.

Year	Population Estimate	Percent Change (per year growth rate)
1970	8,892	-
1980	11,024	2.2% (1970-1980)
1990	12,481	1.2% (1980-1990)
1995	12,899	0.7% (1990-1995)

Table 2-1

Historical Population Data

2.2.2 Population Projections

The New Hampshire Seacoast Area has experienced significant growth over the past few years, including the Town of Exeter. In 1999, Exeter issued the largest number of building permits on record (622). The construction boom is expected to continue, with new residential and commercial developments planned for 2000. The widening of Route 101 to a four-lane highway and the proposed train station, with connections to Portland, ME and Boston, are also anticipated to contribute to future growth within the Town.

CDM has discussed Exeter's development with Town Planner and the Rockingham Planning Commission (RPC). They concur with the OSP population projections, which anticipate the current growth rate to continue into the future. There are significant areas of land available for both commercial and residential development. It is anticipated that the Route 101 project will spur commercial growth along Epping Road, sections north and south of the highway. Additional residential development is anticipated along Kingston Road, Pickpocket Road, and Hampton Road. Table 2-2 summarizes the future Town population through the twenty-year planning period of this project.

Year	OSP Population Projection	Population Growth (per year)
1995	12,899[1]	-
2000	14,497	2.4% (1995-2000)
2010	16,657	1.4% (2000-2010)
2020	19,224	1.4% (2010-2020)

[1] Population estimate

Table 2-2

Population Projections

The work presented in this report section was completed and approved before the 2000 Census results were available. The 2000 Census estimated the population of Exeter to be 14,058 people. This is within 440 people of the OSP population projection. Therefore, because both projections are so close, it was considered reasonable to retain the original population estimate of 14,497 as the basis for population projections.

2.3 Current and Future Serviced Population

There are several small public water systems located outside of the Town's water service area. The New Hampshire Department of Environmental Services (DES) has encouraged cooperation and planning between small public water systems and larger water utilities. Therefore, the populations projections above were further refined to estimate the effect of the Town's growth on the existing water service area and the effect of extending the water system to service the smaller systems. The potential impact was evaluated under three alternatives:

Alternative 1:
Maintenance of the current service area, 'base case';

Alternative 2:
Water service area extended to all areas south of Route 101, plus a limited commercial area north of Route 101, near the Epping Road interchange;

Alternative 3:
Water service area extended to the entire Town.

Figure 2-1 illustrates the Town's historical population and the projected population growth for each of the three service alternatives.

2.3.1 Current Service Area

Population estimates and projections for the existing water service area were based on 1995 OSP population estimates for the entire Town. This year was selected as the basis for population projections because the Town's Geographic Information System (GIS) mapping is based on aerial photography from 1995. Estimates of the households served by the water system were generated from OSP population data and the GIS mapping.

The OSP estimates that there were approximately 12,899 residents in the Town of Exeter in 1995. Additionally, there were estimated to be 2.39 people per household, which corresponds to approximately 5,400 households within the Town. Based on existing zoning and land use patterns within Exeter, it was assumed that all buildings located outside of the water system boundaries were residential buildings (minor adjustments were made to account for buildings that were known to be non-residential, such as the Public Works Complex). Using the GIS information, it was estimated that approximately 4,100 households were serviced by the water system in 1995. This corresponds to a serviced population of approximately 9,780 (based on 2.39 people per house), or 77 percent of the Town's population. Therefore, approximately 1,300 households, corresponding to 3,100 people, were not served by the Town's water system. Of the areas not served by the water system 1,070 households were located south of Route 101, including approximately 730 households within the Sherwood Forest and Lindenshire mobile home parks. These parks are located within the current water service area; however, they rely on private wells for water supply. There are approximately 230 unserviced households located north of Route 101. Table 2-3 summarizes the current population estimates.

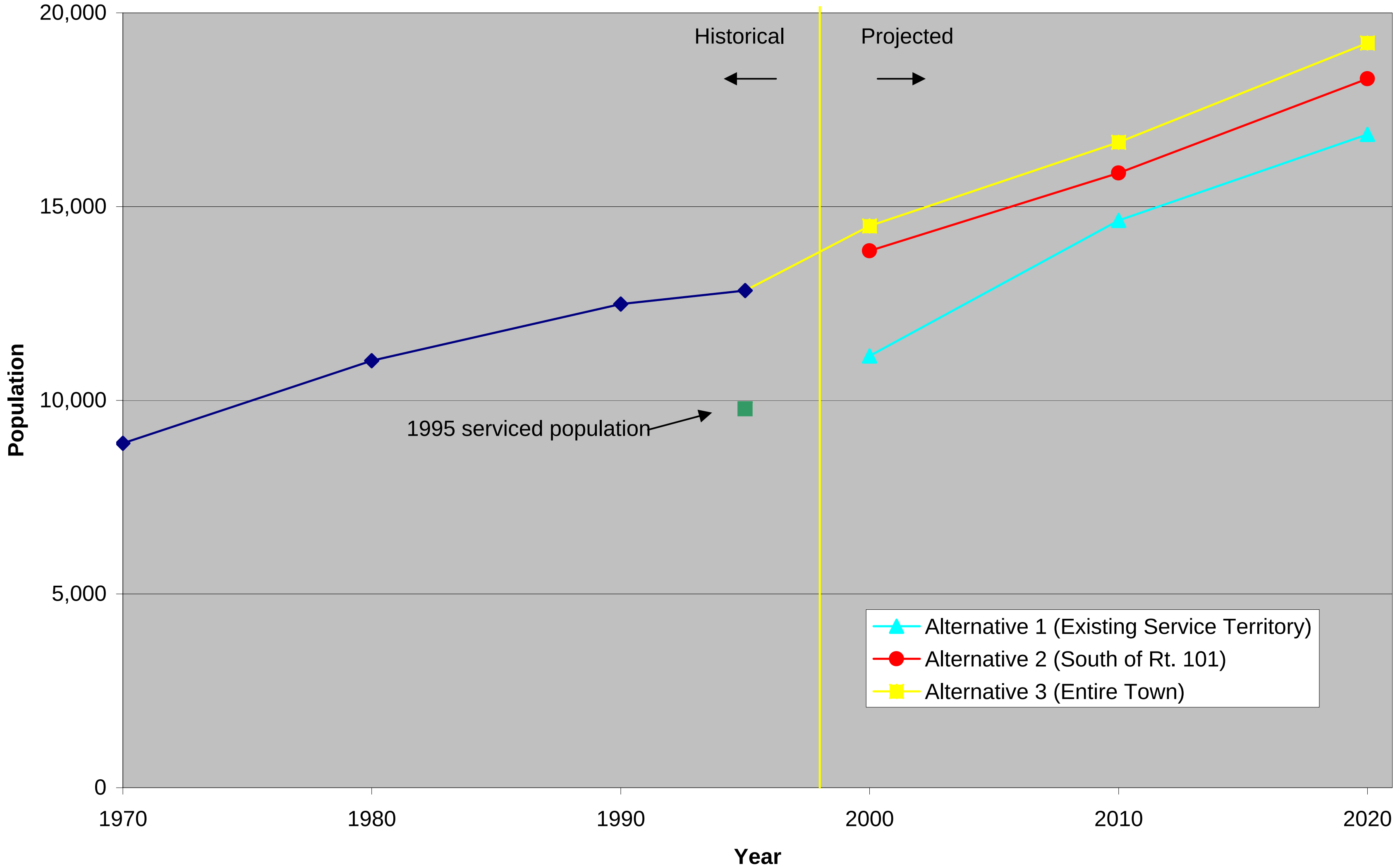


Figure 2-1
Historical and Projected Population

CDM

Alternative	No. of Households	Population[1]
Alternative 1: Existing service area	4,090	9,775
Alternative 2: Service south of Rt. 101		
Sherwood Forest/Lindenshire	720	1,721
Additional residential households	357	853
Total (Alternative 1 plus additional areas)	5,170	12,349
Alternative 3: Entire Town		
Area north of Rt. 101	230	550
Total (Alternative 2 plus additional areas)	5,397	12,899

1 Based on OSP household estimates of 2.39 people per household

Table 2-3

Water Service Area Current Population Estimates

2.3.2 Alternative 1 (Existing Service Area)

Alternative 1 represents the maintenance of the current water system boundaries.

There is limited land available for new residential development within the existing water service area. However, significant residential growth may result from the conversion of existing industrial/commercial facilities to multi-family residential establishments, specifically in the High Street and Lincoln Street areas. The new train station, and the improved access to Boston, is anticipated to attract new residents into Exeter and increase the housing demand in the downtown area (which is within walking distance of the train station). This is expected to result in the conversion of some of the older commercial/industrial buildings in the Lincoln Street area to multi-family residential units. This area is currently zoned commercial, however, discussions with the Town Planner indicate that this area will likely be re-zoned to permit multi-family development. Additionally, the area along High Street is desirable because of its proximity to Route 101. This is expected to result in a gradual conversion of existing commercial facilities to residential. The zoning in this area (residential and neighborhood professional) allows for the conversion of commercial establishments to residential use.

It is also anticipated that commercial/industrial growth in this area will primarily result from re-development of existing establishments. For example, new, larger commercial establishments may replace the existing businesses along Portsmouth Road. Additional commercial development is also expected along Epping Road and Industrial Drive, currently zoned for commercial and corporate technology development.

Philips-Exeter Academy is currently the Town's second largest water user (Section 2.4) and owns a significant amount of undeveloped land within the water service boundaries. Based on discussions with the Academy, it is anticipated that the number of faculty and students will remain the same over the twenty-year planning period of this study. Future capital improvement projects at the Academy are anticipated to focus on the renovation of existing buildings rather than construction of new facilities. Additionally, there are no plans to either sell or develop the area that is currently undeveloped. Therefore, the future water use by the Academy is expected to remain constant over the twenty-year planning period of the study.

The Lindenshire and Sherwood Forest mobile home parks are located within the water system boundaries; however, they rely on private wells for their water supply. The mobile home parks do have a connection to the Town water system, in the event of an emergency. It is anticipated that the mobile home park may abandon their existing private wells in the future and utilize the Town water system. Therefore, for the purpose of population projections, the mobile home park has been included in the residential population estimates for the future, years 2010 and 2020. Table 2-4 summarizes the projected population growth for the area evaluated under Alternative 1.

Area	Residential Population			
	1995	2000	2010	2020
Existing Service Area	9,775	11,146	12,923	15,146
Sherwood Forest/Lindenshire MHP	-	-	1,721	1,721
Alternative 1 Total	**9,775**	**11,146**	**14,644**	**16,867**

Table 2-4
Alternative 1: Population Projections

2.3.3 Alternative 2 (Extending Service South of Route 101)

Alternative 2 represents extending the water system to serve all areas south of Route 101 and to serve a limited area of commercial development just north of Route 101, along Epping Road.

There are large parcels of land available for residential development near Kingston, Pickpocket, and Brentwood Roads. Therefore, it is anticipated that this area will continue to experience residential growth through the twenty-year planning period of this study. Additional residential development is also expected near Hampton Falls Road.

The widening of Route 101 is expected to result in extensive commercial development along Epping Road, both north and south of the highway. The easy highway access and the available land are anticipated to attract national retail chains and other industry. Significant land is available along Epping Road and Continental Road for commercial and industrial development. These areas are currently zoned for commercial and corporate technology park development.

Table 2-5 summarizes the projected residential population growth for the existing service area and additional residential areas south of Route 101. The limited area north of Route 101 was not included in the population projections because this area is zoned commercial.

Area	Residential Population			
	1995	**2000**	**2010**	**2020**
Existing service area	9,775	11,146	12,923	15,146
Sherwood Forest/Lindenshire	1,721	1,721	1,721	1,721
Currently unserviced area south of Route 101	853	992	1,221	1,433
Alternative 2 Total	**12,349**	**13,859**	**15,865**	**18,300**

Table 2-5
Alternative 2: Population Projections

2.3.4 Alternative 3 (Extending Service to Entire Town)

Alternative 3 represents extending the water system to serve all areas within the Town, including the area north of Route 101. This is also an area where residential growth is anticipated to occur through the twenty-year planning period of the study, particularly in the area of Watson and Beech Hill Roads. The available land and proximity to Route 101 are projected to spur additional commercial development along the western portion of Epping Road. Epping Road is zoned commercial from the intersection of Route 101 to Beech Hill Road, the portion west of Beech Hill Road is zoned residential. Discussions with the Town Planner indicate that this section will likely be re-zoned to allow for commercial development in the future.

Table 2-6 summarizes the projected residential population growth for the entire Town: the existing service area, residential areas south of Route 101, and residential areas north of Route 101.

Area	Residential Population			
	1995	2000	2010	2020
Existing service area	9,775	11,146	12,923	15,146
Sherwood Forest/Lindenshire	1,721	1,721	1,721	1,721
Currently unserviced area south of Route 101	853	992	1,221	1,433
Currently unserviced area north of Route 101	550	638	792	924
Alternative 3 Total	**12,899**	**14,497**	**16,657**	**19,224**

Table 2-6

Alternative 3: Population Projections

2.4 Water Consumption Rates

2.4.1 Approach

CDM reviewed water production and consumption records from 1997-1999 to estimate historical water usage and project future consumption rates. This time period was selected because production information from both the treatment plant and Lary Lane Well was readily available. Table 2-7 summarizes the average and maximum day demand for 1997-1999; well production records were not readily available for prior years. Average day demand is defined as the yearly average consumption of water during a twenty-four hour period. Maximum day demand is the largest volume of water produced in a twenty-four hour period, which generally occurs in the summer. A maximum day peaking factor is defined as the ratio of the maximum day demand to the average day demand.

The average day demands were higher in 1999, as compared to previous years. The hot, dry summer, continued development within the water service area, and the construction activities associated with the Water Street Area Sewer Separation Project and the Route 101 widening project may have contributed to the higher water use in 1999.

A maximum day peaking factor of 1.7, representing the peaking factor in 1998, will be used for future maximum day demand projections. A peak hour factor is defined as the ratio of the maximum hourly water demand to the average day demand. Data on Exeter's peak hour demand was not readily available; therefore, a peaking factor of 2.8 will be used for future peak hour projections, based on standard factors from other communities.

Month	Average Day Demands (mgd)		
	1997	1998	1999
January	0.80	0.89	0.96
February	0.85	0.89	0.96
March	0.81	0.87	0.92
April	0.87	0.93	1.01
May	0.88	0.98	1.11
June	1.09	1.00	1.41
July	1.17	1.08	1.35
August	1.10	1.15	1.20
September	0.95	1.11	1.13
October	0.91	1.04	1.02
November	0.85	0.92	1.00
December	0.86	0.94	0.98
Total (gallons)	340,000,000	360,000,000	397,000,000
Average Day (mgd)	0.93	0.99	1.09
Maximum Day (mgd)	1.38	1.66	1.75
Date of Max. Day	29 July	10 August	7 June
Peaking Factor	1.48	1.69	1.61

mgd = million gallons per day

Table 2-7

Historical Production Records

The per capita consumption rate was also higher in 1999 when compared to previous years, as shown in Table 2-8.

Year	Water Service Area Population	Per Capita Consumption (gpcd) [1]
1997	10,302	90
1998	10,576	93
1999	10,857	100

[1] gpcd: gallons per capita per day

Table 2-8

Historical per Capita Consumption Rates

Due to the limited amount of water production data available and the conservative nature of water system planning, future water use projections will be based the 1999 per capita consumption rate of 100 gpcd. This is an aggregate water usage that captures commercial and institutional usages, plus unaccounted-for water. Detailed water usage records delineating residential and commercial usage were not available. Therefore, an aggregate water consumption rate will be used as the basis for future water projections. As each of the future water service areas contain zones of residential and commercial development, this aggregate consumption rate is anticipated to reasonably reflect future water demand for all service alternatives.

Records are available on the Town's largest water users. As shown in Table 2-9, the largest water users (using over 10,000 gallons/day) within Exeter currently account for approximately 33% of the Town's average daily water usage. The average use is based on billing data over the previous ten quarters (first quarter 1998-second quarter 2000).

Company	Average Daily Use (gallons)
Philips-Exeter Academy	92,000
Osram-Sylvania	32,000
Riverwood Condo	24,000
Langdon Place	22,000
First Altid Enterprises	22,000
Exeter Hospital	20,000
Norrisbrook	16,000
Marshall Farm	14,000
Exeter School District	11,000
Deep Meadows Park	11,000
Total	**364,000**

Table 2-9

Largest Water Users

Figure 2-2 illustrates the projected water demand for each of the three service alternatives, summarized in the following sections.

2.4.2 Alternative 1 (Existing Service Area)

The future water demand for the existing water service area will be projected using the aggregate water consumption rate of 100 gpcd and the residential population estimates established in Section 2.3. An aggregate consumption rate will capture the increased demand from residential growth projected in the Lincoln Street and High Street areas and the commercial/industrial growth projected along Portsmouth Ave. and Epping Road. Table 2-10 summarizes the projected future water use if the current water service boundaries are maintained.

Year	Population	Projected Demands (mgd)		
		Avg. Day	Max. Day	Peak Hour
2000	11,146	1.11	1.89	3.11
2010	14,644	1.46	2.48	4.09
2020	16,867	1.69	2.87	4.73

Table 2-10

Future Water Demands - Alternative 1

2.4.3 Alternative 2 (Extending Service South of Route 101)

The future water demand for the area south of Route 101 and the commercial area north of Route 101 will be projected using the aggregate water consumption rate of 100 gpcd and the residential population estimates established in Section 2.3. The aggregate consumption rate captures the increased demand from residential growth projected along Kingston, Brentwood, and Pickpocket Road areas and the commercial/industrial growth projected along Epping Road.

Table 2-11 summarizes the projected future water use if the water system is expanded to serve all areas south of Route 101.

Year	Population	Projected Demands (mgd)		
		Avg. Day	Max. Day	Peak Hour
2010	15,865	1.59	2.70	4.45
2020	18,300	1.83	3.11	5.12

Table 2-11

Future Water Demands - Alternative 2

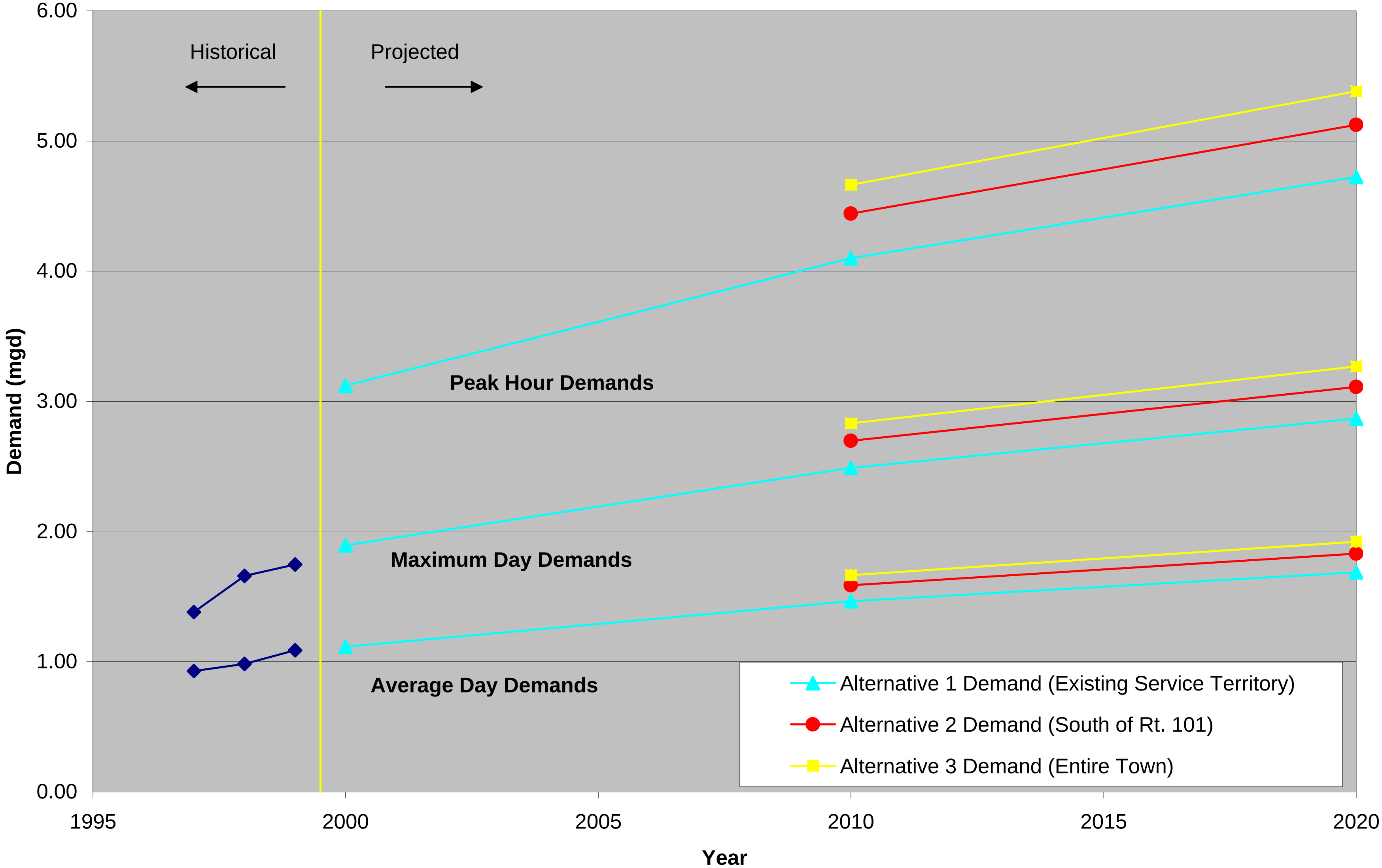


Figure 2-2
Historical and Projected Water Demand

CDM

There are several small public water supplies are located south of Route 101. Table 2-12 summarizes the small water systems that may utilize the Town's water supply if the current service area is expanded.

System	Address	Service Area
Pickpocket Woods	Pickpocket Road	28 residential homes[1]
Louisberg Circle	Route 111-A	22 residential homes[1]
Exeter Health Care	Alumni Drive	institutional
Building Block School	Kingston Road	institutional
Montessori School	Newfields Road	institutional
Chetman Company	Hampton Road	commercial
Exeter Public Works	Newfields Road	institutional
Green Gate Camping Area	Court Street	seasonal
Exeter Elms Family Campground	Court Street	seasonal
Black Bear General Store	Kingston Road	commercial

[1] number of household determined using GIS mapping

Table 2-12

Community Water Systems - South of Route 101

2.4.4 Alternative 3 (Extending Service to the Entire Town)

The future water demand for the entire Town will be projected using the aggregate water consumption rate of 100 gpcd and the residential population estimates established in Section 2.3. The aggregate consumption rate captures the increased demand from residential growth projected along the Watson and Beech Hill Road areas and the commercial/industrial growth along the western portion of Route 101. Table 2-13 summarizes the projected future water use if water service is provided to the entire Town.

Year	Population	Projected Demand (mgd)		
		Avg. Day	Max. Day	Peak Hour
2010	16,657	1.67	2.84	4.68
2020	19,224	1.92	3.26	5.38

Table 2-13

Future Water Demands - Alternative 3

There are several small public water supplies are located north of Route 101. Table 2-14 summarizes the small water systems that may utilize the Town's water supply if the current service area is expanded.

System	Address	Service Area
Exeter Highlands	Watson Road	19 residential homes[1]
Beech Hill Mobile Home Park	Beech Hill Road	28 residential homes[1]
Unitil Service Corp.	Epping Road	commercial

[1] Number of household determined using GIS mapping

Table 2-14

Community Water Systems - North of Route 101

2.5 Unaccounted-for Water

Unaccounted-for water is the difference between the amount of water that is produced and the amount of water that is billed. Unaccounted for water includes water lost through leakage, fire fighting, hydrant flushing, tank overfilling, unmetered bulk water sales, lawn watering in Town parks, and meter slippage. Unaccounted-for water can be a significant component of water use and, depending on its cause, can result in a substantial loss of revenue to the utility.

This section presents the results of an audit of Exeter's water consumption. A water audit determines the current amount of unaccounted-for water, and also recommends future actions to reduce or maintain the unaccounted-for water percentage. As part of this process, Exeter contracted with Moore & Kling, Inc. of Northborough, Massachusetts, to perform a leak detection survey of the entire water system. The work was presented in a report titled "Comprehensive Leak Detection Survey Report", dated August 21, 2000. The results are summarized below.

2.5.1 Current Unaccounted-for Water

Table 2-15 summarizes the volume of water the Town produced in 1999, the volume of water the Town billed in 1999, and leakage detected in the summer of 2000 by Moore and Kling. The Town has a staggered quarterly billing cycle for the three meter districts (i.e., bills are issued in January for District 1, February for District 2, etc.). To compare source production and metered consumption, the quarterly bills for each district were broken into an average monthly consumption. The average monthly consumptions for each district were totaled to determine the yearly metered water consumption.

Type	Volume of Water	Percent
Total Metered Consumption	336,000,000 gal. (0.92 mgd)	84.4%
Leakage	1,600,000 gal. (0.004 mgd)	0.4%
Unaccounted-for Water	60,400,000 gal. (0.17 mgd)	15.2%
Total Source Production	**398,000,000 gal. (1.09 mgd)**	**100%**

Table 2-15

Unaccounted for Water

Assuming the leaks are repaired, Exeter's unaccounted-for water is approximately 15%. Typically, unaccounted-for water can be limited to approximately 10%-15% of the total water produced. Based on the results from the Moore and Kling Report, correctable leakage from pipes, hydrants, services, and valves accounts for only a small percentage of the total unaccounted-for water.

2.5.2 Controlling Unaccounted-for Water

Although the results of the water audit do not indicate an unusually high percentage of unaccounted-for water, a number of actions could be taken by the Town to reduce the percentage, or at least ensure that it does not rise in the future. Suggestions are presented below.

Future Water Audits:
CDM recommends the Town perform an annual water audit. Metered consumption data can be compared to water production data on an annual basis to determine any increase in unaccounted-for water.

Future Leak Detection Surveys:
Should the future unaccounted-for water percentage appear to increase, the Town may wish to perform another leak detection survey to identify leaks that originate after August 2000. Even if no such increase is apparent in future years, CDM recommends that a leak detection survey be performed at regular intervals. Other water utilities which perform regular leak detection surveys have selected intervals ranging from as little as every two years, to as much as every five years or more. We suggest an interval no greater than every four years, and more frequently if possible.

Master Meter Calibration:
During the course of this work, a technician calibrated the instrumentation at the Town's supply source master meters. A full-meter calibration check is recommended, to determine if the master meters are registering accurately. We recommend this be performed as soon as possible, as this is the largest potential source of unaccounted-for water for Exeter.

Consumer Meter Accuracy:
Underregistration of consumer meters is a common problem as those meters age. As part of the upcoming distribution system evaluation during this project, CDM will be

reviewing Exeter's consumer metering program and recommending any appropriate enhancements.

Tank Overflows:
Instrumentation or valving problems can cause storage tanks to overflow, increasing the unaccounted-for water percentage. Any recurring such problems related to storage facilities should be corrected as soon as possible after they are identified. CDM is not aware of any such problems affecting the 1999 water demand data.

Backflow to Water Supply Wells:
Check valves in well pumping stations can malfunction, allowing distribution system to backflow into the well when the well pump is not operating. The facilities should be checked periodically to ensure this is not occurring. Such checks can include listening for noise of water entering the well, and measuring water levels in the well before and after closing an isolation valve in the pumping station.

Hydrant Usage:
Water used through hydrants is generally unmetered, increasing the unaccounted-for water percentage. The Town may wish to estimate the water utilized during hydrant flushing programs and fire fighting, to adjust the unaccounted-for water percentage in future audits. Unless there have been major fires, however, such water use is generally less than 2% of the total. Water utilized during construction projects can also contribute to unaccounted-for water. For example, in 1999, the Water Street Area Sewer Separation Project and the Route 101 Widening Project were ongoing in Exeter. The Town may wish to require contractors to meter and pay for water utilized during construction. Such figures could then be utilized to adjust the unaccounted-for water percentage.

Other Unmetered Usage:
Other unmetered usage may occur through legal or illegal connections. Legal connections may include, for example, irrigation water for Town facilities. The Town could install meters on all municipal service connections and read them annually, if it were desired to account for this water use. Illegal connections are extremely difficult to identify, and such work is generally not warranted unless the unaccounted-for water percentage is high and other remedial measures have been exhausted.

Unavoidable Leakage:
Some minor leakage cannot readily be detected remotely and is generally not considered economical to attempt to detect or repair. This unavoidable leakage, however, is generally considered to be under 1% of a system's total production.

2.6 Recommended Water Demand Projection

CDM and the Town have determined to utilize, for this study, Alternative 3 (extending service to the entire Town) projections, which represents the highest demands of the alternatives evaluated. The differences among the alternatives are relatively small, and this selection represents a conservative approach to water system planning.

The life of water system facilities such as supply sources, storage tanks, and water mains extend considerably beyond the twenty-year planning horizon of this report, justifying the conservative approach.

Section 3
Water Supply Sources

3.1 Current Supply Sources

Exeter derives most of its drinking water from the Water Treatment Plant on Portsmouth Avenue. The Water Treatment Plant (WTP) treats raw water originating from three sources:

- Exeter Reservoir (also known as Dearborn Reservoir or Water Works Pond)
- Skinner Springs
- Exeter River

The Town also produces water from the Lary Lane Well.

The following table shows the total water produced from the WTP and Lary Lane well in recent years.

Supply Source	Production (gallons per day)			
	1997	1998	1999	2000
Water Treatment Plant	828,300 (89%)	882,200 (89%)	947,000 (87%)	912,800 (90%)
Lary Lane Well	99,500 (11%)	110,200 (11%)	139,300 (13%)	107,000 (10%)
Totals	**927,800 (100%)**	**992,400 (100%)**	**1,086,300 (100%)**	**1,019,800 (100%)**

Table 3-1
Water Production by Supply Source

The locations of these supplies are shown on Figure 1-1. Water quality data on all the supplies are in Section 4.3. The supply sources are briefly discussed below.

3.1.1 Exeter Reservoir

The Exeter Reservoir was constructed in 1886 when the waters of Dearborn Brook were first impounded. The reservoir has also been known as Water Works Pond and Dearborn Reservoir in other documents, but will be termed Exeter Reservoir herein in conformance with the official U.S. Geological Survey place name.

The reservoir has a total drainage area of about 1.7 square miles. The surface area and total volume have been cited with various figures in the available literature, as will be discussed further below.

The water treatment plant, located just below the dam, has been upgraded numerous times over the years, as listed in Section 1.3.

3.1.2 Skinner Springs

The Skinner Springs area in Stratham was developed as a supplementary water source for Exeter in 1929. The facility includes production wells, a collector well, and a 10-inch raw water transmission main to the Water Treatment Plant. The original construction included six production wells and the collector well, all at depths of 20-25 feet. The existence of one deep artesian well installed in the bedrock is mentioned in a 1935 letter in the Town's files. Weston & Sampson (1968) indicated there were eight production wells. Whitman & Howard (1986) cites six 30-inch diameter wells, two 42-inch diameter wells, and a 30-foot diameter collector well. The produced water flows by gravity from the Skinner Springs collector well to the Water Treatment Plant.

3.1.3 Exeter River Pumping Station

The Exeter River Pumping Station was constructed in 1972. It includes a single pump which conveys water to either Exeter Reservoir or directly into the Water Treatment Plant. The station is discussed in detail in Section 3.7.

3.1.4 Lary Lane Well

The Lary Lane Well was constructed in 1958. The well station delivers water directly to the distribution system after chemical addition for the purposes of disinfection and iron/manganese control. Current operating experience indicates the well yield is typically in the 0.3-0.5 mgd range. This facility is discussed in more detail in Section 3.8.

3.2 Former Supply Sources

In addition to the above-described current supplies, the Town owns two former water supply wells. The locations of these former supplies are shown on Figure 1-1. Available water quality data for the supplies are in Section 4.3. The supply sources are briefly discussed below. Their potential reactivation is discussed in Section 3.9.

3.2.1 Gilman Park Well

According to Weston & Sampson (1968), the Gilman Park Well was constructed in 1951 as a 51-foot deep, 24-inch diameter well. The well screen was 5 feet long. The well was reportedly abandoned in 1959 due to increasing iron content, and taste and odor problems originating from hydrogen sulfide which causes a characteristic "rotten-egg" odor. No construction log, soils log, or original pumping test information could be located in Town files.

3.2.2 Stadium Well

The Stadium Well was constructed in 1963. It is a 36x24-inch diameter, gravel-packed well. The depth of the well is cited as 54 feet on the construction log, then again on the same log as 59 feet. The latter value appears more likely to be correct. The well screen is a 15-foot long, stainless steel screen, with a 0.120-inch slot opening width. A soils log was not available in Town files. However, a log for test well no. 84-18, installed adjacent to the Stadium Well, was available. This log shows a clay layer extending from 5 to 22 feet below grade, with sand and gravel below the clay to a depth of 49 feet at which point the drilling ceased. The lateral extent of the clay layer is unknown.

At the time of the 1968 Weston & Sampson report, the well was in use, but that report noted elevated iron levels and traces of hydrogen sulfide. The 1984 test well sampling showed elevated iron and manganese levels. By the time of the 1986 Whitman & Howard report, the well had "not been in operation for a number of years". That report goes on to state, "The well casing at the Stadium well is not sealed and has been completely submerged by several feet of standing water resulting in unacceptably high bacteria counts." The 1963 construction log does indicate the presence of a concrete seal, but it appears the Town and Whitman & Howard had reason to believe the seal was not intact as of 1986.

3.3 Surface Water Supply Source Yield

3.3.1 Prior Statements on Yield

The safe yield of a surface water system is affected by many factors, including but not limited to the following:

- Drainage area
- Volume of storage
- Water surface area
- Activities at upstream dams along rivers and streams
- Other withdrawals from, or imports to, the drainage basin

No prior studies of surface water system yield could be located in Town files. Many documents, however, have historically made statements about the yield of the surface water system. Key examples are noted below:

- Safe yield of Exeter Reservoir watershed, 0.3 mgd (<u>Weston & Sampson</u>, 1968).
- Safe yield of Exeter River, 3.5 mgd (<u>Weston & Sampson</u>, 1968, citing <u>Whitman & Howard</u>, 1961), though it is stated that industry had some water rights to river.

The available documents did not state any methodology or basis for the yield estimates. It appears these figures pre-date the mid-1960s drought, which is the drought of record in this area.

3.3.2 Dams on the Exeter River

For the purposes of this study, there are three dams of interest on the Exeter River. The Great Dam, located in the center of town just downstream of Route 108, creates the impoundment from which the River Pumping Station withdraws water for diversion to the WTP. Below Great Dam, the river changes its name to the Squamscott River and becomes tidal. The Pickpocket Dam is located at the Exeter/Brentwood town line. Both these dams are visible on Figure 1-1, and both are owned by the Town. Farther upstream, near the Brentwood/Fremont town line, is the privately-owned Exeter River Hydropower Dam. The owner is listed on a NHDES website as Mr. Paul T. Phillips.

The Great Dam, the Pickpocket Dam, and a former dam site known as King's Falls located downstream of Pickpocket Dam, were acquired by Exeter in 1981. Documents related to the acquisition are included in Appendix B. Exeter's acquisition of the dams and of the water rights to the Exeter River was subject to continuation of the rights of several other parties. First, the State of New Hampshire retained rights related to construction, maintenance, and control of a fish ladder and weirs at each dam. These ladders are currently in operation, and provide anadromous fish with access to upstream spawning areas. Second, the owners of the manufacturing buildings at the Great Dam retained rights to an existing flume or pipeline which conveys water through the buildings, for fire protection purposes.

Information on the operation and legal rights of the Exeter River Hydropower Dam was not located as part of this project. Downstream of this dam, at the Haigh Road bridge in Brentwood, lies the Exeter River's only streamflow gauge. Data for this gauge are available at the following website link:

http://water.usgs.gov/nwis/discharge?site_no=01073587

The U.S. Geological Survey placed this gauge into operation in June 1996. We note, however, that very low flows have already occurred on three occasions in this short period of record. Flows of approximately one cubic feet per second (cfs) appear during the periods August-September 1996, August-October 1997, and September 1999. These values are quite low considering that the drainage area to the gauge is 63.5 square miles. Flows in the nearby Lamprey River were more than double these values (on a cfs/sq. mi. basis) during the worst days of the mid-1960s drought. Thus the dam may be constraining flows in the river during low-flow periods. This is potentially significant to Exeter's water system, as this dam controls flow from about 60 percent of Exeter's water supply watershed.

3.3.3 Safe Yield

For this report, generalized watershed yield curves were utilized for a discussion of safe yield of the Exeter River/Reservoir system. These curves were developed by the New England Water Works Association (NEWWA) based on analysis of several drainage basins in New England, and include the effects of the mid-1960s drought. The curves express the safe yield of a watershed as a function of drainage area, reservoir storage volume, and water surface area.

Drainage areas were taken from U.S. Geological Survey mapping and records. The following areas were used:

Drainage Basin	Area (sq. mi.)
Exeter Reservoir	1.7
Exeter River, upstream of Great Dam, plus Area No. 1 above	108.0
Same as Area No. 2 above, minus the area upstream of the Hydro Dam in Brentwood	47.2

The reservoir surface area has been cited as 25 acres (Weston & Sampson, 1968), and as 18-26 acres (U.S. Army Corps of Engineers, 1980). The Corps' range depended upon whether one was considering the normal pool elevation with stoplogs in place (18-acre area) or the area if water reached the top of the dam (26-acre area). The 18-acre figure was utilized herein.

Establishing a storage volume for use in the review was more problematic. For this purpose, the active storage volume is of interest, rather than total storage. Active storage volume of a reservoir is less than total storage volume, because some of the reservoir's volume lies below the intake, and some is not high enough above the intake to overcome intake system headlosses and allow sufficient inflow to the WTP. No reliable estimates of active storage volume appear in the literature. Further, no bathymetric surveys to determine actual, current reservoir volume (including the effects of siltation over the years) are available.

The Corps' 1980 inspection report gives the following total capacities for the reservoir:

Elevation Site	Elevation (Feet above MSL)	Volume in Acre-Feet (Mil Gal)
Top of dam	24.65	117 (38)
Normal pool, stoplogs in place	22.95	79 (26)
Spillway crest	20.95	52 (17)

Depending on the hydraulic characteristics of the intake and WTP, the active volume of the reservoir could be quite limited. A range of 10-25 MG was utilized herein.

Based on the foregoing, the following safe yields are derived from the NEWWA yield curves:

Drainage Basin	Safe Yield (mgd)
Exeter Reservoir	0.2-0.25
Exeter River, upstream of Great Dam, plus Area No. 1 above	6.0
Same as Area No. 2 above, minus the area upstream of the Hydro Dam in Brentwood	2.6

Not all of the safe yield of the Exeter River/Reservoir system is necessarily available for water supply withdrawals, however. The following factors could, at least in theory, reduce the amount of water available for water supply during a low-flow situation, either now or in the future:

- ***Withdrawals from upstream water supplies***, such as those operated by the Town (Lary Lane Well) or by the Sherwood Forest mobile home park. Based on an estimated serviced population of 1,700, and an assumed average consumption of 75 gallons per capita per day, the average withdrawals from the mobile home park wells would be approximately 0.13 mgd.

- ***Withdrawals from the river by the Academy***, including irrigation and ice rink condenser usage. The Academy estimates that the irrigation use is less than 20,000 gallons per day. The condenser usage is based on the season. From late June through August, up to 1.5 mgd may be utilized. At other times much less water is used. All ice rink condenser water is returned to the river.

- ***Withdrawals by the High School for irrigation usage***. According to Mr. Richard Wendell of the High School, the usage is about 8,000 gallons per day. Mr. Wendell indicated that this usage would be ceased if necessary because of a Town water supply deficit.

- ***Leakage or releases at Great Dam*** including releases through the fish ladder, and leakage or releases at the dam by the WTP.

- ***Water usage by the buildings near Great Dam***, in accordance with their prior rights which were preserved during the sale to the Town.

For some of the above factors, little quantitative information about current or future water quantities is available at this time.

3.3.4 Comments on Surface Water Supply Adequacy

In Section 2 of this report, the 2020 water demands for the Exeter water system were projected on both an average day and a maximum day basis, and for several alternative service areas. In addition, examination of historical records shows the average summer demand, namely the period June through August, can be about 20% above the average day demand. The projected 2020 demands are thus as follows:

Projected Demands	Alternate 2 [1] (south of Rte. 101)	Alternate 3 [1] (entire Town)
Average Day Demand	1.83 mgd	1.92 mgd
Average Summer Day Demand	2.20 mgd	2.30 mgd
Maximum Day Demand	3.11 mgd	3.26 mgd

(1) See Section 2

Comparing these demands to the safe yields cited earlier leads CDM to suggest that the surface water system yield may be considered adequate for the Town's water supply needs during the planning period of this report. This statement is conditional upon the Exeter River Hydro Dam in Brentwood not constraining flows in the river during severe low-flow events, and upon there being no more than minor releases at the Great Dam during droughts.

Note that some additional water supply is available from groundwater and Skinner Springs, to supplement the surface water yields above. Yields from these supplementary supplies are discussed below.

CDM recommends Exeter perform additional work to refine the safe yield estimates for the surface water system, and to verify and control the impacts of other withdrawals upon the Town's ability to withdraw water for water supply purposes during low-flow events.

3.4 Yields of Other Supplies

Yields for Exeter's other supply sources have been cited in prior literature.

In their 1968 report, Weston & Sampson stated that the safe yield of Skinner Springs was 0.125 mgd. Recent discussions with Town officials suggest that the current yield may be in the 0.05-0.10 mgd range.

The Lary Lane Well's original installed pumping capacity was 0.72 mgd in 1958. Weston & Sampson's 1968 report gave a safe yield of 0.65 mgd. After the 1977 redevelopment of this well, the revised well capacity was stated to be 0.45 mgd. In their 1986 report, Whitman & Howard said the pump capacity was "about 0.80 mgd". A new pump was installed during the 1992 improvements program, and the shop drawings from that work cite a pumping capacity of 0.50 mgd. Current operating experience suggests that yields are in the 0.3-0.5 mgd range.

We recommend an annual test of this well's specific capacity. This will allow the Town to monitor the well's condition over time and determine the need for future redevelopment efforts. The Town has considered the possibility of an annual maintenance agreement with a drilling contractor, which would include such testing.

The Gilman Park Well's safe yield was given as 0.44 mgd (Weston & Sampson, 1968). A later report, however, gave the capacity as 0.25 mgd (Whitman & Howard, 1986). Both reports were prepared many years after the well was last used in 1959.

The Stadium Well's installed pumping capacity in 1963 was 0.86 mgd. No estimate of safe yield, nor any discussions of actual operating yield, could be located in the literature.

Adding the highest yield figures on record for all three wells gives a maximum combined capacity of 2.1 mgd for these facilities. Based on available operating information in the literature, such a yield likely could not be sustained for any significant duration. A figure of 1.5 mgd, or possibly less, is more realistic for planning purposes.

3.5 Proposed Instream Flow Rule

The Rivers Management & Protection Program (RMPP) was established by the Legislature in 1988. Under this program's regulations, local Conservation Commissions, watershed associations or other interested parties may nominate river segments to be included in the program. The Legislature must accept the nomination for the river to be included. Over a dozen rivers or river segments have been designated to date.

The Exeter River was nominated and accepted into the Rivers Management & Protection Program in 1995. The designated segment starts at the river's headwaters at the Route 102 bridge in Chester and extends downstream to the river's confluence with Great Brook. The downstream extent of the designated segment is shown on Figure 1-1. The remaining reach of the river, from Great Brook to Great Dam, is not in the RMPP.

The State of New Hampshire is currently in the process of establishing regulations designed to protect the instream flow of these designated rivers. The purpose of these regulations will be to protect river ecosystems from certain effects of river withdrawals especially, though not exclusively, during low-flow events.

The draft Instream Flow Rules have been proposed and re-proposed on several occasions since 1990. The most recent revision was released by the Department of Environmental Services (DES) in June 2001. These regulations would address water withdrawals not only from the designated rivers, but also from wells and surface waters within 500 feet of the designated reaches unless it could be shown (in the case of a well) that the river and aquifer are not hydraulically connected.

Based on the currently-designated river segment and on the proposed 500-foot set-back distance, none of Exeter's water source facilities would be affected by the Instream Flow Rule. The Instream Flow Rule could only ever affect Exeter's water supplies if either of the following occurred:

- If the designated reach were extended downstream to Great Dam, in which case the River Pumping Station would be affected. It is also possible that this would affect all three wells. Note, however, that because of the clay layer between the river and aquifer at the Lary Lane Well, it might be possible to demonstrate that the river and aquifer are separated at this location, and that the Instream Flow Rule should therefore not apply to the well. As discussed earlier, the soil log for test well no. 84-18 adjacent to the Stadium Well indicates about 17 feet of gray clay near the ground surface, so a similar argument may be possible there. We do not have a soil log for the Gilman Park Well, and thus cannot comment on the situation there. Note, however, that the full lateral extent of the clay layer is unknown, and this could have a significant effect on the feasibility of any argument regarding hydraulic separation.

- If the 500-foot setback were increased to 1,000 feet or more, in which case the Lary Lane Well could be affected. This well is about 900 feet from part of the currently-designated river segment.

The Instream Flow Rule would also apply to operation of dams on the Exeter River within the designated reach. The Great Dam would not be affected, but the Town-owned Pickpocket Dam and the privately-owned Exeter River Hydro Dam would be under the jurisdiction of the rule. However, if a dam functions as a run-of-the-river dam, releasing as much water as its impoundment receives, then the dam may be considered exempt from the rules. It is possible, depending on the final rules, that the Exeter River Hydro Dam may be required to operate in a way to eliminate any impact on the river during low flow events, which may be of benefit to the Town's water system.

We recommend that Exeter continue to follow the development of the Instream Flow Rule, and meet with NHDES to determine the impact of the rule upon operation of the Pickpocket Dam and Exeter River Hydro Dam.

3.6 Other Potential Supply Sources

3.6.1 Sand-and-Gravel Wells

The most recent exploration program for sand-and-gravel wells was performed by D.L. Maher Co. in 1982-1984 and summarized in their 1984 report. This study included test well drilling in two main areas. Five wells were installed near the Brentwood town line just south of Route 101 in 1982. About twenty wells were installed in southeastern Exeter in 1984, at sites within about a half-mile of the town line. The sites extended from a point just west of Route 88 to a point just west of Drinkwater Road.

The most favorable locations tested were near Drinkwater Road, as shown on Figure 1-1. After extensive testing, Maher concluded that the area may be capable of yielding an additional 1 mgd. Note, however, that all lands in the area were private property. The land east of Drinkwater Road was known as the Collishaw property, while the land west of Drinkwater Road is owned by Phillips-Exeter Academy. Water quality appeared satisfactory, though long-term increases in iron and manganese are always a possibility. The reason that further work was not pursued by the Town at that time is not known.

Based on our review of the literature, including published U.S. Geologic Survey reports, the area near Drinkwater Road is clearly the most promising sand-and-gravel well site within Exeter. Just west of the Exeter line in Brentwood lie extensive sand-and-gravel deposits oriented in a north-south band, as shown by the gravel pits and sandpits illustrated in this area on Figure 1-1. This area may also be promising for sand-and-gravel well development and has been recommended in the past for testing. However, its distance from the existing distribution system, and its location in another town, make it less favorable than the already-tested Drinkwater Road area.

3.6.2 Bedrock Wells

Bedrock wells have been utilized increasingly as municipal water sources since the late 1970s, when the fracture trace method for locating high-yield bedrock wells was developed. In this method, bedrock fractures are identified from remotely-sensed images, and mapped. Areas where several prominent fractures intersect may be favorable for groundwater development.

Exeter was one of the earliest towns in New England to attempt a bedrock well exploration study (D.L. Maher, 1984). This work included a geophysical evaluation and test bedrock well drilling. Five bedrock test wells were installed. Four did not warrant further consideration, but one was test pumped at 100 gallons per minute. This site is located just north of Route 101 as shown on Figure 1-1. This preliminary result was encouraging and may indicate potential for a municipal-sized wellfield in this general area, but was not pursued further at the time.

If the Town were to pursue bedrock wells further, a revised fracture trace analysis would be warranted as these techniques have continued to improve since the Town's 1984 project. Such analysis, supplemented by further field investigation, could possibly locate more-favorable sites than those tested in 1984. It should be noted, however, that finding bedrock wellfield sites with capacities greater than 1 mgd is extremely unusual, even when using these techniques. If a site of 0.5-1.0 mgd capacity can be located, this is considered a very successful program, but there is no guarantee of success in such programs. Typical testing program budgets for bedrock test well work may be $150-300,000.

3.6.3 Other Surface Water

The possibility of additional surface water development was considered in studies in the early 1960s, and summarized in Weston & Sampson's 1968 report. One alternative included construction of a new dam upstream of the Pickpocket Dam, to provide additional storage. Such construction would be located partly within the Town of Brentwood, and would flood parts of that town. Another alternative was to divert water from the Lamprey River, whose closest approach to Exeter is in Newmarket. Another was a regional approach utilizing the Bellamy Reservoir, Portsmouth's primary water source, but the Portsmouth system does not currently have excess capacity.

None of these alternatives would be considered feasible today, for economic and institutional reasons. Note that it is virtually impossible to obtain permits for new surface water reservoirs today, due to the significant environmental impacts. Desalination of water from the Squamscott River would be technically feasible, and the economics of desalination have improved in recent years, but the nearby presence of the wastewater treatment plant discharge renders this option undesirable.

Surface water augmentation does not appear to warrant further examination.

3.7 Exeter River Pumping Station

The Exeter River Pumping Station was designed and constructed between 1972 and 1974. It is located on the eastern bank of the Exeter River, near the Stadium Well. The station discharges flow to a single, 12-inch diameter pipeline running northerly toward the water treatment plant (WTP) on Portsmouth Avenue.

The ¼-mile access road to the station is entered via a locked gate off High Street, and passes through land owned by Phillips-Exeter Academy. Town of Exeter staff report that this access road is not always maintained during the winter.

3.7.1 Process, Mechanical, and Operations Evaluation

The station features the following equipment:

- Intake pipeline, manually-actuated sluice gate, and stationary water screen.
- One vertical turbine pump, rated for 1,400 gpm at 140 ft Total Dynamic Head; equipped with inverter-duty rated, 75 hp electrical motor.
- Miscellaneous valving, piping, and appurtenances.
- Potassium Permanganate ($KMnO_4$) storage and feed equipment.

- Electrical equipment.

The majority of Exeter's source water is delivered by this facility from approximately April to November each year. The presence of only one pump and lack of standby power gives this station no redundancy, leaving the Town to rely on the Exeter Reservoir (and its poorer warm-weather water quality) when the River Pumping Station fails.

Preliminary hydraulic calculations revealed that the pump tends to operate at too high a rate, unless valves on the discharge pipeline are throttled significantly. Corroborating this, CDM discovered correspondence in the Town's files indicating that such throttling must be practiced, to avoid high amperage draw and subsequent motor failure. Throttling in this matter translates into wasted electrical costs, and is an indication that different pumps and/or variable frequency drives (VFDs) may be beneficial for this facility.

The existing permanganate feed system was added after the original station design, and consists of:

- Drums of powdered chemical in solution;
- One chemical feed pump (the same pump used to feed at the WTP head works when the Exeter Reservoir is on line);
- No operable main line flow meter to accurately and automatically pace the feeding of chemicals; and
- No secondary spill containment.

The station does not provide precise chemical dosing capability, and complete building and fire code conformance is not provided.

Town staff report that clogging of the intake screen is an infrequent occurrence and note that screen clogging can prevent flow from entering the wet well, thereby "starving" the pump. No excessive sedimentation inside the wet well has been reported. Daily water quality sampling is carried out manually inside the station. The addition of motorized intake screens, low wet well level alarm, and a sample sink would further improve operations at this facility.

CDM did not perform structural, architectural, or HVAC audits of the station. Such audits should be performed prior to any major rehabilitation to this facility. Given the age of the station, it is likely that the roof is at the end of its useful life. It is also noted that the HVAC systems are of similar age, and were not designed in accordance with modern building codes or with the knowledge that chemical feed systems would exist within this facility.

3.7.2 Electrical Systems

The electrical systems in the Exeter River Pumping Station are approaching 30 years of age and are in poor condition. There is only one 75-hp pump installed in the station. The following deficiencies were identified in the electrical evaluation:

- The electrical systems are obsolete and at the brink of their life expectancy (30 years). Obtaining spare parts is extremely difficult.
- There is no provision for standby power in the station.
- Installation of an additional 75-hp pump will require an upgrade of electrical service to the station including replacing of utility transformer and main incoming service to the building.
- The station does not have a fire alarm system despite the use of chemicals. This is a violation of the current Building Code requirements.
- Electrical panels and other electrical equipment enclosures located in the station are of NEMA Type 1, suitable for dry locations only. They are corroded and in poor condition. Because of use of chemicals, enclosures of electrical equipment are required to be of NEMA Type 4X, required for corrosive areas.

The maintenance requirements to keep the equipment in service are increasing. The reliability of electrical distribution systems degrades with age and the mean time between failure rate decreases, meaning that failures of components within the system will occur more often. The availability of replacement parts becomes a major concern because the safety of the equipment degrades when non-standard parts are used in place of the original manufacturer's replacement parts. Reliability, safety, and life expectancy issues alone justify the need to upgrade the electrical distribution system in this station. A summary of electrical improvements recommended at the station is as follows:

- The electrical systems need a complete upgrade to accommodate the electrical load of an additional pump and motor. Replace utility transformer and overhead line with system rated sufficiently for the specified pump sizes.
- Install standby power.
- Install main service circuit breaker and auto-transfer switch, and provide electrical panels and other electrical equipment enclosures located in the station being of NEMA Type 4X.
- If process requirements dictate, install Variable Frequency Drives with bypass starters.
- Provide a Fire Alarm System in the station.

- Install new interior and exterior lighting.

3.7.3 Summary

A comprehensive overhaul of the Exeter River Pumping Station is recommended. This renovation would include installation of a second pump, replacement of the existing pump which is over 25 years old, an electrical upgrade, new valving, installation of a pre-oxidizing chemical feed system, and fire alarms. Costs for such work are included in Section 4. Structural, architectural, and HVAC audits of the station should also be performed prior to any major rehabilitation to this facility.

3.8 Review of Lary Lane Well Facility

The Lary Lane Well was constructed in 1958. It is a 94-foot deep, 24x18-inch diameter gravel-packed well. The well screen is 15 feet long, installed from 79 to 94 feet deep. The screen slot opening width is 0.080 inch for the top five feet, and 0.120 inch for the bottom ten feet. The screen is made of Everdur, an alloy consisting of 96% copper, which was a common and effective well screen material before stainless steel became the industry standard. The screened sediment formation is gravel, but this aquifer is capped by a 40-foot-thick clay layer, extending from ten feet to 50 feet below ground surface.

Wells lose capacity over time due to physical reasons (clogging by fine-grained sediment), chemical reasons (precipitation of iron and manganese hydroxides in the gravel pack and well screen), and biological reasons (fouling by iron bacteria or other microorganisms). Most wells must be redeveloped periodically, a procedure which typically includes pumping and surging, and chemical treatments. Town files have records of a redevelopment effort in 1977, but as of the beginning of the current study no such efforts had apparently been conducted since. Wells which are relatively low in iron or manganese may need redevelopment every 5-10 years or so. If iron and/or manganese are high, the need may be much more frequent; such wells can require annual redevelopment.

The Lary Lane Well delivers groundwater directly into the distribution system after dosing the water with calcium hypochlorite (for disinfection) and a blended polyphosphate solution (for sequestering of iron and manganese). The facility features a masonry-block superstructure atop a subgrade basement that houses the pump's discharge piping, valving, and appurtenances. The majority of the mechanical components of the Lary Lane station were retrofitted per design documents dated December 1991. In early 2001, well redevelopment, water level instrumentation upgrades, and telemetry installation were performed to further enhance performance of this system. While it was not CDM's purpose to perform detailed structural, architectural, or HVAC audits of the Lary Lane station, we found the facility to be in generally good condition during our visits.

The Lary Lane Well is equipped with a single, 40-horsepower, constant speed vertical turbine pump. Prior to the 2001 redevelopment, the pump's discharge rate was reduced as a part of regular operations, to avoid over-pumping the well to undesirably low levels. The reduction in flow rate was achieved by throttling an 8-inch butterfly valve located on the pump's discharge pipeline. Since the redevelopment, however, Exeter has been able to operate Lary Lane with that valve fully opened, with no excessive drawdown observed.

Other notes regarding the Lary Lane Well system include:

- The station does not have a Fire Alarm System despite the use of chemicals, which is a violation of the current Building Code requirements for having a Fire Alarm System installed in facilities that store and/or dispense chemicals. Further, secondary spill containment is required, as none exists presently.

- Backup power exists at Lary Lane in the form of a propane fueled auxiliary engine, which was part of the 1991 design. Exeter reports this to be in satisfactory operating condition.

- Access to the basement-level piping gallery is a confined space operation, and requires adherence to proper safety protocol prior to personnel entry.

CDM recommends installation of a code-required fire alarm system and secondary spill containment for chemicals. Costs of such work are estimated at approximately $15,000.

3.9 Review of Groundwater Source Reactivation

The Stadium and Gilman Park Wells, the two former groundwater supplies, could possibly be reactivated for municipal water supply use.

3.9.1 Centralized Groundwater Treatment

One method of doing this would be to construct a centralized water treatment plant for these two wells and for the Lary Lane Well. Such a facility could ensure that the produced water would meet current and anticipated drinking water standards, and also ensure that Exeter's consumers would consider the water to be of high quality.

For the purposes of developing a conceptual cost estimate, the following assumptions were made:

- The new groundwater treatment plant would be constructed outside of the floodplain. Given that the two former wells are located in the floodplain and that the Lary Lane Well is not, it was assumed the Lary Lane site would be selected.

- A 12-inch raw water transmission main would be constructed from the Gilman Park Well to the Lary Lane site, to convey the produced water from the two former wells to the new groundwater treatment plant. This is the route considered in the 1986 Whitman & Howard report and which was investigated further by the Town in the following few years. The intervening land does include some wetlands, but for the purpose of the conceptual estimate, it was assumed the construction was feasible.

- Due to the age and expected condition of the two former wells, it was assumed that they would need to be replaced. Two new 16x10-inch gravel-packed wells with submersible pumps and motors were assumed. Other than the wellheads, the only above-ground facility would be an electrical and instrumentation panel in a pedestal near each well. The pedestal would ideally be above the flood elevation. We assumed the existing buildings would be removed and that no chemical addition would be provided at the wellheads.

- The centralized water treatment plant would include facilities for removal of iron and manganese, and possibly also arsenic. Chemical addition for corrosion control and disinfection would be provided. Further study would be needed to select a process, but greensand filtration was assumed for the purpose of this conceptual estimate. Greensand filtration is common in New England, is proven effective for iron and manganese removal, and can be effective for arsenic removal in some cases also.

- The combined yields of the three wells could be as high as 2.1 mgd from the available literature, but this likely could not be sustained for long periods. The combined safe yield is unknown. We assumed a combined capacity of 1.5 mgd for the purpose of this report.

The conceptual project cost estimate for the facilities described above is $6 million, in 2005 dollars. This is based on the costs of a recent CDM greensand filtration plant, and other recent pipe and well costs.

This facility alone could not meet Exeter's water demands. One of the two following scenarios would also need to be pursued to ensure that all demands could be met:

> ***Scenario 1***. The Town would abandon the surface water facilities, and would locate and develop other groundwater sources of approximately 2.5-3.0 mgd capacity. This would be necessary in order to be able to pump the maximum day demand with the largest well out of service, as is customarily recommended for groundwater systems. However, based on available information, it appears unlikely that the Town could locate and develop this much additional groundwater supply. Even if such supply were eventually proved to exist, it would most likely be found in multiple locations requiring multiple treatment facilities.
>
> ***Scenario 2.*** The Town would pursue rehabilitation or replacement of the existing surface water treatment plant (see Section 4) to supply the rest of the needed demands beyond what the groundwater treatment plant could provide. However, since the surface water sources alone can meet the Town's demands for at

least the next 20 years, there seems to be little advantage to also expending the significant funds required for a groundwater treatment plant.

The concept of a separate groundwater treatment facility for these three wells thus seems to have little merit and was not considered further.

3.9.2 Raw Water Supply to Surface Water Treatment Plant

Another possibility for use of the two former groundwater supplies would be to restore them as raw water sources to the surface water treatment plant. Piping already exists for the purpose, as the wells could discharge into the same piping that conveys water from the Exeter River Pumping Station to the WTP. There is some merit in this possibility, as the WTP would thus appear to have additional reliability, and the wells would produce water low in organic content. This could result in lower disinfection byproducts in the finished water which, as discussed in Section 4, is an important upcoming regulatory consideration.

In view of the overall recommendations of this project which will be presented in Sections 4 and 5, however, CDM is recommending the Town not immediately pursue restoration of these two wells as raw water sources. The Town should, however, retain the ability to do restore them at a later date should circumstances change. The reasons for our recommendation are as follows:

- These two wells are not a necessity for Exeter to meet its water demands. The surface water system alone appears to have sufficient yield for Exeter to meet its anticipated demands during the planning period of this report.

- As will be presented in subsequent sections, major capital improvements are needed in the treatment and distribution systems. Funding these high-priority improvements will be major challenge to the Town. The Town should not attempt to include lower-priority items in the initial funding package(s), as this would increase the burden to the ratepayers.

- If Exeter ever desires to regularly sell water outside its Town limits, it is possible additional supply sources beyond the surface water system would be needed. If so, Exeter may wish the recipient town to share in the costs of bringing those sources on-line.

- The true safe yield of these two wells is not known. No hydrogeological study has ever been performed to determine the hydraulic interconnection between the groundwater system and the nearby Exeter River. The existence of a direct or indirect connection would mean that the safe yield of the wells during drought periods is dependent in part upon the river flow, which the Town can already tap. The net increase in safe yield represented by the two wells could thus be much less than their installed pumping capacity.

3.10 Recommendations

The following list summarizes the recommendations of the supply source review:

- Exeter should continue to rely on surface water sources for the substantial majority, if not all, of its demands. Replacing the surface water system in its entirety by groundwater supplies would be extremely difficult or impossible.

- Exeter should keep the Lary Lane Well in proper operating condition and use it as much as possible, provided its water quality meets federal and state standards. Use of this well is a very cost-effective means of meeting water demands. Exeter should monitor the progress of federal and state authorities as they implement the new drinking water standard for arsenic, and determine the long-term status of this well over the next few years. Assuming the well will continue operation for at least a few years, CDM recommends installation of a code-required fire alarm system and secondary spill containment for chemicals. Costs of such work are estimated at approximately $15,000.

- Exeter should retain the ability to restore the Gilman Park and Stadium Wells to service at a future time. While the benefits and expense of this work do not now appear warranted, it is always possible that circumstances could change in the future.

- Exeter should perform a hydrologic study to quantify the safe yield of its surface water supply system, especially if the Town ever desires to sell water outside its boundaries for extended periods. This study would need to include assessment of other nearby users of the Exeter River, and may also involve examination of the legal rights of other parties to the river water. If possible, the Town should develop agreements with other users for them to curtail their water withdrawals during droughts. Depending upon the desired degree of effort, the costs of such a study may be $30-40,000.

- While the NHDES's proposed Instream Flow Rule does not appear at this time to have a negative effect on Exeter's water supply system, the Town should continue to monitor the development of this rule. The rule may affect the Town's operation of its Pickpocket Dam, and could possibly also affect operation of the privately-owned Exeter River Hydro Dam in Brentwood in a way beneficial to Exeter's water system.

- The Exeter River Pumping Station is in need of major renovations. This work would include installation of a second pump, replacement of the existing pump, an electrical upgrade, new valving, installation of a pre-oxidizing chemical feed system, and fire alarms. Costs for such work are included in Section 4. Structural, architectural, and HVAC audits of the station should also be performed prior to any major rehabilitation to this facility.

Section 4
Water Treatment Plant

4.1 Introduction

The goal of this portion of the project is to identify both short- and long-term needs at Water Treatment Plant (WTP) for inclusion in the master plan and develop a prioritized, phased capital improvement plan (CIP). In conjunction with the plant-specific evaluation tasks, the following question is considered: "Will it be more beneficial in the long term to rehabilitate the existing facility or to construct an entirely new water treatment plant?"

The demand analysis in Section 2 of this report concluded that the maximum daily demand in 2020 would be about 3.3 mgd. This value is quite close to the Phase II WTP Upgrade (Contract Documents dated 1992) design criteria of 3.4 mgd. Therefore, this section will evaluate the WTP and examine its ability to produce 3.4 mgd in the Year 2020.

4.2 Safe Drinking Water Act (SDWA) Regulatory Analysis

Looking ahead to existing and future regulations is critical to long-term planning. Exeter's primary source of water is surface water, which is the focus of the following analysis of Safe Drinking Water Act (SDWA) implications on the Exeter Water Treatment Plant. Groundwater regulations were discussed in Section 3. Table 4-1, below, provides an assessment of regulatory compliance and related issues facing the Exeter water system in light of current and anticipated state and federal drinking water regulations.

Regulation	Regulation Status	Specific Provision	Exeter Status	Comments
Total Coliform Rule (TCR)	Promulgated June 1991	No greater than 5% total coliform (TC) positive in distribution system	In compliance	Compliance verified through verbal communication with Town staff
Lead and Copper Rule (LCR)	Promulgated June 1989	Lead Action Level of 0.015 mg/L and Copper Action Level of 1.3 mg/L at 90th percentile of first draw tap samples	High lead levels in mid-1990's prompted 1997 PO_4 implementation. In October 2000, >10% failed lead analysis after alternate inhibitor used.	Additional sampling recommended; Examination of PO_4 residual as phosphate suggested
Consumer Confidence Reports Rule (CCR)	Promulgated August 1998 Next CCR due July 1, 2002.	• Consumer Confidence Report to be issued to water customers annually on July 1st.	In compliance	Next CCR due July 1, 2002
Filter Backwash Rule (FBR)	Promulgated June 8, 2001 Report to State required by Dec. 2003 Compliance required by June 2004 *(by June 2006 if major modifications are required)*	• All recycle flows required to be returned to a location such that all processes of treatment system are employed. • Notification to state regarding recycling practices; collect and maintain information on an ongoing basis	• In compliance (recycle is not practiced) • Not applicable	Exeter does not currently recycle filter backwash water
Stage 1 Disinfectants/ Disinfection Byproducts Rule (D/DBPR)	Promulgated December 16, 1998 Compliance required by December 2001	Maximum residual disinfectant levels (MRDLs), disinfection byproducts Maximum Contaminant Levels (MCLs), and required removal of Total Organic Carbon (TOC) are governed by this regulation.	See Table Nos. 4-2, 4-3, and 4-4 for discussion.	WILL NOT be in compliance on 1/1/2002 – see referenced tables.
Interim Enhanced Surface Water Treatment Rule (IESWTR)	Promulgated December 16, 1998 Compliance required by December 2001	• Combined filter effluent turbidity # 0.3 NTU in 95% of samples • Maximum combined filter effluent turbidity < 1.0 NTU • Individual filter turbidity monitoring • Reporting requirements for individual filter turbidity levels	• OK • OK • In compliance • See Table 4-5 for discussion	Observations at WTP and discussion with WTP staff indicate turbidity compliance will be achieved.
Stage 2 Microbial / Disinfection Byproducts Rule (M/DBPR)	Promulgation Anticipated by May 2002 Anticipate Compliance Required by 2008-2010	• Initial Distribution System Evaluation (IDSE) required – requires selection of new sites to assure critical TTHM and HAA5 locations are captured.	• Rule features same DBP levels but for a Location Running Annual Average (LRAA). Exeter likely cannot comply without changes.	Future requirements discussed in Table 4-3.
Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)	Promulgation Anticipated by May 2002 Anticipate Compliance Required by May 2005	• A treatment technique rule, requires simultaneous compliance with M/DBPR • *Cryptosporidium, E. coli,* and turbidity source water monitoring will be required for 24 months for systems serving > 10,000 people.	• Undetermined at this time. Town has no existing data on *Cryptosporidium* to evaluate. Source water monitoring will determine which "bin" Exeter will fall into, per Table 4-6.	The 24-month monitoring will have to begin in 2003 or 2004.

Table 4-1
Surface Water Regulatory Compliance Assessment

Disinfectant Residual	MRDLG (mg/L)	MRDL (mg/L)	Compliance Based On	Exeter Status	Comments
Chlorine	4 (as Cl_2)	4 (as Cl_2)	Annual Average	In Compliance	Maximum chlorine dose at WTP reported as 2.4 mg/L
Chloramine	4 (as Cl_2)	4 (as Cl_2)	Annual Average	Not applicable	
Chlorine Dioxide	0.8 (as ClO_2)	0.8 (as ClO_2)	Daily Samples	Not applicable	

MRDLG = Maximum Residual Disinfectant Level Goal
MRDL = Maximum Residual Disinfectant Level

Table 4-2
Stage 1 Disinfectants / Disinfection By-Products Rule
Disinfectant Residual Requirements

Disinfection Byproducts	MCLG	MCL	Compliance Based On	Exeter Status	Comments
Total trihalomethanes (TTHM) • Chloroform • Bromodichloromethane • Dibromochloromethane • Bromoform	N/A 0 0 60 µg/L 0	80 µg/L	Annual Average	Would NOT be in compliance as of 12/31/01.	Per 1999 TTHM monitoring: • 4-Quarter System-Wide Average TTHM = 81.59 µg/L – LRAA's should also be examined.
Haloacetic Acids (five) (HAA5) • Dichloroacetic Acid • Trichloroacetic Acid	N/A 0 0.3 mg/L	60 µg/L	Annual Average	Would NOT be in compliance as of 12/31/01.	Per 1999 HAA5 monitoring: • 4-Quarter System-Wide Average HAA5 = 80.34 µg/L – LRAA's should also be examined.
Chlorite	0.8 mg / L	1.0 mg/L	Monthly Average	(status not verified)	Typically a byproduct of chlorine dioxide, which is not used in Exeter. Decomposition products of sodium hypochlorite, however, include chlorite and chlorate. Water should be tested for chlorite. Chlorate is not yet regulated.
Bromate	0	0.010 mg/L	Annual Average	(status not verified)	Typically a byproduct of ozonation, which is not practiced in Exeter.

MCLG = Maximum Contaminant Level Goal
MCL = Maximum Contaminant Level
µg/L = micrograms per liter = parts per billion
mg/L = milligrams per liter = parts per million

Table 4-3
Stage 1 Disinfectants / Disinfection By-Products Rule
Disinfection By-Products Requirements

Source Water TOC, mg/L	Source-water alkalinity, mg/L as $CaCO_3$			Exeter Status & Comments
	0 - 60	**> 60 – 120**	**> 120**	
2.0 – 4.0	35%	25%	15%	Town's source water features typical TOC and alkalinity levels that dictate a 45% TOC removal requirement. September 2000 sampling indicated this requirement is being met. Monthly TOC & alkalinity monitoring will be required beginning in January 2002.
> 4.0 – 8.0	45%	35%	25%	
> 8.0	50%	40%	30%	

Table 4-4

Stage 1 Disinfectants / Disinfection By-Products Rule
Enhanced Coagulation – TOC Percent Removal Requirement

In addition to the requirements listed in Table 4-1, the Interim Enhanced Surface Water Treatment Rule (IESWTR) requires strict reporting of filter turbidity exceedances. If routine measurements demonstrate any of the characteristics listed in Table 4-5, systems must report individual filter turbidity measurements within 10 days after the end of each month the system serves water to the public.

Condition Measured	Reporting Required	Follow-up Action Required
Any individual filter having a measured turbidity level > 1.0 NTU in two consecutive measurements taken 15 minutes apart	• Filter number • Turbidity measurement • Date(s) on which the exceedance occurred	• Produce a filter profile for the filter within 7 days of the exceedance (if the system is not able to identify an obvious reason for the abnormal filter performance) and report that the profile has been produced, ***Or*** • Report the obvious reason for the exceedance
Any individual filter having a measured turbidity level > 0.5 NTU in two consecutive measurements taken 15 minutes apart at the end of the first four hours of continuous filter operation after the filter has been backwashed or otherwise taken offline	• Filter number • Turbidity measurement • Date(s) on which the exceedance occurred	• Produce a filter profile for the filter within 7 days of the exceedance (if the system is not able to identify an obvious reason for the abnormal filter performance) and report that the profile has been produced, ***Or*** • Report the obvious reason for the exceedance
Any individual filter having a measured turbidity level > 1.0 NTU in two consecutive measurements taken 15 minutes apart at any time in each of three consecutive months	• Filter number • Turbidity measurement • Date(s) on which the exceedance occurred	Conduct a self-assessment of the filter
Any individual filter having a measured turbidity level > 2.0 NTU in two consecutive measurements taken 15 minutes apart at any time in each of two consecutive months	• Filter number • Turbidity measurement • Date(s) on which the exceedance occurred	Contact the State or a third party approved by the State to conduct a comprehensive performance evaluation.

Table 4-5

Individual Filter Performance Reporting Requirements of the IESWTR

As noted in Table 4-1, the upcoming Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) requires source water monitoring for Cryptosporidium. As shown in Table 4-6 below, the result of this monitoring will ultimately dictate treatment requirements to satisfy LT2ESWTR.

Bin Number	Average *Cryptosporidium* Concentration	Additional treatment requirements for systems with conventional treatment that are in full compliance with IESWTR
1	*Cryptosporidium* < 0.075 oocysts / L	No action
2	0.075 oocysts / L <= *Cryptosporidium* < 1.0 oocysts / L	1-log treatment (systems may use any technology or combination of technologies from toolbox [1] as long as total credit is at least 1-log).
3	1.0 oocysts / L <= *Cryptosporidium* < 3.0 oocysts / L	2.0 log treatment (systems must achieve at least 1-log of the required 2-log treatment using ozone, chlorine dioxide, UV, membranes, bag/cartridge filters, or in-bank filtration)
4	*Cryptosporidium* >= 3.0 oocysts / L	2.5 log treatment (systems must achieve at least 1-log of the required 2.5 log treatment using ozone, chlorine dioxide, UV, membranes, bag/cartridge filters, or in-bank filtration)

(1)The “Microbial Toolbox Components” appear in Figure 4-1 on the following page.

Table 4-6

LT2ESWTR Bin Classification Table

Microbial Toolbox Components
To Be Used in Addition to Existing Treatment

APPROACH	Potential Log Credit 0.5	1	2	>2.5
Watershed Control				
Watershed Control Program (1)	X			
Reduction in oocyst concentration (3)	As measured			
Reduction in viable oocyst concentration (3)	As measured			
Alternative Source				
Intake Relocation (3)	As measured			
Change to Alternative Source of Supply (3)	As measured			
Management of Intake to Reduce Capture of Oocysts in Source Water (3)	As measured			
Managing Timing of Withdrawal (3)	As measured			
Managing Level of Withdrawal in Water Column (3)	As measured			
Pretreatment				
Off-Stream Raw Water Storage w/ Detention ~ X days (1)	X			
Off-Stream Raw Water Storage w/ Detention ~ Y weeks (1)		X		
Pre-Settling Basin w/Coagulant	X	→		
Lime Softening (1)	→	→		
In-Bank Filtration (1)		X	→	→
Improved Treatment				
Lower Finished Water Turbidity (0.15 NTU 95% tile CFE)	X			
Slow Sand Filters (1)				X
Roughing Filter (1)	X	→	→	→
Membranes (MF, UF, NF, RO) (1)				X
Bag Filters (1)		X	→	→
Cartridge Filters (1)			X	
Improved Disinfection				
Chlorine Dioxide (2)	X	X		
Ozone (2)	X	X	X	
UV (2)				X
Peer Review / Other Demonstration / Validation or System Performance				
Peer Review Program (*ex. Partnership Phase IV*)		X		
Performance studies demonstrating reliable specific log removals for technologies not listed above. This provision does not supercede other inactivation requirements.	As demonstrated			

Key to table symbols: (X) indicates potential log credit based on proper design and implementation in accordance with EPA guidance. Arrow indicates estimation of potential log credit based on site specific or technology specific demonstration of performance.

Table footnotes: (1) Criteria to be specified in guidance to determine allowed credit, (2) Inactivation dependent on dose and source water characteristics, (3) Additional monitoring for *Cryptosporidium* after this action would determine new bin classification and whether additional treatment is required.

This figure was copied from USEPA's September 14, 2000 Signature Copy of Stage 2 M-DBP Agreement In Principle

Figure 4-1
Stage 2 Microbial/Disinfection Byproducts (M-DBP) Rule Microbial Toolbox Components To Be Used In Addition To Existing Treatment

4.3 Source Water Quality

The Town draws water from several sources, including the Exeter River, the Exeter Reservoir, Lary Lane groundwater well, and Skinner Springs. Two other wells, the Stadium and Gilman Park wells, are available but are presently inoperable. Untreated water quality, listed by source, is as follows:

4.3.1 Exeter River

The Exeter River is a low- to moderate alkalinity, slightly acidic water source, typical of sources throughout New England. Its turbidity is typically low. Iron and manganese levels in the source water dictate removal in the treatment process. The Exeter River's rural watershed characteristics add a relatively high level of organic matter and color. Table 4-7 summarizes some of the Exeter River's characteristics.

Parameter	Count (n)	Minimum	Average	Maximum
General Parameters (Based on Daily Records from April 23, 2000 to November 12, 2000)				
pH	204	6.24	6.87	7.52
Alkalinity, mg/L as $CaCO_3$	204	7.0	19.7	29.0
Hardness, mg/L	204	20.0	34.9	46.0
Turbidity, NTU	204	0.87	1.97	8.90
Temperature, °C	197	6.8	16.7	23.4
Chlorides, mg/L	204	20.0	30.4	48.0
Color (apparent color units)	204	41.0	81.5	152.0
Iron and Manganese (Special Sampling Conducted on September 20, 2000 and September 28, 2000)				
Iron (Total), mg/L	2	0.56		0.60
Iron (Dissolved), mg/L	2	0.45		0.46
Manganese (Total), mg/L	2	0.099		0.105
Manganese (Dissolved), mg/L	2	0.093		0.096
Organics (Special Sampling Conducted on September 20, 2000 and September 28, 2000)				
Total Organic Carbon, mg/L	2	6.48		7.50
Dissolved Organic Carbon, mg/L	2	6.45		6.85
UV-254, cm^{-1}	2	0.268		0.324
SUVA, L/mg-m	2	4.34		4.37

Table 4-7

Exeter River Water Quality

4.3.2 Exeter Reservoir

The Exeter Reservoir, fed from a watershed to its north and east and by the Exeter River pumping station, features many of the same water quality characteristics as the Exeter River itself.

Parameter	Count (n)	Minimum	Average	Maximum
General Parameters (Based on Daily Records from September 28, 1999 to April 22, 2000)				
pH	206	6.27	7.12	7.48
Alkalinity, mg/L as $CaCO_3$	205	14.0	23.2	29.0
Hardness, mg/L	207	32.0	49.8	76.0
Turbidity, NTU	204	1.30	2.54	10.00
Temperature, °C	207	1.9	6.5	18.5
Chlorides, mg/L	207	28.0	43.7	60.0
Color (apparent color units)	207	26.0	45.9	85.0
Iron and Manganese (Special Sampling Conducted on September 28, 2000)				
Iron (Total), mg/L	1		0.228	
Iron (Dissolved), mg/L	1		0.113	
Manganese (Total), mg/L	1		0.103	
Manganese (Dissolved), mg/L	1		0.030	
Organics (Special Sampling Conducted on September 20, 2000 and September 28, 2000)				
Total Organic Carbon, mg/L	2	6.45		6.85
Dissolved Organic Carbon, mg/L	2	6.03		6.58
UV-254, cm^{-1}	2	0.215		0.236
SUVA, L/mg-m	2	3.26		3.91

Table 4-8

Exeter Reservoir Water Quality

4.3.3 Lary Lane

The Lary Lane groundwater well provides water that is presently chlorinated, dosed with a blended polyphosphate solution, and pumped directly into the Town's distribution system. Lary Lane water features high alkalinity (buffering capacity). It has high levels of manganese and occasionally high levels of iron.

In October 2001, EPA promulgated a stricter drinking water standard for arsenic, reducing the MCL from 0.05 mg/L to 0.01 mg/L. The Lary Lane Well water's arsenic concentration typically is at or slightly above this standard. Exeter will need to monitor the arsenic levels and review developing treatment technologies over the next few years to determine the long term status of this well. EPA regulations call for compliance with the new standard in 2006.

EPA proposed regulation on radon in the Federal Register in February 1999, calling for an MCL of 300 picoCuries/liter (piC/L) and an alternative MCL (AMCL) of 4,000 piC/L. The final radon rule was sent to the Office of Management and Budget (OMB) on January 19, 2001, but did not clear OMB review before the Bush Administration took office. The radon rule was sent back to EPA for clearance by a Bush Administration official, after which it would go back to OMB. The final radon regulation is expected in 2002.

Parameter	Count (n)	Minimum	Average	Maximum
General Parameters (Based on Monthly Reports from November 1999 to October 2000, unless otherwise noted)				
pH	13	7.61	7.96	8.30
Alkalinity, mg/L as $CaCO_3$	13	83.0	104.4	110.0
Hardness, mg/L	13	50.0	109.5	130.0
Turbidity, NTU	13	0.060	0.227	0.620
Chlorides, mg/L	13	14.5	21.7	34.0
Color (apparent color units)	13	0.0	3.8	8.0
Iron (unspecified form), mg/L(1)	13	0.065	0.139	0.376
Manganese (unspecified form), mg/L(1)	13	0.141	0.239	1.263
Arsenic, mg/L (2)	10	0.006	0.010	0.015
Radon Gas, pCi/L (3)	3	690.0	723.3	760.0

(1) Typically expressed as "total" when form not specified.

(2) Per samples taken December 6, 1989, August 26, 1992, December 28, 1993 and October 16, 1995. An additional six samples, taken between December 2000 and May 2001, are also included.

(3) Per samples taken December 6, 1989, August 26, 1992, and October 16, 1995.

Table 4-9

Lary Lane Water Quality

4.3.4 Skinner Springs

Skinner Springs is a natural springs formation north of State Route 101, located in the Town of Stratham, New Hampshire. This water is presently conveyed from the source by gravity, and directed into the WTP upstream of the filtration process. It features moderate alkalinity, low turbidity, and low levels of iron and manganese.

Parameter	Count (n)	Minimum	Average	Maximum
General Parameters (Based on Monthly Reports from November 1999 to October 2000, unless otherwise noted)				
pH	15	6.60	6.88	7.30
Alkalinity, mg/L as $CaCO_3$	15	43.0	48.7	52.0
Hardness, mg/L	15	68.0	84.1	96.0
Turbidity, NTU	15	0.055	0.219	0.970
Chlorides, mg/L	15	35.5	48.3	88.0
Color (apparent color units)	14	0.0	3.4	11.0
Iron (unspecified form), mg/L (1)	15	0.002	0.055	0.114
Manganese (unspecified form), mg/L (1)	15	0.000	0.012	0.019
Arsenic, mg/L (2)	2	Not Detected (< 0.005 mg/L)		
Radon Gas, pCi/L (2)	2	580.0	840	1,100.0

(1) Typically expressed as "total" when form not specified.

(2) Per samples taken August 26, 1992 and October 16, 1995.

Table 4-10

Skinner Springs Water Quality

4.3.5 Stadium Well

Stadium Well has been out of service for many years. The last water quality sampling of Stadium Well occurred in 1989, which was the only data available for this report. Its iron content is high, as is its color. Further sampling and water quality data gathering is required for future planning for this water source.

Parameter	Result
General Parameters (Based on December 6, 1989 Sample)	
pH	6.8
Alkalinity, mg/L as $CaCO_3$	13.0
Hardness, mg/L	27.2
Turbidity, NTU	2.00
Chlorides, mg/L	18.79
Color (apparent color units)	70.0
Iron (unspecified form), mg/L [(1)]	0.400
Manganese (unspecified form), mg/L [(1)]	0.040
Arsenic, mg/L	Not Detected (< 0.005 mg/L)
Radon Gas, pCi/L	Not Detected (< 100 pCi/L)

[(1)] Typically expressed as "total" when form not specified.

Table 4-11

Stadium Well Water Quality

4.3.6 Gilman Park Well

Gilman Park Well, like Stadium Well, has been out of service for many years. The last water quality sampling of Gilman Park Well occurred in 1989, which was the only data available for this report. Its iron and manganese contents are very high, likely causing its high color. Further sampling and water quality data gathering is required for future planning for this water source.

Parameter	Result
General Parameters (Based on December 6, 1989 sample)	
pH	7.5
Alkalinity, mg/L as $CaCO_3$	199.0
Hardness, mg/L	226.0
Turbidity, NTU	50.0
Chlorides, mg/L	60.76
Color (apparent color units)	65.0
Iron (unspecified form), mg/L [(1)]	3.300
Manganese (unspecified form), mg/L [(1)]	0.550
Arsenic, mg/L	0.010
Radon Gas, pCi/L	550.0

[(1)] Typically expressed as "total" when form not specified.

Table 4-12

Gilman Park Well Water Quality

4.4 Site and Dam Evaluation

4.4.1 General

The site is generally set in a bowl-like depression, south of State Route 101, on the east side of Portsmouth Avenue. The "bowl" is formed by the higher land surrounding the WTP: the Exeter Reservoir Dam to the east, a retail plaza to the south, Portsmouth Avenue to the west, and Osram-Sylvania's property to the north. Flooding has been a major concern at this plant site, with the most recent episode occurring in October 1996. That flooding event damaged equipment and rendered the WTP inoperable for eight days.

In addition to the core project team, CDM's water resource and geotechnical dam specialists researched past dam reports and assessed the adequacy of the site itself. The conclusions and recommendations are presented in a technical memorandum and dam inspection report, respectively, which are appended to this report (Appendix C and Appendix D).

The inspection report included in Appendix D concluded that relatively minor maintenance is required in the short term. The technical memorandum in Appendix C addresses site flooding. Several major conclusions were reached in that memorandum, as follows:

- The spillway can pass the 100-year flood.
- The discharge channel (downstream of the spillway) cannot pass the 100-year flood.
- Modifications to dams require the spillway to pass the Probable Maximum Flood (PMF). The PMF flow rate of 3,870 cfs is over four times the 100-year flood flow rate. Neither the spillway, nor the discharge channel, nor the recently-installed culverts beneath Portsmouth Avenue can convey the PMF.
- An alternative to the PMF approach would be to negotiate with the State to design improvements for the ½ PMF approach. That less stringent design criteria (1,935 cfs) exceeds the 500-year flood flow rate (1,593 cfs).
- CDM, as a matter of practice, designs WTPs outside of the 100-year floodplain, and preferably outside of the 500-year floodplain. Viewed differently, even if the spillway channel were to be improved to pass the 100-year flood, there would be a 1% chance in any given year that the WTP would still flood. Furthermore, CDM would not endorse building a new WTP at the base of a dam whose spillway and outlet channel cannot pass the Probable Maximum Flood (PMF). The PMF or ½ PMF approach is therefore recommended for spillway and spillway channel retrofit.
- The ½ PMF approach, if accepted by the State, would require a <u>major</u> construction effort. As the reservoir cannot store adequate volumes, the Town would have to

make provisions for passing this flow. The scope of work to accomplish this would require the following:

- Remove approximately 25 feet of the dam (south of the existing spillway) and lengthen the existing spillway.

- Widen existing spillway channel from its existing 8-ft width to 20-ft wide. Channel would be constructed from dam to Portsmouth Avenue. Transition channel section tapering width from 55 feet to 20 feet would be required at spillway discharge. Walls would feature average height of 4 feet.

- Construct retaining (flood protection) wall between new channel and WTP. Average estimated wall height would be approximately 10 feet. This wall could be the channel wall on the south bank.

- Install additional box culverts (possibly 2 or more) beneath Portsmouth Avenue.

- If left piped to the existing discharge channel, the existing catch basin system in the WTP driveway area would allow flood water to flow from the proposed "floodwall impoundment" back to the driveway area. Therefore, construction of a stormwater pumping station would be necessary to transport drainage from the existing parking lot area into the channel and prevent backflow.

- *This item is recommended whether the WTP remains at the existing site or if a new WTP site is pursued:* The gates and stoplogs must be easy to move and remove. At lengthened spillway, install new sluice gates, stop logs, and replace existing gates and logs. Electric actuation of the gates and mechanically-assisted stop log hoists is recommended. Provide level element in reservoir. The WTP staff is urged to inspect and operate these facilities monthly.

Given the magnitude of the above-described construction, one might ask of the practical necessity for such action. In fact, some flooding frequency could be viewed by a water system as "tolerable" if all of the points below were true:

- IF loss of life in the event of a dam failure was unlikely, and

- IF customers would not be threatened through water quality risk in the event of WTP flooding and subsequent WTP contamination, and

- IF the WTP would sustain only minimal damage in the event of a flood, and

- IF there were sufficient backup systems in place to assure adequate water supply and fire protection for the Town (groundwater sources, interconnections from neighboring communities, adequate tower storage, etc.)

At the present time, none of the above "IF" bullets are true. Therefore, flooding risk at the Exeter WTP should not be viewed as "tolerable". CDM recommends action be taken to either (a) improve the existing site and WTP, or (b) abandon this site in favor of a new WTP site.

4.5 Process Evaluation

4.5.1 General

A brief process review is necessary to adequately discuss future treatment needs. Figure 4-2 is a schematic depiction of the existing WTP process.

4.5.2 Source Water Delivery / Initial Treatment

As depicted on Figure 4-2, source water may be drawn from the Exeter Reservoir, a naturally recharged water supply pond, or pumped directly into the WTP from the Exeter River. Due to the annual bloom of algae and other plant life in the reservoir during warm weather months, source water historically has been pumped from the Exeter River directly to the plant from mid-Spring through mid-Autumn. The reservoir typically supplies the plant during the remaining months.

The WTP operations feature continuous aeration of the source water around the reservoir intake. Three compressors, each rated at fractional horsepower, deliver compressed air to the reservoir. This continuous aeration is consistent with a recommendation made in Whitman & Howard, Inc.'s Report on Water Supply System for the Town of Exeter, New Hampshire, dated December 1986. The intention was to "...eliminate rapid temperature fluctuations..." and to provide for "...oxidation of iron and manganese constituents enabling plant operations to proceed with relatively constant chemical application." Given the minimal operational cost for this aeration and the likely benefit of oxidation and thermocline agitation, CDM recommends maintaining this practice *when the reservoir is feeding the WTP directly*. Aeration appears to be an unnecessary measure while the reservoir is off-line.

A challenging episode was experienced in the summer of 2000, when the Town received customer complaints of "colored" tap water. This occurred while the Exeter River was being utilized as a supply source. At the time, potassium permanganate ($KMnO_4$) was being fed only at the inlet chamber upstream of the pre-oxidation process - the $KMnO_4$ feed system at the Exeter River Pumping Station was not yet activated. Shortly after $KMnO_4$ feed system activation at the river site, finished water color and turbidity diminished significantly. This event proved the value of contact time between the oxidant ($KMnO_4$) and the source water. Dosing the oxidant solely at the inlet chamber may not have allowed sufficient time for oxidation to occur, particularly given the relatively low pH (typically below pH 8 at all points throughout the process). Operators have indicated that $KMnO_4$ is fed at the reservoir outlet when the reservoir is used as the sole source of water. This practice provides a slightly longer time for oxidation to occur.

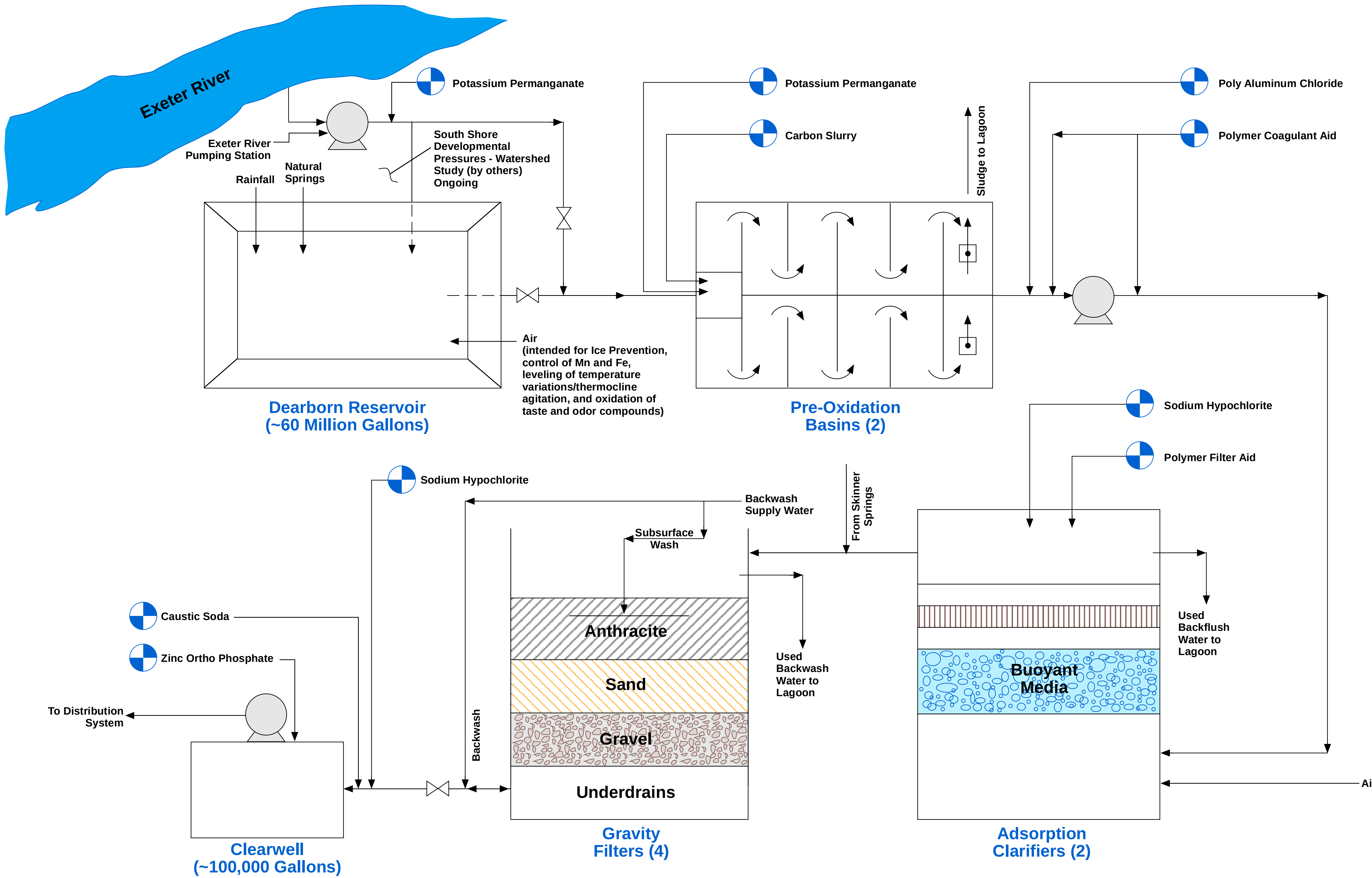


Figure 4-2
Exeter's Existing Water Treatment Facility Process

Given the Summer 2000 "color complaints" experience, it is recommended that Exeter continue to vigilantly monitor water quality through the process – regardless of the supply source being utilized - to assure adequate iron and manganese oxidation is achieved prior to entry to the distribution system.

Traditionally, the Exeter River has not been directly utilized during winter months. The reasons for this practice are based on water quality and a desire to only pump when necessary. Discussions with operations staff indicate that water is pumped from the Exeter River into the Exeter Reservoir even during the winter months when the Reservoir is feeding the WTP, in an effort to maintain adequate levels in the reservoir.

To highlight the seasonal changes in source water quality, the following example is pertinent: While utilizing the Exeter River source water in the fall of 2000, the WTP operations staff noted lower color and higher alkalinity (35 APCU and 35 mg/L, respectively) existed in the reservoir than in the River (70+ APCU and 19 mg/L, respectively). Operations staff concluded the reservoir would be easier to treat, and therefore made the seasonal source water switch on November 13, 2000.

4.5.3 Pretreatment

Water enters an inlet chamber via a 20-inch pipe at the southern end of the pretreatment building. This chamber was once used as a flash mixing chamber complete with mechanical mixer. The mixer was removed, however, when the 1992 design moved the coagulant feed point from the inlet chamber to a point just upstream of the three transfer pumps. Present operations feature the addition of potassium permanganate ($KMnO_4$) and powdered activated carbon (PAC) slurry at the inlet chamber. The following items are of interest:

- It was noted during CDM's field visits that the "pink water" (caused by highly concentrated $KMnO_4$) tended to favor flowing over the easternmost weir. This can pose a potential hindrance to good oxidation, likely caused by uneven chemical diffusion hydraulics, which may be the result of poor diffuser design/performance, unlevel/unequal weir crests, or hydraulic imbalance from the influent pipe's entry to the flash mix chamber.

- Simultaneous feeding of both $KMnO_4$ and PAC can promote a "competition" between oxidants. Because both chemicals are relatively expensive, we recommend the Town evaluate the necessity to feed both oxidants concurrently. Over-use of PAC tends to increase sludge production, as well.

From the inlet chamber, water enters two parallel pre-oxidation basins, which served as horizontal paddlewheel flocculation basins until the 1992 design improvements were constructed. A serpentine flow pattern was constructed to promote increased contact time between oxidizing chemicals and the raw water. Sludge collection equipment consists of a single pump, piped to withdraw from either basin, and to discharge to the solids lagoon. Significant findings include:

- Settled solids in the pre-oxidation basin must be periodically removed, at risk of taste and odor compound accumulation causing deleterious downstream aesthetic effects.

- There are no means by which floating scum and foam (largely an aesthetic issue) can be drawn off.

- There are no means by which the basins can be drained by gravity – a portable pump must be lowered into the basin for complete draining.

Following pre-oxidation, water is dosed with polyaluminum chloride (PACl, PC605 from the Holland Company) and a polymer "filter aid" (from Betz-Dearborn). Three intermediate transfer pumps receive flow from the preoxidation basins and deliver it into two adsorption clarifiers operating in parallel. These pumps also serve as the supply of backflushing water for clarifier cleaning. The pumps, of the vertically mounted, horizontal split case variety, reside at the bottom of what was once part of the sedimentation basins. Piping, valves, electrical valve actuators, pressure gauges, and other items of importance are located in this subgrade area, as well. Several major points are noted concerning this sub-facility follow:

- ***Operator safety*** – This area is a confined space. Standard operating procedures should not permit one operator to enter this area unattended. This can be a challenge, as the plant is often staffed with only one person. If entry to this area is absolutely necessary during a one-person shift, an on-call staffing plan should be in place to provide an attendant during entry.

- ***Accessibility*** – The means of access to the transfer pump "pit" is a vertical ladder, descending nearly 15 feet. Improved access would be highly desirable.

- ***Operational cost*** – The necessity for this intermediate pumping is examined in Section 4.6 of this report, Hydraulic Profile. It should be noted that continuous, intermediate pumping of all process water is an operational practice and expense not required at most WTPs. A fundamental design goal in WTP design is to pump as few times as possible. While the 1992 design had a technically-justifiable basis for including intermediate pumping, this remains an undesirable feature.

- ***Area Drainage*** - There are no means by which this area, if flooded, can be drained by gravity – a portable pump must be lowered into this area for complete draining.

CPC Engineering Corporation manufactured the adsorption clarifiers, known as Microfloc Trident Clarifiers. (Note that CPC Engineering was, in 1994, a Wheelabrator Technologies Company. This equipment is now carried under the USFilter Microfloc line of products.) These adsorption clarifiers combine flocculation and clarification in a single unit which contains naturally buoyant adsorption media. The clarifiers operate in an upflow fashion, discharging into fiberglass troughs near the top of the clarification basins. Clarifier flows then fall from the troughs into a common concrete channel, where sodium hypochlorite and/or filter aid polymer may be added. The channel feeds a 20-inch diameter pipe en route to the filtration process. Noteworthy observations follow:

- During CDM's one-week surveillance in August 2000, the combined turbidity of the water exiting the two clarifiers was observed to be below 1.0 NTU at all times – it was usually on the order of 0.5 NTU. This is a very acceptable turbidity for water entering the filtration process.

- Backflushing Exeter's adsorption clarifiers consumes more water than is used with conventional pretreatment. It is CDM's opinion that WTP operators are currently flushing the clarifiers at appropriate intervals. The duration of each backflushing cycle, as currently programmed into the Aquaritrol control unit, significantly exceeds what is called for in the 1994 Operations & Maintenance manual. This would indicate a substantial opportunity for waste flow reduction, although experience has shown that the longer run times are necessary to adequately clean the clarifiers, according to WTP staff.

- Backflushing occurs when a given clarifier reaches four feet of head loss. The operating run times are consistently shorter for Clarifier No. 1 (easternmost unit) than they are for Clarifier No. 2. It was noted that in the period from August 1, 2000 to August 21, 2000, inclusive, that unit No. 1 averaged 3.8 backflushes per day versus unit No. 2's average of 2.5 backflushes per day. Section 4.5.7 further examines the issue of washwater volume and handling.

- The difference in clarifier performance is likely due to the fact that Clarifier No. 1 is equipped with rolled, smooth, oval shaped media, while Clarifier No. 2 has a ground, rough, "flaky" angular media. Operations staff have stated that the different media were originally installed "...to see which one worked better, but they never came back to retrofit the worse of the two." Performance testing occurred in May 1994, shortly after these units were installed. The testing report, dated August 1, 1994, notes that the difference in media exists, but offers no comments or conclusions on performance differences. The poorer performance of Clarifier No. 1 has caused the Town to use greater volumes of wash water than would otherwise be necessary.

- The manufacturer provided a process guarantee for each adsorption clarifier unit. Each unit is warranted to produce water of a quality that will not exceed turbidity levels of 0.7 NTU (average) and 1.2 NTU (maximum) for flow rates up to 1,600 gpm (2.3 mgd). Other raw water stipulations were stated as a condition of that guarantee.

- Three blowers are in place to deliver air to scour the adsorption clarifiers. The air is delivered via PVC discharge piping. This piping has melted when all three of the blowers are inadvertently operated at once. CDM does not, as a rule, specify PVC for air conveyance – instead, stainless steel piping material is typically recommended for such applications. Furthermore, an electrical interlock could be installed to prevent unintentional operation of all three blowers at once.

- The transformer serving the pre-oxidation / adsorption clarifier building is located outdoors. Operations staff had indicated concern that maintenance access during inclement weather can be hazardous. During a site visit in August 2000, CDM's electrical engineer found no deficiencies with the NEMA classification of the enclosure, or with the equipment's location with respect to applicable electrical codes. In inclement weather, however, it is generally more desirable to have such equipment indoors.

- There are no means by which the basins can be drained by gravity – a portable pump must be lowered into the basin for complete draining.

4.5.4 Filtration

Clarified water exits the adsorption clarifiers via a 20-inch diameter pipeline, and is directed to the four rapid dual media filters. The existing filter design criteria are as listed in Table 4-13:

Table 4-13: Existing Filtration System Design Criteria

Parameter	Filter Number			
	1	2	3	4
Year Placed in Service	1993	1993	1974	1974
Bay Width, feet	12.75	12.75	20	20
Bay Length, feet	12.0	12.0	10	10
Number of Bays	1	1	1	1
Area, square feet	153	153	200	200
Max. Spec'd Loading Rate, gpm	709	709	Assumed 920	Assumed 920
Max. Spec'd Loading Rate, mgd	1.02	1.02	1.33	1.33
Max. Spec'd Surface Loading Rate, gpm/sf	4.6	4.6	Assumed 4.6	Assumed 4.6
Filter Media				
Anthracite				
• Depth, inches	20	20	20	20
• Effective Size, mm	1.0 – 1.1	1.0 – 1.1	1	1
• Max. Uniformity Coefficient	1.30	1.30	1.5	1.5
• Specific Gravity	1.60	1.60	1.55 minimum	1.55 minimum
Silica Sand				
• Depth, inches	10	10	10	10
• Effective Size, mm	0.45 – 0.55	0.45 – 0.55	0.50	0.50

Parameter	Filter Number			
	1	2	3	4
• Max. Uniformity Coefficient	1.40	1.40	1.5	1.5
• Specific Gravity	2.6	2.6	Not specified	Not specified
Support Gravel				
• Depth, inches	8	8	8	8
• Top layer	(2”) $^{1}/_{8}$” to #10 mesh	(2”) $^{1}/_{8}$” to #10 mesh	(2”) $^{1}/_{8}$” to #10 mesh	(2”) $^{1}/_{8}$” to #10 mesh
• Second layer	(2”) ¼” x $^{1}/_{8}$”	(2”) ¼” x $^{1}/_{8}$”	(2”) ¼” x $^{1}/_{8}$”	(2”) ¼” x $^{1}/_{8}$”
• Third layer	(2”) ½” x ¼”	(2”) ½” x ¼”	(2”) ½” x ¼”	(2”) ½” x ¼”
• Bottom layer	(2”) ¾” x ½”	(2”) ¾” x ½”	(2”) ¾” x ½”	(2”) ¾” x ½”
Media Installation Date	1993	1993	1974	1974
Subsurface Wash System Installation Date	1993	1993	1993	1993
Underdrain Installation Date	1993	1993	1974	1974
Backwashing System Specifications				
Low Rate Backwash Rate, gpm	1,150	1,150	1,500	1,500
Low Rate Backwash Rate, gpm/sf	7.5	7.5	7.5	7.5
High Rate Backwash Rate, gpm	2,300	2,300	3,000	3,000
High Rate Backwash Rate, gpm/sf	15	15	15	15
Low / High / Low Cycle Duration, seconds	150 / 500 / 310	150 / 500 / 310	150 / 600 /430	150 / 600 /430
Volume of Backwash Water, gallons(1)	28,000	28,000	44,500	44,500
Subsurface Wash System Specifications (per May 11, 1993 shop drawings)				
Number of Arms per Filter	1	1	2	2
Minimum Operating Pressure, psi	70	70	50	50
Flow at Minimum Operating Pressure, gpm	116	116	79	79
Flow at 100 psi, gpm	142	142	115	115

(1) Excludes volume of initially drained filter and subsurface wash usage volume.

Table 4-13

Existing Filtration System Design Criteria

CDM notes numerous items of concern related to the filters:

- The filter subsurface wash arms were observed to be moving very slowly during backwashing. It was also noted that it takes about three full minutes before solids can be observed rising out of the filters. This is much longer than desired and is inefficient (excess water is needed to remove solids). The 1994 plant operation and maintenance manual calls for the subsurface wash to be “...supplied directly by the finished water pumps and indirectly by the distribution system." It was found, however, that the finished water pumps are typically turned off during a filter backwash cycle, likely because CT requirements for disinfection would be compromised when the clearwell is depleted. The non-use of the finished water pumps causes the subsurface wash system to be supplied from the distribution system pressure only. This source of supply does not deliver a controlled flow rate or pressure. To ensure proper supply, water should be delivered to the subsurface wash arms by dedicated "slave pump(s)", or similar concept.

- The same piping connection that allows distribution system supply to the subsurface wash system also provides a pathway through which unclean water in the filter can travel to the distribution system. This is a cross-connection, which must be eliminated. A suitable reduced pressure backflow preventer (RPBP) should be installed, or the cross-connection severed completely, to meet NHDES regulations.

- Filter media inspection for all four filters is recommended, as the subsurface wash operation provides reason to believe effective backwashing is not occurring. This is advisable also because it has not been done in at least 6 years (possibly longer for Filter Nos. 3 & 4).

- By observing the water surface during filter backwashes, CDM concluded that no significant "dead spots" exist within the media. Filter No. 1 was not in operation during CDM's weeklong surveillance in August 2000.

- It is not common practice to backwash conventional filters using only flow moving upward from the underdrains. This philosophy should prompt the Town to troubleshoot the subsurface wash system or consider eventual addition of air scour capabilities to the filtration system.

- Per Table 4-13 above, it is noted that the underdrains in Filter Nos. 1 and 2 are approximately 6 years old, while the underdrains in Filter Nos. 3 and 4 are over 26 years old. Neither set of underdrains is equipped to accept air scour. Furthermore, the older underdrains are likely nearing the end of their useful lives, and should be inspected on the basis of age alone.

- It was observed that several valves in the basement piping gallery were leaking to varying degrees.

- While not required by law in the State of New Hampshire, it is noted that the Exeter WTP has no filter-to-waste (FTW) capability. Filtering to waste after a backwash cycle is a practice recommended to "ripen" the newly-cleaned filter media before placing the filter back into service. This "ripening" protects the public from "turbidity spikes" known to occur shortly after a filter is returned to service. CDM observed the turbidity spike phenomenon in Exeter after filters were returned to service, and therefore recommends filter-to-waste be included in long-term WTP planning.

- The backwash supply pump motors were observed to be leaking motor oil.

- The backwash supply pumps were not observed to operate in an alternating use mode.

- The filter console set points indicated Filter Nos. 3 and 4 were to receive a high rate wash of 3,000 gpm, but process values registered no more than 2,420 gpm. CDM confirmed that the backwash supply pumps' nameplates indicate the ability to deliver 3,000 gpm. CDM reviewed older documentation, and found that the 1994 Operations and Maintenance Manual states (on page III-2) that the backwash supply venturi flow meter possesses a 0-2,300 gpm measurement range, which is adequate for the smaller filters (Nos. 1 and 2) but not for the larger filters. The same document (on page III-6) calls out 2,300 gpm as the high rate backwash rate. Again, this is not consistent with the 3,000 gpm design criteria identified elsewhere. It is possible that the 4-20 mA flow meter signals correspond to a 0-2,300 gpm range, or that the flow element supplied was the wrong unit for the application. The cause of these discrepancies should be investigated. If it were found that the backwash supply system was delivering only 2,300 gpm to Filter Nos. 3 and 4, inadequate filter backwashing may be occurring.

- Even after the above-noted troubleshooting is completed, Exeter's high rate backwash, 15 gpm/sf, is still suspected to be inadequate for warm water conditions. The typical recommended rate for Exeter's media is 21 to 22 gpm/sf. The goal of dual media filtration and backwashing system design is to provide unmixed, stratified media layers. Stratification allows the coarsest media to remain at the top of the filter bed, with finer layers beneath, allowing floc to be captured at several levels within the filter. Inadequate backwash rates can prevent media from being stratified. Unstratified media can act as monomedia, which can tend to capture floc atop the media, creating shorter filter run times – rendering the filter less effective than a properly stratified dual media filter.

- Filter No. 3's loss of head meter needs to be bled after completion of each backwash to remove captured air.

4.5.5 Disinfection and Disinfection Byproducts (DBPs)

4.5.5.1 Disinfection

Disinfection is practiced through the use of free chlorine, provided in the form of liquid sodium hypochlorite (NaOCl) solution which is dosed as the filtered water enters the clearwell.

The Surface Water Treatment Rule (SWTR) establishes drinking water regulations requiring filtration and/or disinfection of surface water supplies. The SWTR mandates at least a total 99.9 percent (3-log) inactivation of *Giardia* cysts and 99.99 percent (4-log) inactivation of viruses. Exeter's conventional filtration system receives 2.5-log inactivation credit for *Giardia* cysts, and 2-log inactivation credit for viruses. This means that the disinfection in the clearwell and finished water pipeline (between the WTP and the first tap, which happens to be the WTP's own tap) must provide the remaining 0.5-log inactivation of *Giardia* cysts and 2-log inactivation of viruses. The inactivation credit achieved by disinfection is determined using "CT", calculated as:

> The time "T", in minutes, that the disinfectant has come into contact with the water
>
> Multiplied by The disinfectant residual "C", in mg/L, measured at the end of the contact time.

The required CT values are specified in separate SWTR tables for *Giardia* and for viruses, and are dependent on (1) the disinfectant type, (2) disinfectant residual concentration, (3) pH, and (4) temperature.

The clearwell structure, over 13 feet in depth, was constructed under the 1972-1974 work. Baffles were installed in the clearwell per the 1992 design documents, to increase the disinfectant/water contact time ("T"). A baffling coefficient of 0.7 was assigned to the Town's clearwell for CT calculation purposes, based on NHDES approval. The clearwell's present high water set point is at a depth of 11.5 feet, which translates to a volume of just over 89,000 gallons. At the time of CDM's August 2000 WTP inspection, the low water set point was 3 feet, below which 23,000 gallons is stored.

Exeter's relatively small clearwell poses a challenge to meeting these disinfection requirements. As previously noted, finished water pumping does not occur during a filter backwash, to ensure consumers receive adequately disinfected water. Concerned over the low water set point's adequacy for satisfying CT requirements under all conditions, CDM issued a letter dated September 27, 2000 to the Town, to provide further guidance to assure CT requirements are met during all conditions. That letter is appended to this report in Appendix E.

A conservative approach to clearwell sizing involves accounting for CT requirements at maximum plant flow rate under "worst case disinfection conditions" (i.e., cold water, low chlorine dose, high pH) plus adequate filter backwashing storage volume. A conservative design criterion is to provide filter backwashing volume equal to that required to wash each of the filters one time. The combined CT plus filter backwash volume would be nearly 223,000 gallons, well in excess of the existing approximate 89,000-gallon capacity. From these analyses, CDM concludes greater clearwell capacity is required.

Looking forward to future *Cryptosporidium* monitoring (and subsequent, possible treatment requirements), the need for alternative disinfection systems must be planned for. Alternative disinfectants may include ozone, ultraviolet light, or chlorine dioxide. The results of future *Cryptosporidium* monitoring and process pilot testing will more clearly define Exeter's future disinfection requirements. Existing site constraints may pose significant challenges to implementing such technologies.

4.5.5.2 Disinfection Byproducts (DBPs)

The Town's monitoring of Disinfection Byproducts (DBPs) has revealed that concentrations of Total Trihalomethane (TTHM) and the suite of five Haloacetic Acids

(HAA5) will exceed the upcoming requirements of the Stage 1 D/DBPR, as noted in Table 4-3. This may be due to one or more of the following factors:

- TTHM precursors, primarily natural organic matter (NOM), can be indicated by Total Organic Carbon (TOC) levels. Chlorine, in combination with NOM, can react to form TTHM's. The Town's September 20, 2000 and September 28, 2000 monitoring revealed that approximately 3 mg/L of TOC typically remains in the finished water. The TOC removal as a percentage was over 50% on both days, which satisfies one portion of the Stage 1 D/DBPR, as indicated in Table 4-14. While it would be desirable to lower the finished water TOC further, it appears Exeter is removing TOC on a percentage basis as well as could reasonably be expected.

- The chlorine residual at the WTP is somewhat high, as compared with industry standards. On September 27, 2000, the Town decreased the residual from 2.4 mg/L to 1.6 mg/L. Town staff have stated that chlorine residual would be lost in parts of the distribution system if a residual less than 1.6 mg/L was provided.

Action will have to be taken to lower the DBP levels. Chloramines, or other options, should be investigated. The following table lists potential solutions to DBP non-compliance:

CDM recommends the Town take the following steps with regard to disinfection and DBP reduction:

- Evaluate effects of moving the pH adjustment point from the entry point to the exit point of the clearwell. This would allow disinfection to occur at lower pH, where disinfection would be more effective. It may promote some reduction in DBP's as well.

- Conduct a chloramines study (as secondary disinfectant) before implementation of chloramination. The study would precede implementation, which may involve a temporary, trailer-mounted ammonia feed system designed per the findings of the study.

- Re-evaluate frequency and quantity of sodium hypochlorite (NaOCl) chemical orders, and examine finished water in distribution system for chlorite and chlorate. CDM noted that sodium hypochlorite (NaOCl) is stored at the Exeter WTP for relatively long periods of time. In addition to losing its strength over time, NaOCl degradation can potentially form chlorite, and eventually the more harmful chlorate.

Potential Solution	Exeter's Status
1. Remove Organic Precursors	
a. Carbon ❑ PAC ❑ GAC	 ❑ Available and often utilized, little precursor removal effect realized. ❑ Requires retrofit of filters or construction of GAC contactors
b. Coagulation	Already >50% (45% EPA goal)
c. Enhanced Coagulation	Acid addition needed to lower coagulation pH. Lowering pH will have adverse impact on manganese removal.
2. Destroy Organic Precursors	
a. Preoxidation ❑ $KMnO_4$ ❑ Ozone	 ❑ Available and utilized, but insufficient organic precursor destruction benefit realized ❑ Requires major plant upgrade
3. Change System Operations / Management	
a. Increase reliance on water sources featuring less organic precursors	Significant groundwater source development would be required
4. Change Disinfection Practices	
a. Decrease Cl2 dose and/or contact time	Already at minimal levels; CT requirements govern
b. Alternative primary disinfectant ❑ Chloramines ❑ Chlorine Dioxide ❑ Ozone	 ❑ Not enough contact time ❑ Moderate plant upgrade; Disinfection Byproducts may be of concern ❑ Major plant upgrade
c. Alternative secondary disinfectant ❑ Chloramines	 ❑ Addition of ammonia; relatively low cost; relatively easy to implement

Table 4-14
Potential Solutions to DBP Non-Compliance

4.5.6 Final pH Adjustment and Corrosion Control

Sodium Hydroxide (also known as NaOH, or "caustic soda") is presently dosed upon entry to the clearwell, to adjust pH for corrosion control. The Town also currently utilizes zinc orthophosphate (SLI-321 from Shannon Chemical Company) as a corrosion inhibitor. This chemical is added just upstream of the finished water pumps, and, according to the manufacturer's literature, is said to form "a highly resistant zinc orthophosphate film on potable water distribution system piping and on other plumbing materials (lead and copper)".

The Town consistently delivers finished water at pH 7.2 to 7.4. CDM contacted the chemical supplier on September 22, 2000, who stated that their SLI-321 chemical performs best at pH levels between 6.5 and 7.8. Shannon Chemical believes the Town's typical pH level of 7.3 (+/-) is acceptable.

The Town's October 2000 round of lead and copper sampling revealed non-compliance with the Lead and Copper Rule. This is the first event since 1997 where Exeter did not satisfy the Rule's requirements. Perhaps not coincidentally, this was also the first event where Exeter practiced reduced monitoring – a relaxation of sampling requirements granted to systems with a history of compliance. The Town is encouraged to pursue the following steps to correcting this "non-compliance":

- Examine zinc orthophosphate residual concentrations in distribution system. Data reviewed by CDM revealed typical phosphate concentrations greater than 1 mg/L. It is not specified on Town data sheets if this is expressed "as ortho", or as a total. If the latter is true, increasing the zinc orthophosphate dose at the WTP may improve this situation.

- Re-sampling, or returning to non-reduced sampling, may reveal compliance. Statistical chances of satisfying the Lead and Copper Rule are increased with more data points.

4.5.7 Solids and Washwater Handling

Waste flows travel via gravity from the WTP process to an unlined, single-cell, earthen lagoon on the northwest side of the WTP site, north of the spillway channel. The lagoon receives flow from several sources, as indicated in the WTP schematic (Figure 4-2). As computed from August 2000 observations, the pie chart below, Figure 4-3, depicts the source-by-source contribution of waste flows at the Exeter WTP.

During the period from August 1, 2000 to August 21, 2000, it was calculated that the Town produced an average of 0.3 mgd of waste flow, with a minimum day of 0.17 mgd and a maximum day of 0.41 mgd.

It was found that an average of 25% of flow entering the WTP exited as waste flows. This is a very high ratio, as optimized conventional treatment plants will waste no more than approximately 4% of daily flows as pretreatment and filter waste wash water. Exeter falls in line with these criteria for its filter waste wash water volume. However, the difference at the Exeter WTP is the presence of the adsorption clarifiers. These units, as discussed previously, demand significant backflushing volume by nature. While some optimization of clarifier backflushing and filter backwashing practices is possible, CDM did not observe any such operational procedures that were significantly out of the ordinary, and that could significantly reduce the wasted volume of water.

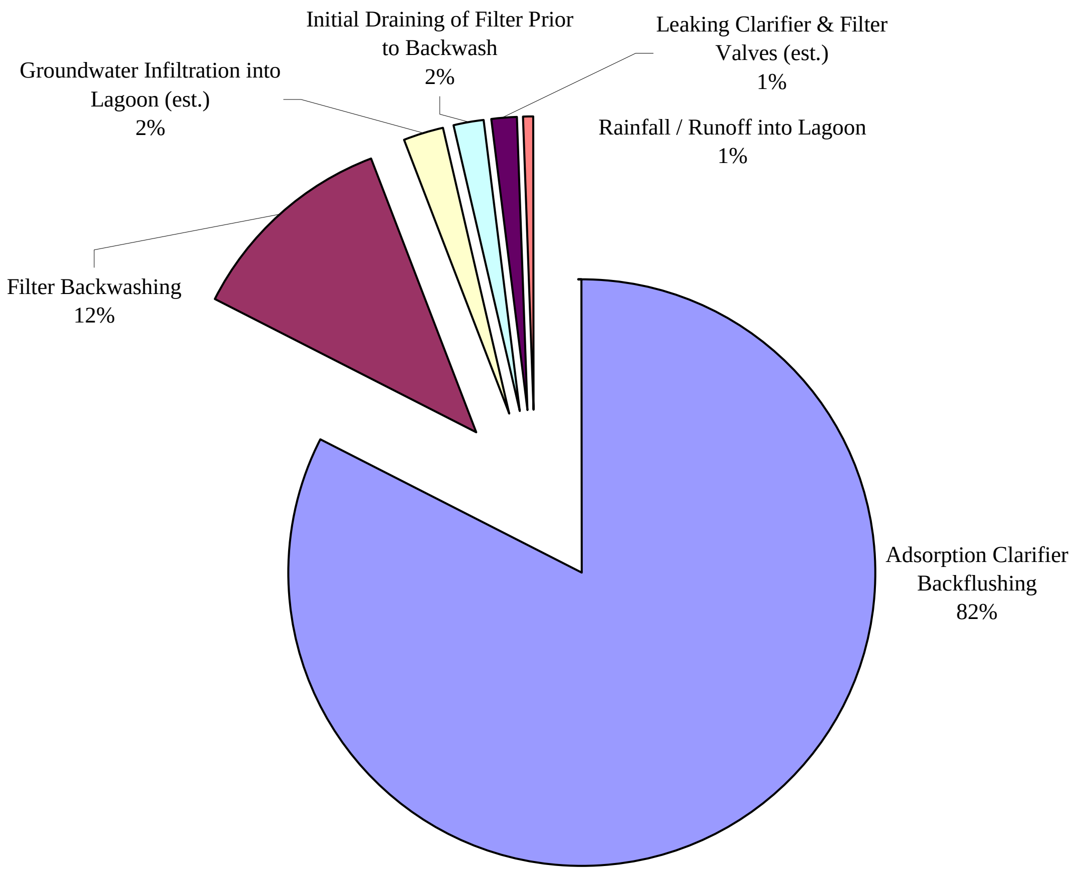


Figure 4-3

Town of Exeter, New Hampshire
Sources of Waste Flows at WTP

The lagoon is periodically pumped out (level-controlled, automatic pump activation) to discharge to the Town's gravity sewer collection system. These flows are conveyed to the Webster Wastewater Pump Station, which pumps the flow to twin barrel inverted siphons laid beneath the Squamscott River. Town staff have reported that this siphon periodically becomes clogged, and attribute the clogging to solids from the lagoon settling out in the siphon. There is no flow metering on the washwater pumped discharge piping.

It should be noted that the two solids lagoon pumps are each rated at 550 gpm. The existing control logic is such that only one of the two pumps may run at any given time. CDM's August 2000 field observations verified that the pumps are operating quite close to their design point. It should be noted that the discharge capacity of the

Webster Wastewater Pump Station is also on the order of 500 to 700 gpm. Therefore, solids lagoon pumping during periods of low sewer system flow rates is recommended.

It was noted that there are no alarms for the waste lagoon pumping system. A simple red light indication of pump failure atop the enclosure, and a relay to the Control Room should be considered.

If the 25% waste rate were to continue until the Year 2020, when maximum day demand is projected to be 3.4 mgd, an equalized, continuous waste flow rate of 1.2 mgd (833 gpm) could be expected. Mitigation of the quantity and quality of waste flows must be pursued. This would require significant capacity increases in the sewerage system, treatment of waste flow to remove solids, implementation of treatment processes that produce less waste flow, return of washwater to the headworks of the WTP (possibly to the reservoir), or procurement of an NPDES permit for discharge to the Squamscott River via Wheelwright Creek.

If the existing WTP were to remain in service for an extended term, washwater flow meter installation would be recommended, as is pumping during periods of low sewer system flow rates. Installation of a baffle curtain could be considered as a means of segregating solids from the water being pumped to the sewer system. If other solids mitigation measures are not found to be feasible, acquisition of a belt filter press process could be considered to dewater solids and store for off-site disposal.

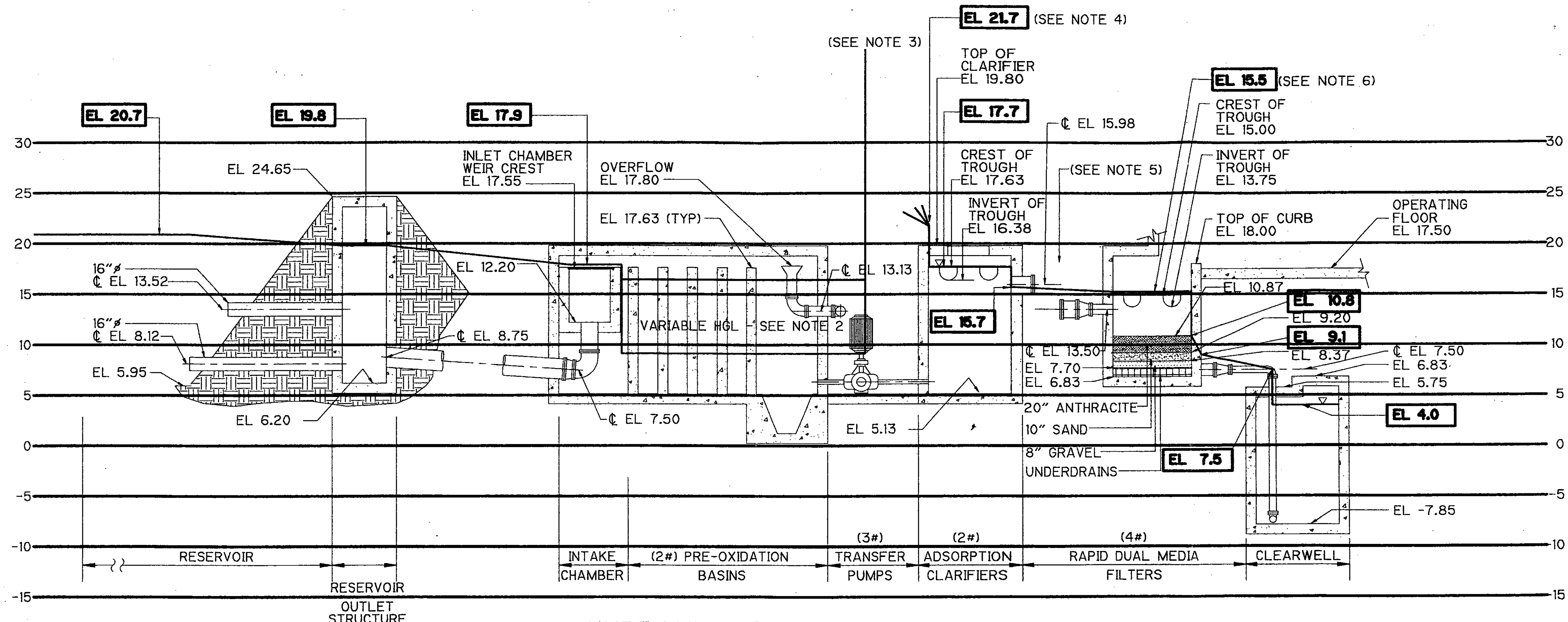
4.6 Hydraulic Evaluation

4.6.1 General

The scope of work for this project includes development of a hydraulic profile through the existing WTP. This evaluation is intended to supplement the process capacity analyses discussed in Section 4.5, above.

Hydraulic profiles created as part of WTP investigations are intended to detect potential hydraulic limiting factors within the existing plant process. This information allows the engineer to account for “bottlenecks” when evaluating a plant’s potential for upgrade. The existing plant’s hydraulic profile is included as Figure 4-4.

In conducting the hydraulic profile analysis, focus was placed on determining the reason(s) for implementing intermediate pumping between the pre-oxidation and adsorption clarification processes. It is obvious that some source of pumped flow is needed for clarifier backflushing. At first glance, however, it seems surprising that continuous intermediate pumping would be necessary near the toe of a water supply dam. Upon further review, CDM concludes the following logic was applied in development of the 1992 Contract Documents:



NOTES:

1. PHYSICAL STRUCTURE ELEVATIONS ARE TAKEN FROM DESIGN DRAWINGS FROM PRIOR PLANT IMPROVEMENT PROJECTS, AND NOT FIELD SURVEYED BY CDM. ELEVATIONS REFER TO NATIONAL GEODETIC DATUM OF 1929.
2. HGL IN PRE-OXIDATION BASINS CONTROLLED BY AQUARITROL UNIT LOGIC, NOT PHYSICAL HYDRAULIC FEATURES. THE HGL ELEV. RANGE SHOWN IS APPROXIMATE.
3. THE USE OF 1, 2, OR 3 PUMPS AFFECTS HGL ELEVATION IN THIS REGION.
4. CLARIFIER HEADLOSS SHOWN TO BE 4-FT, PER MFR.-STATED MAXIMUM.
5. FLOW PASSES THROUGH FORMER SUBSIDING BASIN IN THIS REGION. OVERFLOW EXISTS AT EL. 16.85.
6. BASED ON FIELD MEASUREMENTS AFTER FILTER BACKWASH.

HYDRAULIC PROFILE

SCALE:
VERTICAL: 1"= 10'-0"
HORIZONTAL: NTS

VERTICAL SCALE: 1" = 10'-0"
5 0 10

LEGEND:

HYDRAULIC GRADE LINE AT 3.4 MGD PLANT FLOW — EL XXXX.X

HYDRAULIC PROFILE THROUGH EXISTING WATER TREATMENT PLANT - TOWN OF EXETER, NH

DATE 01/05/01	SHEET NO.	LOCATION	ADDENDUM NO.	FIGURE NO.
	-	EXETER, NH	-	4-4

CDM Camp Dresser & McKee

It was determined an increase in the plant capacity from 1.5 mgd to 3.4 mgd was necessary to meet future demands.

- Additional sedimentation basins would be needed to increase the WTP capacity. However, eastward or westward expansion of the (former) tube settler basins was likely deemed undesirable due to site constraints and/or high capital costs. High rate adsorption clarifiers could, on the other hand, be installed to provide the higher plant capacity within the confines of the existing basins.

- The physical size of the "standard" adsorption clarifier modules was such that the top of trough elevation had to be within 2.2 feet of the operating floor elevation in the pretreatment building. The clarifiers have a clean bed headloss of about 18-inches and build up as much as 4 feet of headloss before being backflushed. As such, an upstream water surface elevation (in the pre-oxidation basins) higher than the floor would be necessary to produce the driving head needed to push flow through the clarifiers. Therefore, intermediate pumping provided a solution that avoided raising the pre-oxidation basin hydraulic grade line, and thus, the pretreatment building itself.

Individual unit process capacities can often limit an entire WTP's rated capacity. All processes are assigned a "firm capacity" by examining the maximum capacity that can be handled while one of that process' largest units is out of service. Following is a tabulation of Exeter's existing, critical unit process capacities:

Process	Number of Existing Units	Capacity of Process with All Units Operating (mgd)	Firm Capacity Capacity of Process with Largest Unit out of Service (mgd)
Exeter River - Raw Water Pumping	1 Pump	Approximately 2.0	0
Adsorption Clarifiers	2 clarifiers	4.6	2.3
Rapid Dual Media Filters	4 filters	4.7	3.4
Clearwell – Finished Water Pumping	2 pumps	Approximately 4.0	Approximately 2.0
Clearwell – Storage Capacity	1 clearwell	Existing storage volume sufficient for meeting CT but not for storing full backwash volume under all conditions. Finished water pumping must cease, presently, while a filter is backwashed.	

Table 4-15

Capacity of Existing Unit Processes

Based on a Year 2020 design criteria of 3.4 mgd, the above analysis of unit process firm capacity indicates that the WTP is lacking in firm capacity in raw water pumping, clarification, pumping, and clearwell storage capacity. Remedies are listed in the table below. Note, however, that greater firm capacity would be needed at the existing WTP if the 25 percent waste rate were not reduced to a more typical 4 percent.

Process	Remedy	Comments
Exeter River - Raw Water Pumping	Replace existing single pump and provide (2) 3.4 mgd pumps	Can be accomplished within existing pump station, utilizing existing raw water transmission pipeline
Adsorption Clarifiers	Construct third pretreatment process train	Site constraints pose significant construction challenge; keeping WTP operational during this addition will be very challenging; adsorption clarifiers' high waste flow volume lend cause to consider alternate pretreatment technologies
Rapid Dual Media Filters	No expansion necessary	No expansion necessary, but reconstruction may be necessary as noted previously.
Clearwell - Finished Water Pumping	Provide third pump and VFD	Straightforward installation – existing piping configured to connect a third pump. Procurement initiated by Exeter in 2001.
Clearwell – Storage Capacity	Expand existing clearwell, utilize former backwash equalization tank as "supplemental" clearwell, or build ancillary storage.	High capital cost; site constraints will make this challenging.

Table 4-16

Remedies for Providing 3.4 mgd Firm Capacity

4.7 Facility and Operations Audit

4.7.1 Control / Monitoring / SCADA System Status

Exeter's WTP is operated in a largely non-automated fashion. An annunciator panel / autodialer is in place to provide local indication of alarm conditions and monitoring data, including:

- Clearwell high water level alarm
- Clearwell low water level alarm
- Adsorption clarifier high headloss alarm

- Raw water flow monitoring
- Finished water flow monitoring
- Turbidity monitoring
- pH monitoring
- Chlorine residual monitoring
- Hampton Road Standpipe level – continuous monitoring and recording
- Epping Road Standpipe level – continuous monitoring and recording

The WTP obtained its first personal computer late in the summer of 2000. Neither a local printer nor on-line access (i.e., e-mail, world wide web) are yet available to the WTP staff. Until November 2000, daily logs were recorded exclusively with paper, pencil, and clipboard. Monthly reconciliation of the daily reports, similarly, was carried out with paper, pencil, clipboard, and calculator. The use of the personal computer is expected to facilitate daily record keeping, automate calculations, and decrease the likelihood of reporting errors.

Although the Town's wastewater system is in the midst of a significant SCADA modernization effort, there are no immediate plans to implement a modern SCADA system for the Town's water system. It is CDM's opinion that, as a minimum, SCADA control of the off-site water facilities would be of great benefit to the WTP operation. It is recommended this be pursued further whether the existing WTP remains in place or not. The WWTP and WTP systems should be the same software package to facilitate use by cross-trained employees.

4.7.2 Operations and Maintenance

The scope of work for this project includes a review of Exeter's staffing levels as compared to water treatment plants of similar size. Prior to the summer of 2000, only one operator was on duty at the Exeter water treatment plant at any given time. The hiring of a fourth operator has provided some staff overlap, which is intended to foster good communication, improve maintenance productivity, cover distribution system needs, staff vacation without utilizing overtime, and provide staff time to attend continuing education and training classes.

The Exeter WTP presently is staffed with four operators including a chief operator (Class III operations license) supervising three Class I operators. Two of the Class I licensees have worked at the Exeter WTP for over a decade, and the third is a recent hire (summer 2000). The plant is operated a maximum of 18 hours per day – less on weekends but more during fire hydrant flushing. The following table depicts a schedule followed for a given week in October 2000. Note that there is some shift alternation regularly practiced, but the following depicts a "typical" coverage scheme.

Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
12:00 midnight							
1:00 am							
2:00 am							
3:00 am							
4:00 am							
4:30 am	Tony Calderone	Tony Calderone	Tony Calderone	Tony Calderone	Tony Calderone		
5:00 am	Tony Calderone	Tony Calderone	Tony Calderone, Matt Berube	Tony Calderone	Tony Calderone		
6:00 am	Tony Calderone, Joe Goss	Tony Calderone, Matt Berube, Joe Goss	Tony Calderone, Matt Berube	Tony Calderone	Tony Calderone		Joe Goss
7:00 am	Tony Calderone, Joe Goss	Tony Calderone, Matt Berube, Joe Goss	Tony Calderone, Matt Berube	Tony Calderone	Tony Calderone	Joe Goss	Joe Goss
8:00 am	Tony Calderone, Joe Goss	Tony Calderone, Matt Berube, Joe Goss	Tony Calderone, Matt Berube	Tony Calderone	Tony Calderone	Joe Goss	Joe Goss
9:00 am	Tony Calderone, Joe Goss	Tony Calderone, Matt Berube, Joe Goss	Tony Calderone, Matt Berube	Tony Calderone	Tony Calderone	Joe Goss	Joe Goss
10:00 am	Tony Calderone, Joe Goss	Tony Calderone, Matt Berube, Joe Goss	Tony Calderone, Matt Berube	Tony Calderone	Tony Calderone	Joe Goss	Joe Goss
11:00 am	Tony Calderone, Joe Goss	Tony Calderone, Matt Berube, Joe Goss	Tony Calderone, Matt Berube	Tony Calderone	Tony Calderone	Joe Goss	Joe Goss
12:00 noon	Tony Calderone, Joe Goss, Jim Boland	Tony Calderone, Matt Berube, Joe Goss, Jim Boland	Tony Calderone, Matt Berube, Jim Boland	Tony Calderone, Matt Berube	Tony Calderone, Matt Berube	Joe Goss	Joe Goss
12:30 pm	Tony Calderone, Joe Goss, Jim Boland	Tony Calderone, Matt Berube, Joe Goss, Jim Boland	Tony Calderone, Matt Berube, Jim Boland	Tony Calderone, Matt Berube	Tony Calderone, Matt Berube	Joe Goss	Joe Goss
1:00 pm	Joe Goss, Jim Boland	Matt Berube, Joe Goss, Jim Boland	Matt Berube, Jim Boland	Matt Berube	Matt Berube	Joe Goss	Joe Goss
2:00 pm	Joe Goss, Jim Boland	Matt Berube, Joe Goss, Jim Boland	Matt Berube, Jim Boland	Matt Berube	Matt Berube	Joe Goss	Joe Goss, Jim Boland
3:00 pm	Joe Goss, Jim Boland	Matt Berube, Joe Goss, Jim Boland	Matt Berube, Jim Boland	Matt Berube	Matt Berube	Joe Goss	Joe Goss, Jim Boland
4:00 pm	Joe Goss, Jim Boland	Matt Berube, Joe Goss, Jim Boland	Matt Berube, Jim Boland	Matt Berube	Matt Berube	Joe Goss	Joe Goss, Jim Boland
5:00 pm	Joe Goss, Jim Boland	Joe Goss, Jim Boland	Jim Boland	Matt Berube	Matt Berube	Joe Goss	Jim Boland
6:00 pm	Jim Boland	Jim Boland	Jim Boland	Matt Berube	Matt Berube		Jim Boland
7:00 pm	Jim Boland	Jim Boland	Jim Boland	Matt Berube	Matt Berube		Jim Boland
8:00 pm	Jim Boland	Jim Boland	Jim Boland	Matt Berube	Matt Berube		Jim Boland
9:00 pm	Jim Boland	Jim Boland	Jim Boland	Matt Berube	Matt Berube		Jim Boland
10:00 pm	Jim Boland	Jim Boland	Jim Boland	Matt Berube	Matt Berube		Jim Boland
11:00 pm							Jim Boland
12:00 midnight							Jim Boland

Shaded areas in the above table indicate times during which the WTP is off-line and shut down

Table 4-17
Typical WTP Operations Staffing for October 2000

The WTP operations staff voiced opinions that more help is needed to maintain and operate the WTP. It is CDM's opinion that staffing needs to be in the form of skilled maintenance and electrical/instrumentation staff dedicated to the plant. This could be accomplished by providing training for the operators presently on staff, and, if necessary, hiring outside contractors on an annual contract basis or hiring/assigning additional Town personnel to respond to the WTP.

If a 24-hour per day operation were eventually implemented at the Exeter WTP, the hiring of a fifth operator would be recommended. That operator should be of experience, given the present demographics of the WTP operations staff. Without a complete SCADA system in place, unmanned operation is not recommended for the Exeter WTP.

The nature of the present-day water works industry demands municipalities strive to place themselves in a competitive position. One of the key methods of achieving competitiveness is employing a well-trained, versatile staff. Water treatment has been, and should continue to be, the primary focus of water treatment plant operators. The most competitive municipal water suppliers, however, employ operators that possess a multitude of skills. Operators who also have proficiency with such skills as distribution system expertise, mechanical repair, electrical, instrumentation, welding, carpentry, etc. tend to benefit their employer and derive more satisfaction from their jobs than those without such additional skills. Training is available through many avenues, including the New England Water Works Association, local technical schools, state-sponsored operations seminars, and others. Exeter should make it a priority to assure its present and future operations staff are cross-trained and multi-skilled. Increased productivity and morale are likely to be realized as results of such a management philosophy.

Callout protocol for the plant (i.e., backup staffing for the plant to address emergencies, sick coverage, etc.) is non-existent. Various personnel have cited the absence of compensation for time spent "on call" as the reason for this breakdown in procedure. CDM has observed that the majority of water systems have an "on call" system in place, with those personnel on call being compensated for it.

As a consequence of the "on call" system absence, the existing autodialer alarm system presently has no one to call. Operations staff are forced, in essence, to "watch and wait" in the control room for alarm conditions to occur. If an operator is working on a shift alone, he must periodically check in on the annunciator panel to assure no alarm conditions are ongoing. This situation prevents all operators from performing preventative maintenance without periodic interruption. To that end, it was recommended the Town:

- Implement an on-call protocol and compensate individuals for assuming "on-call" status

- Equip the operators on duty with a beeper, which would be activated under alarm conditions

The Town has taken steps during late summer 2001 to implement both of these recommendations.

The 1997 publication, Treatment Practices of New England Surface Water Supplies, by the New England Water Works Association Filtration Committee, 2nd Edition, lists 50 New England WTP's that possess a capacity between 1 and 5 mgd. Adding Exeter to this list makes 51 WTPs. It was found that:

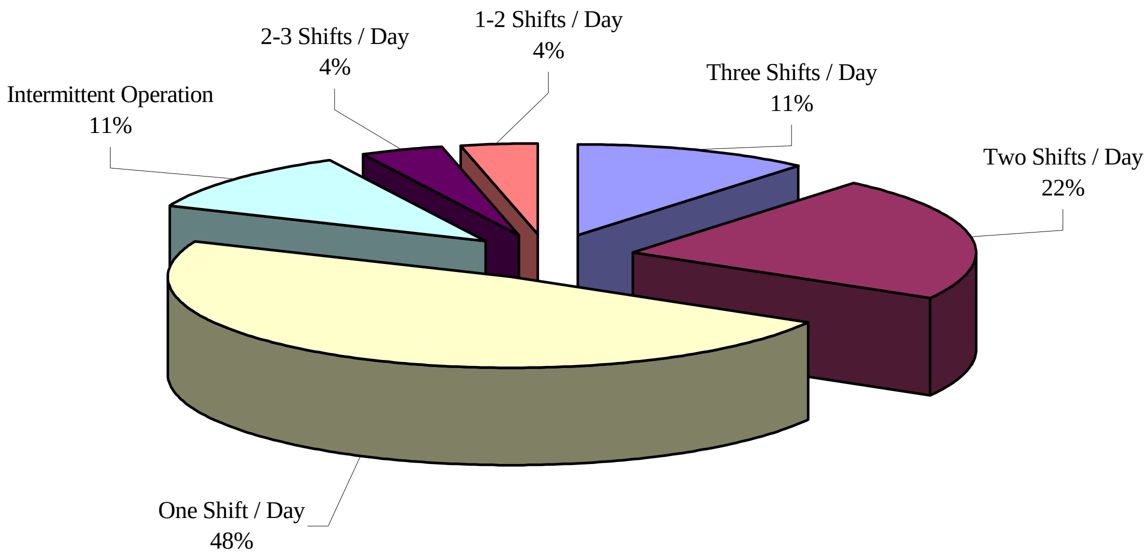
- 53% of those WTPs had a SCADA system. Exeter does not. Given the strong economy and technological advances from 1997 to present, this percentage may actually be higher now.

- Those WTP's in the group with SCADA systems had an average staff of 2.5 empolyees per MGD of average daily flow, whereas those WTP's without SCADA systems had an average staff of 3.9 mgd employees per MGD of average daily flow. Exeter, a non-SCADA WTP, employs 3.7 employees per MGD of average daily flow, according to 2000 staffing levels and 1999 flow records.

The WTP operations objective at the beginning of a day is to fill the distribution system storage tanks, which are typically depleted throughout the night while the WTP is off-line. The tanks, similarly, are "topped off" in the evening through WTP production.

As can be seen in Figure 4-5, the majority of New England WTP's in the 1 – 5 mgd capacity range operate only one shift per day, according to the 1997 publication, Treatment Practices of New England Surface Water Supplies, by the New England Water Works Association Filtration Committee, 2nd Edition. Operating more shifts per day, while requiring increased operational coverage, lessens the required flow rate that the plant must be able to process, and (in the design stage) lessens the physical size of the facility. Also, stopping and starting a treatment plant can lead to increased waste production – a problem realized in Exeter. The amount of distribution storage available also affects the operation of the WTP.

Figure 4-5
Typical Number of Operating Shifts
(Based on a 1997 survey of (27) WTPs with capacities of 1 to 5 mgd, without SCADA)



4.7.3 Laboratory Facilities

The Exeter WTP laboratory facilities consist of a 12-foot countertop with varied analytical equipment, including:

- Jar testing equipment
- Turbidimeter, Model 2100A, manufactured by Hach
- Hach DR/2010 Spectrophotometer
- Orion Model 410A pH meter

The jar testing equipment is old, and replacement may be warranted. Although the adsorption clarifiers do not represent "conventional" pretreatment, CDM nonetheless recommends jar tests be performed on a weekly basis to continually optimize the treatment process.

The turbidimeter is over 15 years old, and, despite regular calibration, the operations staff has questioned its reliability. The other analytical equipment is relatively new and said to be in good working condition.

4.7.4 Filter Pipe Gallery Flooding

The Exeter WTP has experienced basement flooding events in recent years. This can be attributed to the lack of an overflow at the clearwell. Causes of such flooding can include:

- Skinner Springs isolation valve left open when WTP shut down for night
- Finished Water Pump failure while the rest of the WTP is on line
- Failure (in the open position) of Finished Water Pump check valves upon pump shutdown, allowing distribution system water to return to the clearwell.

Level floats are installed in a sump in the filter pipe gallery area. When activated, an alarm is sounded in the WTP's main control room, and the autodialer is activated, as well.

A sewerage ejector pump is in place as a basement sump pump, but it is not intended to provide adequate protection in case of clearwell overflow. The ejector pump serves only as a reactive means to clean up after a flooding event.

In addition to implementing fail safe automation to circumvent the causes of flooding, construction of suitable overflow piping is recommended to mitigate overflows. This holds true for plant retrofit or new plant construction. After reviewing the 1972 and 1992 design drawings, CDM notes that overflows do exist upstream of the filters and within the pre-oxidation basins, thus protecting those facilities from flooding.

4.7.5 Physical Plant Facilities

A comprehensive structural, architectural, and HVAC audit of the existing facility was beyond the scope of this contract. It is noted, however, that the majority of the major structures on site are products of the 1972-1974 upgrade. CDM made several significant observations in relation to the existing facilities:

- Boiler / HVAC System is circa 1971 equipment – assumed to be at the end of its useful life.
- Low clearance door (5'-8") is means of egress from Boiler / HVAC room – a head-bumping hazard.
- Inadequate climate control in finished water pump VFD room.

- Finished water pump VFDs have history of high maintenance needs, despite the fact that they are only 6 years old. Spare parts are becoming difficult to find for these units.
- All chemical feed pumps need to be raised to a level easier to monitor and control.
- A majority of the chemical feed pumps are calibrated and controlled from under the chemical loading platform. This is a confined, dangerous area, as quick egress from this area in case of emergency is not possible.
- Chemical Feed Room secondary containment is of inadequate volume.
- Chemical Feed Room features chemical feed pumps outside of secondary containment areas. A hose rupture would thus not be contained.
- Chemical feed pipe carrier sleeve (12-inch diameter) observed to be full of groundwater where it exits from main chemical storage room.
- Inadequate ventilation for chemical storage tanks and feed pumps in WTP basement.
- Control room functions not only as main control room, but as office, laboratory, conference room, break room, kitchen, and training room. The annunciator panel occupies over half of the total floor space in this room.

4.7.6 Electrical Systems Evaluation

CDM's electrical engineer visited the site for one day during the week of August 21 – 25, 2000 to make general observations of the electrical systems and to investigate several, specific items of concern to the Town. Although not an exhaustive electrical facilities audit, the electrical systems evaluation appears as Appendix F.

4.8 Alternatives

4.8.1 General

This report has detailed key points surrounding the existing WTP and relevant drinking water regulations. CDM notes that the existing WTP, while in need of significant improvements, generally produces good water. The existing facility is an investment, warranting careful evaluation of its potential for future use. A second alternative for Exeter's future water treatment would be to abandon the plant in favor of a new plant on a new site. These two alternatives are discussed below.

4.8.2 Alternative A – Protect Site from Flooding and Rehabilitate Existing WTP

A fundamental component of this alternative is to first protect the WTP from flooding. The Town should not invest further, significant amounts of money in upgrading the existing WTP without first protecting the WTP from flooding. Thus, to pass adequate storm flows, the "rehabilitation alternative" would first require major spillway, discharge channel, and dam improvements, as described in subsections above. As presented in Appendix G the construction would feature installation of cofferdams for spillway enlargement, demolition of the entire existing spillway channel, construction of a new, 20-ft wide spillway channel; a new floodwall approximately 10 ft in height; installation of at least two new box culverts beneath Portsmouth Avenue; and construction of a dedicated storm water pumping station in the WTP parking lot area. The lower solids lagoon would be displaced by this work, and would require reconstruction north of the new spillway channel. The northern portion of the WTP site after this work would bear little resemblance to the way it looks today.

The dam / spillway / channel / culvert component of Alternative A has an estimated capital cost of approximately $1.4 to $2.2 million, including engineering and contingencies. The stormwater pumping station is estimated to cost an additional $200,000 to $400,000, including engineering and contingencies. Such work is not deemed necessary by CDM if Exeter were to abandon the existing WTP in favor of a new WTP on a new site. Sluice gate renovation is the only "site" component common to both alternatives, and is therefore not carried in this comparative cost analysis.

In concert with the site improvements work, existing WTP rehabilitation would begin. Given the findings in subsections above, the most significant required existing WTP improvements are as follows:

- The clarification process lacks firm capacity to treat projected future flow rates. A third process train of adsorption clarifiers could be added to remedy the lack of firm capacity. Given the process information obtained during the course of this study, it does not appear that adsorption clarification is the best process for Exeter's highly colored source water. For planning purposes, a pretreatment process that can handle high dosages of coagulants and preoxidants is desirable. A new conventional pretreatment process building would likely offer other benefits: (1) Provide adequate firm capacity; (2) Allow construction of a new, safer, intermediate pumping process; (3) Significantly decrease waste flow volume; (4) Provide a simpler, less maintenance-intensive process to operate. Such a building may be constructable in the area currently occupied by the abandoned backwash recycle building. If so, the existing pretreatment process could remain in operation during construction. Pending pilot testing, high rate settling, such as with inclined plate settlers or ballasted flocculation (Actiflo or equal) may be beneficial, minimizing capital costs and decreasing physical size requirements.

- The WTP must be able to continuously utilize the clearwell to deliver finished water to the Town. Given its small volume, this will not always be possible while a filter is being backwashed. A new storage tank, of approximately 150,000 gallons, would need to be provided to supplement the existing clearwell volume as backwash supply, chlorine contact time source, and/or supplemental storage.

The existing volume would ideally be located on the WTP's hydraulic grade line, to avoid further intermediate pumping. Expanding the existing clearwell through common wall construction would not be easily constructed, in CDM's opinion, as a 52-foot westward expansion would be necessary. Consideration could be given to locating a backwash supply pumping station at the former backwash recycle basin, and leaving the existing finished water pumping station in place. This would not be feasible either, if a new pretreatment building were to be constructed in that location. Further consideration is required to accurately assess how this component of the "rehabilitation alternative" could be feasibly implemented.

- Enlarging the spillway channel will displace the existing lower solids lagoon and associated pumping equipment, requiring lagoon reconstruction further to the north.

- Looking ahead to future *Cryptosporidium* monitoring (and subsequent, possible treatment requirements) the need for alternative disinfection systems must be planned for, with hydraulic and physical space reserved for ozonation or ultraviolet disinfection.

The following table of improvements is also recommended for rehabilitating the existing WTP. Those marked with asterisks (*) were recommended by CDM in its draft Recommended Year 2001 Capital Improvements memorandum.

Table 4-18. Alternative A – Plant Portion of Rehabilitation Scope of Work

Description of Improvement	Constructability Issues	Capital Cost (1)
Instrumentation and Control		
Construct and Implement Supervisory Control and Data Acquisition (SCADA) system.		$500,000
Implement automatic alarm dialer / pager system*		
Chemical Storage and Feed Facilities		
Re-construct and expand chemical feed room to improve safety, provide secondary containment, fire alarming, and proper ventilation. This would feature moving caustic soda and zinc orthophosphate out of the basement of the WTP and making provisions for an automatic batching machine for the dry polymer feed system. Re-install 12-inch chemical carrier sleeve to exclude groundwater in future.	Maintaining operational facility during reconstruction would be challenging.	$500,000
Continue dosing refinement and continual calibration*		
Pretreatment Building		
Demolish Abandoned Backwash Recycle Bldg.	Necessary to accommodate new Pretreatment Building	$3,500,000
Construct 3.4 mgd Pretreatment Building		
Construct 3.4 mgd Intermediate Pumping Station		
Demolish Existing Pretreatment Building	To provide room for future facilities	
Influent Pipeline from Skinner Springs		
Add relay to flow meter		$10,000
Add sampling point to influent line, transferring this source water to a common sampling sink		
Automate valves to ensure closure upon plant shutdown		
Filters		
Level wash water troughs*		$500,000
Correct high rate backwash readout discrepancy in control system		
Provide dedicated source of supply for subsurface wash system and eliminate cross-connection		
Inspect and analyze filter media*		
Replace underdrains to allow for future air scour capability		
Replace aging, poorly-seating valves and deteriorating pipe		
Provide air scour blowers & dedicated building		

Description of Improvement	Constructability Issues	Capital Cost [1]
Evaluate filter-to-waste feasibility and implement if possible	Not likely feasible – no cost carried	
Pending piloting, install granular activated carbon		
Clearwell		
Install third finished water pump, motor, and VFD*		$600,000
Purchase spare parts for two existing finished water pump VFDs*		
Provide increased clearwell capacity, including pump relocation contingency		
Solids Lagoon		
Modify as noted above		$900,000
Install flow metering for sewer discharge flows		
Sewer System Upgrade Allowance		
Physical Facility		
Replace boilers and HVAC systems in full		$750,000
Construct additional administrative area		
Provide Clearwell Overflow Capability		
Separate combined electrical and I&C wiring in common conduit*		
Lighting fixture repair*		
Additional light installation*		
Install GFI-type outlets in restroom / locker room*		
Miscellaneous Site Improvements		
Correct non-watertight valve and meter vaults		$1,100,000
Associated landscaping work		
Electrical items identified in Appendix F		
Architectural repairs allowance		
Structural repairs allowance		

(1) Without Engineering, Contingencies, and Escalation to midpoint of Construction.

Table 4-18

Alternative A – Plant Portion of Rehabilitation Scope of Work

The cost of the site and WTP improvements is presented in Table 4-19, below. While likely feasible, the engineering and construction of such work will be quite complex. The scope of work described above would require significant coordination with the WTP operations staff, as the facility would have to remain operable for the duration of the renovation. The cost of the site and WTP improvements is presented in Table 4-19, below.

Capital Cost Component		Planning-Level Capital Cost Estimate (1)
Rehabilitation of Existing WTP (from Table 4-18)		$8 million to $9 million
Exeter River Pumping Station Rehabilitation		$0.4 million
Subtotal of Capital Construction Cost		$8.4 million to $9.4 million
General Contractor's Overhead and Profit	15%	$1.3 million to $1.4 million
Subtotal		$9.7 million to $10.8 million
Construction Contingencies	25%	$2.4 million to $2.7 million
Dam, Spillway, Channel, Culvert and Storm Water Pumping Station Construction		$1.6 million to $2.6 million
Total Construction Cost (November 2000 ENR 6223.97)		$13.7 million to $16.1 million
Construction Costs at Mid Point of Construction		$16.7 million to $19.6 million
(2000 to 2005, 4% per year)		
Engineering Costs	20%	$3.3 million to $3.9 million
Implementation Costs	5%	$0.8 million to $1.0 million
Land Acquisition / Easement Costs		N/A
Opinion of Probable Project Costs		$20.8 million to $24.5 million

(1) Ozonation would add approximately 10% to cost of rehabilitated WTP.

Table 4-19
Alternative A – Rehabilitation Capital Cost Estimate

4.8.3 Alternative B – Construct New WTP at New Site

4.8.3.1 General

This alternative features abandonment of the existing WTP site in lieu of a new WTP on a new site. The WTP in this alternative would also require a firm capacity of 3.4 mgd. Ideally, it would be located on a site high enough to avoid flooding, be close to the existing WTP to reduce the amount of distribution system reconfiguration, and be as near as possible to the source waters.

Pilot treatment process testing would be needed to say exactly which treatment technologies would be required at a new Exeter WTP. It is likely, as dictated by source water organic and color levels, that some form of pretreatment would be required. Filtration utilizing granular activated carbon (GAC) should also be planned for.

4.8.3.2 Evaluation of Sportsman's Club Parcel

A site northeast of the existing WTP was identified by the Town as a potential location for a new WTP. CDM's project scope required a preliminary evaluation of the suitability of that property for use as a new WTP site. The portion of the parcel under consideration is of a triangular shape, measures nearly 8 acres in area, and is currently used by the Exeter Sportsman's Club as a trap shooting and general firing range.

The parcel is depicted in Figure 4-6. The Town Assessor's office lists Tax Map No. 65, Lot No. 123 as Town-owned, with a right-of-way portion of that parcel owned by Exeter Sportsman's Club, Inc. Further research is required by the Town to determine the precise limits of right-of-way ownership.

The site's proximity to the existing WTP and the reservoir makes it a highly feasible option. Raw water and finished water delivery into and out of a new plant on that site would require pipeline installation but not major distribution system pipeline modifications.

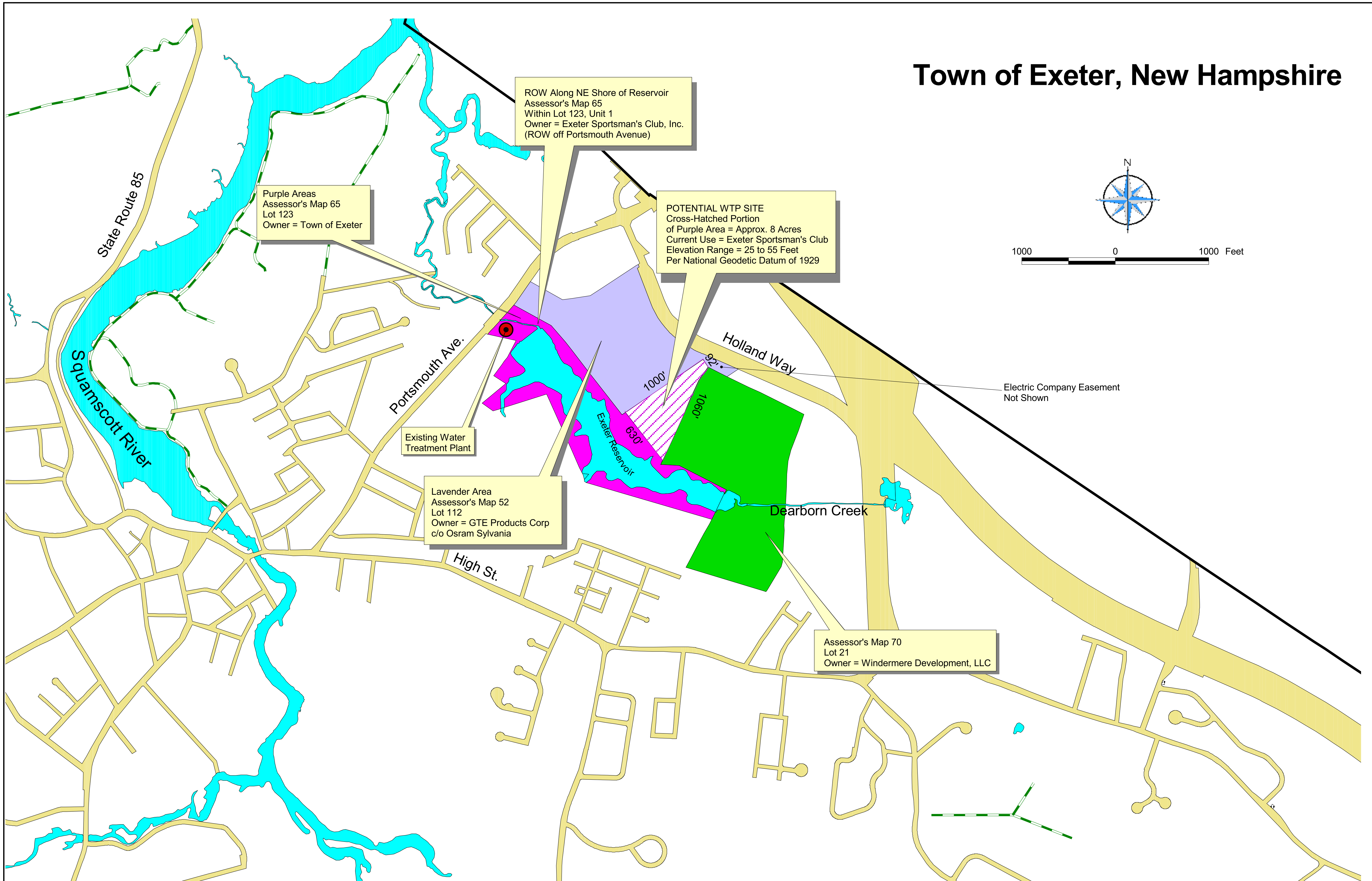
The Town and CDM walked the site in full on August 29, 2001. The widest portion of the site is occupied by the Sportsman's Club, which is where the potential for lead shot remediation exists. A wetlands area exists in the middle portion of the parcel, suggesting new plant siting in the northern (narrowest) portion of the site should be examined. If siting in the northern portion is proved to be feasible under future conceptual design efforts, it is possible that the new WTP and existing Sportsman's Club could co-exist, and the lead abatement issue be avoided. Operator safety will obviously require consideration prior to detailed development of such a design.

Other comments regarding this site's suitability follow:

- The text, Integrated Design and Operation of Water Treatment Facilities (by Susumu Kawamura, 2nd Edition, copyright 2000, p. 18) presents an equation for approximating required area for a conventional WTP. The equation, $A \langle Q^{0.7}$ (where A is the area in acres and Q is the ultimate plant capacity in mgd), yields just over 3 acres for a 5 mgd WTP. This suggests, despite the site's odd, triangular shape, that the site may be large enough to accommodate a water treatment facility.

The site elevation, per USGS quadrangle maps, ranges from approximately 25 to 50 feet, per the National Geodetic Datum of 1929. The site's varying topography lends itself well to gravity flow through a WTP process without the need for intermediate pumping. The site is also safely above the shores of the Exeter Reservoir, and predominantly out of critical floodplain areas.

Town of Exeter, New Hampshire



CDM

Figure 4-6

Potential Water Treatment Plant Site

- No wildlife was observed on site during CDM's field visit, but environmental studies would be required prior to proceeding.

- The adjacent parcels are owned by Osram-Sylvania to the northwest and by Windermere Development, LLC to the east. Also, the electric company has an easement between Holland Way and the proposed new WTP parcel. The Osram-Sylvania facility is a commercial/industrial operation, and would not likely be strongly opposed to a WTP nearby. As indicated in Figure 4-6, access between Holland Way and the new WTP site would require discussion, takings, and/or easement procurements with both Osram-Sylvania and the electric company. Residential homes are being constructed on southern portions of the large Windermere parcel. The Town may wish to begin discussions with that developer if it decides to proceed with a new WTP on this site. The Town should also continue working with its Conservation Commission on the ongoing Exeter Reservoir watershed study, being done by others.

- The current use by the Exeter Sportsman's Club may require mitigation measures, such as providing a new Sportsman's facility elsewhere in Town. Costs for such mitigation are not included below.

If a new WTP were to be located at the existing Sportsman's Club parcel, planning-level capital costs are estimated to be as indicated in Table 4-20 below.

4.9 Recommended Improvements

It is recommended that the Town pursue Alternate B, a new WTP on a new site. This alternative features less capital cost than the rehabilitation option; the "virgin" site lends itself to construction with very minimal disturbance to existing WTP operations; provides space for future expansion; avoids re-use of aging structural and architectural components; and would provide a convenient facility layout.

Immediate improvement recommendations, as well as those improvements not unique to either Alternative A or B, are outlined in the overall Recommended Capital Improvements Plan, appearing in a later section of this report.

4.10 Implementation Program and Schedule

The implementation of Alternate B would feature longer planning time than would Alternate A. The design and construction phases, however, would be simplified and therefore shortened significantly under Alternate B.

An estimated time line for implementation of Alternative B is presented in Figure 4-7. Other milestones with respect to demand and regulatory factors are called out, as well.

Improvement		Lower End		Upper End
New WTP plus extensions to finished and raw water pipelines		$ 6,600,893		$ 8,581,161
Access Improvements to new WTP		$ 40,000		$ 40,000
Lead Shot Removal (Allowance)		$ 100,000		$ 100,000
Decommissioning of Existing WTP (Allowance)		$ 100,000		$ 100,000
Exeter River Pumping Station Rehabilitation		$ 400,000		$ 400,000
Subtotal of capital construction cost		$ 7,240,893		$ 9,221,161
General Contractor's Overhead and Profit	15%	$ 1,086,134	15%	$ 1,383,174
Subtotal		$ 8,327,027		$ 10,604,335
Construction Contingencies	25%	$ 2,081,757	25%	$ 2,651,084
Total Construction Cost (November 2000 ENR 6223.97)		$ 10,408,784		$ 13,255,419
Construction Costs at Mid Point of Construction (2000 to 2005, 4% per year)		$ 12,663,877		$ 16,127,244
Engineering Costs	20%	$ 2,532,775	20%	$ 3,225,449
Implementation Costs	5%	$ 633,194	5%	$ 806,362
Land Acquisition / Easement Costs (Allowance)		$ 100,000		$ 100,000
Opinion of Probable Project Costs		$ 15,929,846		$ 20,259,055
Recommended Range		$ 16,000,000		$ 20,000,000

Ozonation would add approximately 10% to cost of new WTP.
Mitigation for displacement of Sportsman's facility NOT included in costs above.

Table 4-20

Alternative B – New WTP Capital Cost Estimate

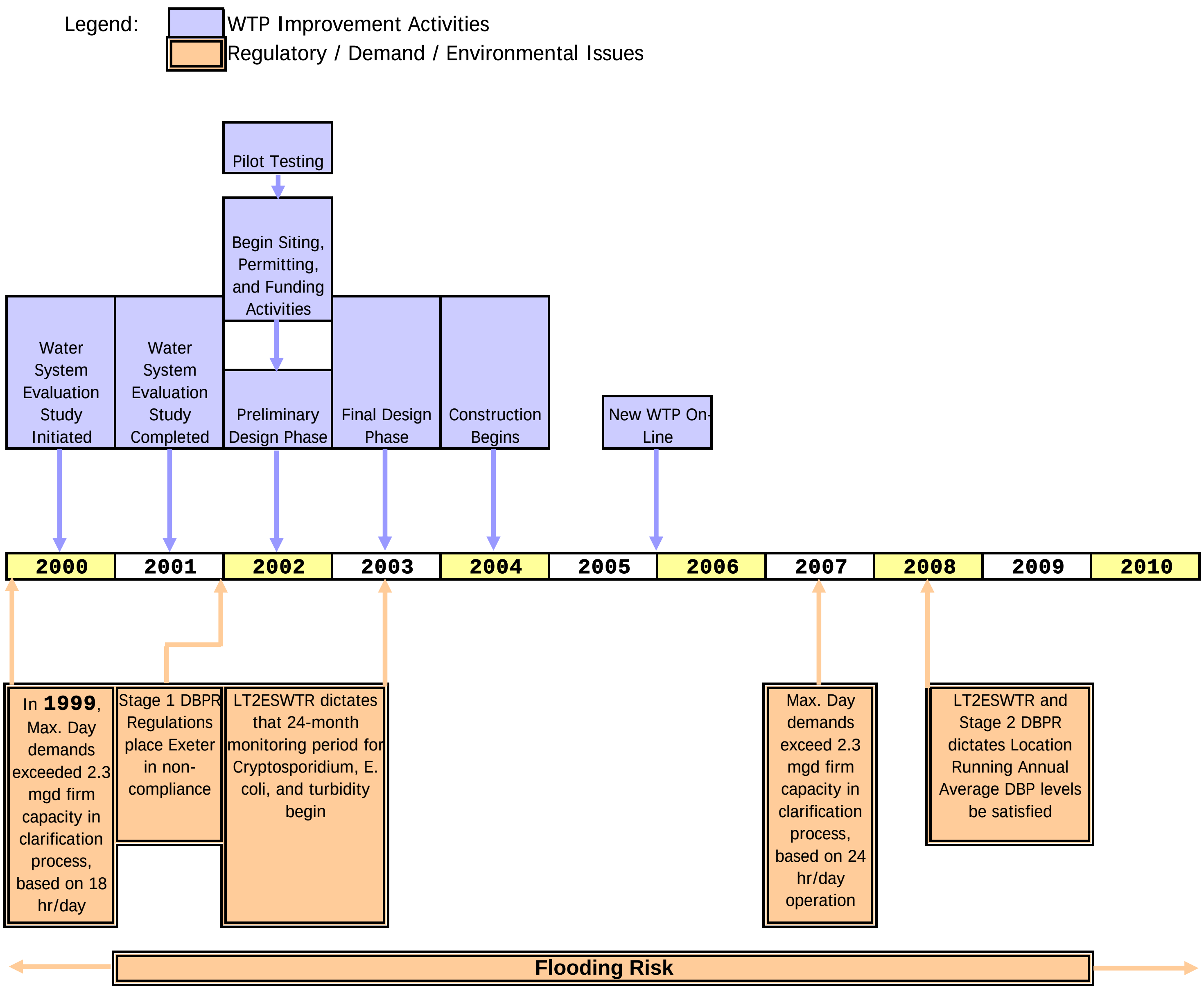


Figure 4-7
New WTP Construction - Implementation Schedule

Section 5
Distribution System Evaluation

5.1 Introduction

This section of the report evaluates the water distribution system and identifies water system improvements that are required to address deficiencies within the existing distribution system. Using water demand projections established in Section 2, CDM identified water distribution system piping and facility improvements that are required to meet the current and future needs of the Town.

The major objectives of this part of the study are to:

- Develop and calibrate a computer model of the water system.
- Identify current and future water storage capacity and operational deficiencies.
- Evaluate the integrity of the existing piping network and make recommendations to improve fire flows and system pressures.
- Develop a prioritized improvements program for the recommended distribution improvements.

5.2 Description of Existing System

5.2.1 General

Exeter's distribution system is comprised of three pressure zones. The largest pressure zone is the *Main Service Zone*, which provides water to the majority of the system, including the downtown, Hampton Road, and Court Street areas. Water is supplied to the main service zone by the water treatment plant and Lary Lane Well. The Epping Road and Hampton Road Tanks provide storage for this service area.

From the main service zone, water is pumped to the Kingston Road and Epping Road High Pressure Zones. The *Kingston Road High Service Zone* serves the higher elevations along Kingston Road, Cross Road, and Pickpocket Road. The Cross Road Tank provides storage for this area. The *Epping Road High Service Zone* serves the higher elevations along Epping Road and Industrial Way. There is no storage within the Epping Road High Service Zone.

Figure 1-1 shows the locations of the key components of the Exeter water system.

5.2.2 Overview of System Facilities/Operations

5.2.2.1 Main Service Zone

Water is supplied to the main service zone by the water treatment plant (WTP) and the Lary Lane well. The treatment plant generally operates approximately 16 hours per day, from 6:00 am- 10:00 pm. Typically, the Epping Road and Hampton Road Tank levels dictate WTP operations. In the morning, the WTP produces relatively high flows in order to refill the water tanks, which are drawn down through the night. In the afternoon, the WTP production rate is reduced to maintain the water levels in the tanks. The plant shuts down in the evening (typically around 10:00 pm) when the tanks are completely filled. Lary Lane Well is used during periods of high demand and on weekends to help maintain tank levels.

The piping network within the main service zone consists of many small diameter, unlined cast iron mains, especially in the downtown area. These mains have become heavily tuberculated over time and restrict flows to the western portion of the service zone and the Epping Road Tank. Correspondingly, the water treatment plant staff report problems draining and filling this tank. The Hampton Road Tank is located in the eastern part of the system and is relatively well connected to the supply sources with 10- and 12-inch diameter ductile iron and asbestos cement mains. Therefore, the two tanks rarely fluctuate together.

Typical pressures in the main service zone range from approximately 100 psi at the water treatment plant to 30 psi at the highest elevations along Hampton Road. Based on the elevations along Hampton Road, it is not possible to maintain the NHDES-required minimum operating pressure of 35 psi in all areas, even when the tanks are full. This results in frequent pressure complaints in this area of the distribution system. The Exeter Fire Department has reported that they rely on pumper trucks for providing fire protection in the Hampton Road area due to concerns of creating negative pressures if water is pumped from the hydrants at high rates, particularly during times when the water treatment plant is off-line.

5.2.2.2 Kingston Road High Service Zone

The Kingston Road Pump Station pumps water from the main service zone (HGL 205 feet) to the Kingston Road High Pressure Zone (HGL 224 feet). The pump station operates based on water levels in the Cross Road Tank, allowing the tank to fluctuate approximately 15 feet. Fluctuation any greater than this leads to pressures below 35 psi at the highest elevations. Coliform bacteria were detected in this section of the distribution system during the early- to mid-1990s. Therefore, pump station operations were modified to provide maximum tank fluctuation and minimize water quality problems resulting from water stagnation. Additionally, chlorine (added via a tablet chlorinator) is added at the pump station to provide a higher chlorine residual within the Kingston Road High Service Zone. There have been no coliform detections since these measures were implemented.

5.2.2.3 Epping Road High Service Zone

The Epping Road Booster Station pumps water from the Epping Road Tank to the Epping Road High Service Zone. The pump station operates based on demand within the system, as there is no dedicated storage in this zone.

There are two pressure reducing valves PRVs located on Colcord Pond Road and Michael Avenue. These PRVs reduce the pressure from approximately 80 psi to 50 psi. These PRVs are necessary because of concerns regarding service pipe integrity. There is a small mobile home park located off Colcord Pond Road. The service pipe for this development is inadequate to withstand pressures of 90 psi. Accordingly, PRVs have been installed to reduce the pressure. When the service pipe is upgraded in the future, the PRVs will be abandoned.

5.2.3 Distribution System Storage

Exeter has three water storage tanks to meet demand fluctuations and provide fire flow storage. The Epping Road and Hampton Road tanks serve the Main Pressure Zone. The Cross Road Tank provides storage for the Kingston Road High Pressure Zone. The distribution storage facilities are summarized in Table 5-1.

5.2.3.1 Epping Road Tank

The Epping Road Tank is a 125 foot standpipe approximately 37 feet in diameter, with a total capacity over 1.0 million gallons (mg) and an overflow elevation of 205 feet (United States Geologic Survey, 1929 Mean Sea Level datum). This tank is located in the western portion of the distribution system and provides storage for the Main Service Zone.

The Epping Road Tank generally fluctuates up to 15 feet during the day. However, as noted earlier in this section, the water treatment plant operators have reported difficulties filling and draining this tank. Additionally, the tank does not fluctuate with the Hampton Road Tank, also in the Main Service Zone. A review of tank charts from the July 2000 high demand period, show periods when the water levels in the Epping Road Tank are more than 10 feet lower than water levels in the Hampton Road Tank. This is likely because of the poor hydraulic connection between the Epping Road Tank and the rest of the distribution system. The majority of the distribution system piping that connects the Epping Road Tank to the supply sources is unlined cast iron and severely tuberculated.

5.2.3.2 Hampton Road Tank

The Hampton Road Tank is a 85 foot standpipe approximately 46 feet in diameter, with a total capacity over 1.0 million gallons (mg) and an overflow elevation of 205 feet (United States Geologic Survey, 1929 Mean Sea Level datum). This tank is located in the eastern portion of the distribution system and provides storage for the Main Service Zone.

Tank	Tank Type	Total Capacity (gallons)	Overflow Elevation (feet)[1]	Base Elevation (feet)[1]	Height (feet)[1]	Diameter (feet)	Volume per Foot (gallons)	Year of Construction
Epping Road	Steel standpipe	1,019,000	205	80	125	37	8,100	1950
Hampton Road	Steel standpipe	1,064,000	205	120	85	46	12,400	1958
Cross Road	Glass-fused-to-steel standpipe	478,000	224	138	86	31	5,600	1993
TOTALS		**2,561,000**					**26,100**	

[1]Elevation above mean sea level

Table 5-1
Summary of Distribution Storage Facilities within Exeter

The Hampton Road Tank generally fluctuates up to 10 feet during the day. There is an altitude valve located at the tank that closes when the tank water level reaches an elevation of 202 feet (3 feet below tank overflow). Town staff report that this valve has 'slammed' shut in the past, creating a water hammer in the distribution system. Recent modifications to this valve to allow it to close more gradually, appear to have reduced the occurrence of water hammers in the system. Additionally, as noted above, this tank does not fluctuate with the Epping Road Tank. The Hampton Road Tank water levels can be up to 10 feet higher than water levels in the Epping Road Tank. This is because the Hampton Road Tank is relatively well-connected to the supply sources and the rest of the distribution system with 10- and 12-inch diameter water mains.

5.2.3.3 Cross Road Tank

The Cross Road Tank is an 86 foot Aquastore® Tank (glass fused to steel) approximately 30.8 feet in diameter, with a total capacity about 0.48 million gallons (mg) and an overflow elevation of 224 feet (United States Geologic Survey, 1929 Mean Sea Level datum). This tank provides storage for the Kingston Road High Service Zone.

The Kingston Road Booster Station is programmed to allow Cross Road Tank to fluctuate about 15 feet. After the tank is filled, the water level is allowed to drop 15 feet (the minimum water level to maintain 35 psi minimum operating pressures in the area) prior to the pump re-filling the tank. These operating parameters were designed to maximize tank fluctuation, as there have been water quality concerns resulting from water stagnation in the past. In the early- to mid-1990's, samples tested positive for coliform bacteria in the Kingston Road High Service Zone. It was believed that the combination of water stagnation and diminished chlorine residual contributed to the problem. At that time, the pump operated in such a manner that there was minimal exchange of water in the Cross Road Tank. Since making the operational adjustments and adding a tablet chlorinator at the booster pump station to increase chlorine residuals, there have been no coliform detections in this area of the system.

Prior to 1997, which was the period when the Cross Road Tank was manufactured, Aquastore® tanks were constructed with a single layer of glass fused to the steel tank wall. A number of these tanks experienced frost spalling, during which the bubble structure within the glass was infiltrated by water, causing spalling after repeated freeze/thaw cycles. In cases where the bubbles (voids) were close together, the spalling was observed to travel from bubble to bubble, eventually reaching the steel tank wall. To remedy this problem, Aquastore® now includes cathodic protection in all new tanks constructed after 1997. Additionally, tanks constructed after 1997 are equipped with two layers of glass coating to further mitigate the potential for spalling.

The Cross Road Tank has been inspected on three occasions since the potential for a spalling problem was identified by Aquastore® in 1995:

- 1996- the tank was inspected above the water level by Robert Merithew Company. No spalling was noted.

- 1997- an underwater inspection of the tank was conducted by Underwater Solutions. The videotape from the inspection proved "inconclusive", as the Town believes silt in the water coated the inner tank walls, preventing a clear view of the walls.

- 1998- the tank was completely drained and visually inspected by Town staff and an Aquastore® representative. The inspection revealed areas where strips of sealant had come loose from where the plates butt together. Aquastore® has subsequently described any problems observed in the Cross Road Tank as "insignificant".

In 1999, Aquastore® installed cathodic protection at the Cross Road Tank (at no cost to the Town). Additionally, Aquastore® is planning another inspection of the tank in 2003 and they have extended the Town's warranties for rust and corrosion and spalling until 2003 and 2018, respectively. The Town will continue to work with Aquastore® to monitor and resolve any potential problems.

The Town also reports that several winters ago, an accidental overfilling of the Cross Road Tank occurred while ice was present within the tank. When the exterior of the tank warmed, the rapidly rising ice layer collided with the tank ceiling, resulting in $20,000 in roof damage.

5.2.4 Distribution System Pumping Stations

The Town of Exeter operates two booster pumping stations: the Kingston Road Booster Pumping Station and the Epping Road Booster Pumping Station. Other stations serving the distribution system include the water treatment plant's finished water pumping station and the Lary Lane groundwater well.

A summary of the equipment installed at each station is summarized in Table 5-2.

5.2.4.1 Kingston Road Booster Pumping Station

The Kingston Road Booster Pumping Station is equipped with two, 7.5-horsepower (hp) booster pumps and a single 3-hp jockey pump. The station includes a calcium hypochlorite tablet chlorinator to boost chlorine residuals.

The original station design (1985) incorporated two 5-hp booster pumps and a 530-gallon hydro-pneumatic storage tank, with no provisions for supplemental chlorination. Town staff indicate that the tank failed in 1991, after which the entire station was re-engineered. A sodium hydochlorite feed system was added in the mid-1990's to boost the chlorine residual after several samples in the Kingston Road Pressure Zone tested positive for coliform. After continual problems with pump air binding, the Town switched to the existing tablet chlorinator.

Location	Pumps	Flow (gpm)	Design Head (ft)	Motor Horsepower	Chlorine Addition	Standby Power / Backup Capability
Kingston Road	Jockey	Data Not Available, Pump Tag Illegible		3.0	Yes – Calcium Hypochlorite Tablet Feed	None
	Booster No. 1	Maximum 140 gpm	Shutoff 200±	7.5		
	Booster No. 2	Maximum 140 gpm	Shutoff 200±	7.5		
Epping Road	Jockey	135	97	7.5	None	Yes – Diesel Engine-Driven Fire Pump
	Booster No. 1	315	97	15		
	Booster No. 2	315	97	15		
Water Treatment Plant	FINW Pump No. 1	1400	300	150	Yes – Sodium Hypochlorite Liquid Feed	Yes – Diesel Engine Generator
	FINW Pump No. 2	1400	300	150		
	FINW Pump No. 3	1400	300	150		
Lary Lane	1	350	225	40	Yes – Calcium Hypochlorite Tablet Feed	Yes – Propane-Fired Engine to Drive Pump

Table 5-2
Distribution System Pumping Station Summary

Table 5-3 summarizes station deficiencies noted during CDM's field inspection. Structural, architectural, and HVAC audits were not conducted as part of this work.

5.2.4.2 Epping Road Booster Pumping Station

The Epping Road Booster Pumping Station was significantly renovated in 1998. The station is equipped with two, 15-hp booster pumps and a single 7.5-hp jockey pump. This station is not equipped with supplemental chlorination.

Deficiency	Comment
Pumps and other related equipment are located in basement-level of station.	A confined space entry configuration exists, requiring special attention to personnel safety issues while accessing the subgrade area. Electrically, some equipment is located in a humid, potentially wet environment that will decrease its longevity.
Pumps and their motors have failed repeatedly.	Town staff have noted that pumps and motors have been replaced at the rate of 2 or more units annually for the last several years. Informal accounts from Town staff attribute this to high amperage draw and/or inadequate electrical service. CDM recommends investigation of existing pump discharge characteristics vs. system requirements. A cursory review of this indicates that the pumps may be oversized (too much head production) for the needs of the system. If this is true, pumps operating far right on their curve may be causing the high amperage draw.
Standby power is not available.	While a dedicated generator is not mandatory, CDM recommends making provisions for connection of stand-by power (install transfer switch and power receptacle for portable generator connection).
The station does not have a Fire Alarm System despite the use of chlorination tablets.	This is a violation of the current Building Code requirements. The requirements for Fire Alarm System in chemical areas is in BOCA National Building Code/1999 Article 918.4.3 for occupancies in Use Group H-4 (which is specified in BOCA article 307.6) and include materials that are health hazards, such as corrosive, irritants, toxic, etc.
Chlorine analyzer not available.	Installation of an on-line analyzer would be a useful operations tool, as manual field testing is now required.
No exterior lighting exists at station.	Installation of exterior lighting would enhance safety for those accessing station at night.

Table 5-3
Kingston Road Booster Pumping Station Deficiencies

The Epping Road Booster Pumping Station and its ancillary systems are in excellent condition, with only minor deficiencies identified. Too-frequent pump cycling was observed during CDM's fall 2000 inspection, but has since been remedied. Electrical systems in the station are new and in excellent condition. The station also contains a diesel fire pump which operates under low pressure conditions. The manufacturer of the pump (Detroit Diesel Allison) and control system manufacturer (Lexington Controls, Inc.) are no longer in the business, which makes equipment maintenance and spare parts procurement extremely difficult.

Structural, architectural, and HVAC audits were not conducted as part of this work.

5.2.4.3 Water Treatment Plant – Finished Water Pumping Station

The WTP's finished water pumping station is equipped as detailed in Table 5-2 and is further described within Section 4.

5.2.4.4 Lary Lane Well

The Lary Lane Well facility is equipped as detailed in Table 5-2 and is further described within Section 3.

5.2.5 Distribution System Piping

Exeter's water distribution system consists primarily of cast iron, ductile iron, and asbestos cement water mains. There are about 50 miles of pipe in the distribution system, ranging in size from 4- to 16-inches. The oldest section of the distribution system, dating back to the 1890s, is located in the area around Water Street, Front Street, and Main Street. This is part of the original piping network designed to convey flow from the Dearborn Reservoir to the downtown area. The mains in this area are primarily 4-, 6-, and 8-inch cast iron mains. As discussed herein, C-value testing performed in this area indicates that these mains are heavily tuberculated and flow through the mains has been significantly reduced over time.

Since the construction of the original piping network at the turn of the century, the water system has been continuously extended to serve the Town's growing population. Until the 1940s, water mains in Exeter were almost exclusively unlined cast iron. The more recent water main construction (post-1950) designed to serve Hampton Road, Linden Street, Kingston Road, and Epping Road, includes asbestos cement and ductile iron mains. In 1999, water improvements were combined with sewer and drainage improvements in the Water Street area. The existing 8- and 10-inch cast iron water mains along Water Street were replaced with a 16-inch ductile iron main.

Exeter's distribution system piping has been continually expanded away from the system 'core' in the downtown area to serve new development. The majority of these new distribution mains are 8- to 12-inch diameter ductile iron and asbestos cement mains. However, the original piping in the system 'core' remains 6-inch and 8-inch unlined cast iron water main. For example, while most of the piping within the Kingston Road and Epping Road High Service Zones are 8- to 12-inch ductile iron, each service zone is connected to the supply sources largely by 6- and 8-inch unlined cast iron water mains.

Based on a review of the Town's existing distribution system maps, a breakdown of the piping system by unlined cement mains versus ductile iron and asbestos cement mains, by diameter, was developed (Table 5-4). All cast iron pipe within Exeter's distribution system is unlined.

Size	Pipe Material (feet)			% Cast Iron
	Unlined Cast Iron	Other	Total	
4-inch	15,900	4,000	19,900	80%
6-inch	32,500	48,800	81,300	40%
8-inch	8,700	67,900	76,600	11%
10-inch	10,000	34,200	44,200	23%
12-inch	3,900	32,000	35,900	11%
16-inch	0	2,400	2,400	0%
Total	**71,000**	**189,300**	**257,500**	**28%**

Table 5-4
Unlined Cast Iron Pipe in Exeter's Distribution System

5.2.6 Distribution System Appurtenances

5.2.6.1 Hydrants

There are approximately 275 hydrants within the Town of Exeter. Until recently, the DPW staff, along with a representative from the Fire Department, would flush approximately 1/3 of the system hydrants each fall and spring, if scheduling allowed. In conjunction with the flushing program, the Fire Department records the flow and residual pressure at each hydrant and maintains comprehensive hydrant flow testing records.

Historically, the Town has not had a formal annual hydrant maintenance or inspection program. Broken or inoperable hydrants encountered during daily routines, fires, or the flushing program, are serviced or replaced by the Town as soon as possible. However, in fall 2001 the DPW will institute a more rigorous hydrant and valve maintenance program. It is the DPW's goal to operate each hydrant at least one time per year.

5.2.6.2 Valves

The Town has approximately 470 valves within the distribution system. Historically, during the semi-annual flushing program, a limited number of valves are closed to isolate sections of main and increase flushing velocities. Historically, the program has not included all system valves and the Town has not had a formal inspection program to verify the condition of the remaining valves to ensure reliable operation of all valves during emergencies. However, any inoperable valves that are encountered during system operation are repaired or replaced by the Town.

In conjunction with the hydrant program, the DPW will institute a more rigorous valve maintenance program in Fall 2001. The DPW has recently purchased an automatic valve turning machine to allow them to operate every valve at least once per year.

5.2.6.3 Meters

There are approximately 3,200 meters in use in the distribution system. The meters are all read using touch-pad technology. In practice, DPW staff walks up to the meter and keys in the reading. The readings are then downloaded into a computer. At least 1/3 of the existing meters are more than 15 years old. Accordingly, the DPW has initiated a program to replace these meters. A memo prepared by CDM evaluating meter reading technologies for the Town is attached as Appendix H.

5.3 Distribution System Modeling

A model of Exeter's water distribution system was developed by CDM to evaluate system adequacy under existing and future water demand conditions (2020). The H2ONet® computer model by MW Soft, Inc. was used as the modeling "tool". Data used to develop the model was provided by the Town and was primarily based on existing GIS water distribution system maps. CDM conducted C-value testing and used available hydrant flow data to calibrate the model to field conditions. The calibrated model was then used to identify water system deficiencies.

5.3.1 Development of System Schematic

A schematic of Exeter's distribution system was prepared using H2ONet as a guide to establish model input data and for system analysis. The schematic is a representation of the piping system in which pipes are represented as numbered "links" and pipe intersections and changes in pipe size or material are represented as numbered "nodes". Points of supply are also represented as nodes. All mains 4-inches in diameter and larger were included in the schematic.

Information used to develop a computer model of Exeter's water system included:

- pipe length and diameter,
- pipe c-value (friction factor),
- ground elevations at each node,
- system demands,
- connectivity,

- pump curves (for the WTP, Lary Lane Well, and booster pumping stations).

Most data needed for the preparation of the model was available from Town records. Existing GIS plans show pipe diameters, material, and location. Ground elevations were assigned to each node using USGS topography data.

Selection of the pipe friction factors (C-values) and the distribution of water consumption in the model, however, required additional work as described below.

5.3.2 Assignment of Demands to Nodes

Water demands in distribution system models are typically aggregated and averaged across the model nodes. The allocation of demands can be performed in this manner because water distribution models are generally not sensitive to the distribution of average customer demands. For example, the conveyance of typical system flows (which are distributed across the system) results in minimal pipeline flow velocities and headlosses. Conversely, high demands scenarios, such as hydrant flow tests and fire flows, can result in much higher velocities and headlosses. For this reason, hydrant flow tests, which stress the system at discrete locations and create significant headlosses, govern system calibration.

Exeter's 1999 average water consumption--the most recent data at the time the model was created--was used as the basis for assigning demands to the model. While the Town does have billing information broken into three meter routes, the delineation of each route was not readily available. Therefore, Town-wide demands were used. Additionally, the average water usage by Osram-Sylvania (the second largest user) was assigned to a node representing its location within the water distribution system (Table 5-5). The water demand by Phillips-Exeter Academy was not assigned to an individual node because the usage for the Academy is not a point demand, but is spread out over a wider area. Therefore, this usage was included with the remaining Town demands.

Company	Average Daily Use (gallons per minute)
Philips-Exeter Academy	60
Osram-Sylvania	22

Table 5-5
Two Largest Water Users

The 1999 average day demand, minus the demand of the largest two users modeled separately, was distributed evenly among the model nodes. Unaccounted-for water was also distributed evenly across the demand nodes. Generally, this method provides a satisfactory representation of actual system demands as there are more nodes in areas with larger demands (e.g., downtown).

Accordingly, the current model demand condition reflects the 1999 average day demands. To represent daily demand variations (i.e., maximum day, peak hour, etc.) or future demands, a global peaking factor is applied to each nodal demand. By multiplying all demands by an appropriate peaking factor, the base model demand can be globally increased or decreased to reflect the analysis conditions.

5.3.3 Pipe Friction Factors

Unlined cast iron water mains that transport soft (i.e., corrosive) water usually develop a deposit of metallic salts on the interior after having been in service for a number of years. Accumulation of these deposits, or tubercles, has a twofold effect on the hydraulic flow capacity: (1) it reduces the actual inside diameter of the main and hence the amount of water that the pipe can deliver, and (2) it causes increased frictional headlosses because of turbulence resulting from the roughness and unevenness of deposits.

The Hazen-Williams C-value is a relative measure of the hydraulic capacity of a water main. At a constant flow rate, the smaller the value of C, the greater the drop in water pressure along a given length of main. For example, a 6-inch pipe having a C-value of 100 will transport over twice as much water with the same pressure drop, as a 6-inch pipe of the same length with a C-value of 50. It should be noted that any obstruction, such as a partially closed valve, would also reduce the calculated C-value.

For ductile iron cement lined pipes, C-values for 6- to 16-inch pipe were assumed to range from 100-120. Unlike cast iron pipe, C-values for asbestos cement mains tend to increase over time. Corrosive water tends to 'dissolve' the pipe material and the carrying capacity of the main can actually increase over time. C-values used for 6- to 12-inch asbestos cement mains ranged from 120-130.

Based on discussions with the Town, it seems that all of the cast iron pipe was installed between 1890-1950. Accordingly, all the cast iron pipe (none of which is lined) is assumed to be at least 50 years old, with some sections in the downtown area over 100 years old. C-values for older, unlined pipe can be predicted using an established curve that shows the general relationship between the age of the pipe and its current hydraulic capacity. This curve was used to assign initial C-values to the mains in Exeter's system. Initial C-values for 6- to 12-inch unlined cast iron mains ranged from 50-100. However, corrosion rates and the resultant C-values will be different for each water system.

Many adjustments to these initial C-value assumptions, however, were made during calibration based on C-value field testing and hydrant flow results.

5.3.4 Model Calibration

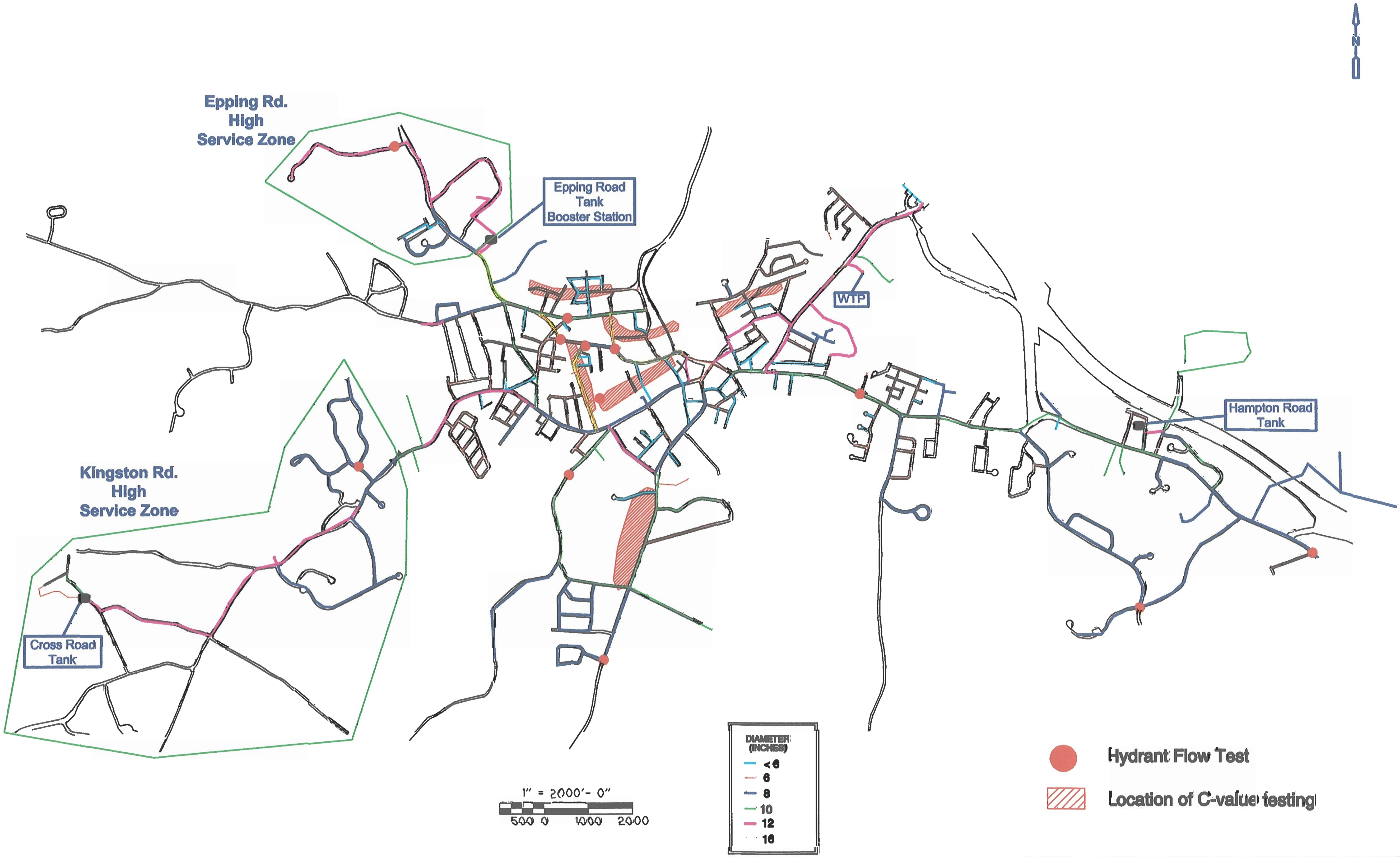
Calibration of water distribution models generally involves simulating hydrant flows (based on field tests performed throughout the system) in the model and comparing field test results against model results. Adjustments are then made to the model to make it more closely match the actual field testing data. The greatest variable in the calibration of the model is the C-value of unlined cast iron mains. Therefore, the C-values of these mains are adjusted during calibration, such that the model simulates the headlosses calculated during the hydrant flow tests.

5.3.4.1 Hydrant Flow Testing Data

During the Town's semi-annual hydrant flushing program, the Exeter Fire Department collects hydrant flow data, including date and time of test, hydrant flow rate, static pressure, and residual pressure. The system conditions during the test can be established from treatment plant records, including the water treatment plant flow rate and tank water levels. Therefore, hydrant flow data collected by the Fire Department after October 1999 (after the Water Street Improvements were completed) was used as the basis for model calibration. Table 5-6 summarizes the hydrant flow testing results. Flow test locations were generally selected in areas with unlined pipes, problematic areas, and/or at the system extremities to ensure that the model reflected actual system conditions. Figure 5-1 summarizes the hydrant flow test locations. The hydrant flow testing data is also included in Appendix I.

Location	Static Pressure (psi)	Residual Pressure (psi)	Hydrant Flow (gpm)	Flow Available at 20 psi (gpm)
Main Service Zone				
Hampton Road (at end)	30	18	710	640
Hampton Falls Rd. @ Exeter Falls Dr.	55	30	930	1,120
High Street @ Rocky Hill	46	40	1,060	2,300
Court St. @ end	85	62	950	1,660
Linden St. @ High School	70	55	1,020	1,950
Main St. @ Lincoln St.	67	53	850	1,640
Kingston Road High Service Zone				
Colonial Way @ Heritage Way	65	52	950	1,900
Epping Road High Service Zone				
Epping Rd. @ Continental Dr.	74	65	1,380	3,640

Table 5-6
Hydrant Flow Tests



CDM

January 2002

Figure 5-1
Field Testing Locations

5.3.4.2 C-Value Testing Program

The Exeter Fire Department had extensive hydrant flow test data available, therefore the field testing program was used to evaluate the C-values of unlined cast iron mains in Exeter.

The C-values of unlined cast iron mains can very greatly depending upon age, water quality, and typical flow rate through the main. Therefore, field tests were conducted to evaluate the amount of corrosion that has occurred within Exeter's unlined cast iron pipes and the corresponding C-value. C-values can be estimated in the field by measuring the flow rate and corresponding headloss through a known length of pipe, and utilizing these values in the Hazen-Williams formula.

Locations of C-value tests were selected based on pipe diameter and hydraulic significance within the distribution system. For example, a test was conducted on the 10-inch diameter main on Park Street, which is a primary feed to and from the Epping Road Tank. Tests were also conducted on Lincoln Street and Front Street to evaluate the C-value of 1890s vintage 6- and 8-inch mains. The locations and results of the C-value tests are summarized in Table 5-7, Figure 5-1 and Figure 5-2. Appendix I contains the field data from the C-value testing program.

Test Location	Age	Result
12" cross-country main (near Jady Hill)	1951	Test results not used to due insufficient headloss during test (< 10 psi)
10" on Park Street	1930's	Test results not used to due insufficient headloss during test (< 10 psi)
8" on Main Street	1887	Average C-value = 37
8" on Front Street	1887	Average C-value = 28
6" on Lincoln Street	1887	Average C-value = 37
10" on Court Street	1933	Average C-value - 96

Table 5-7
C-Value Tests

In general, the C-value tests indicated that there has been a significant loss of capacity in the smaller mains. About 60% to 75% of their original carrying capacity has been lost. The relatively small pressure drops in the 10-inch main on Park St. and the 12-inch cross-country transmission main along Jady Hill indicates that less tuberculation has occurred in these mains than the smaller diameter mains. The mains on Jady Hill and Park Street convey significant flows (and accordingly have higher flow velocities) and this may have resulted in less corrosion and higher C-values. Table 5-8 summarizes the C-values used for unlined cast iron mains in the model.

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Figure 5-2
Water Distribution System Deficiencies

2′ x 3′ color, GIS map

Size (inches)	C- Value Used for Cast Iron Mains	C- Value Used for Lined Mains
6	30	105
8	40	110
10	90	115
12	95	120

Table 5-8
C-Values Used in the Model

5.3.4.3 Initial Calibration Results

Calibration was performed by comparing the static and residual pressures measured during hydrant flow tests to the pressures predicted by the computer model. C-values of the pipes were adjusted in the model to 'match' the results observed in the field. The model was generally considered calibrated when the residual pressure drops simulated on the computer model were within 10 percent of the actual field residual pressure drops (usually within 2 psi).

Generally, most of the required adjustments to pipe C-values are reasonable, given the results obtained in the field testing program, the relative age, and condition of the pipes. However, to calibrate the model, a number of pipes were assumed to have closed or partially closed valves, including:

- On Ashbrook Road, near Hampton Falls Road
- On Court St. between Pine St. and Crawford Ave.
- In the area near Main St. and Cass St.

It is important to note that typically the computer model cannot identify specific locations where valves are closed, only general areas of restrictions. Shortly after the initial calibration was completed, CDM advised the Town to check for closed or partially closed valves. During the field checks that occurred between November 2000 and April 2001, the Town located a closed valve on Ashbrook Road, near Hampton Falls Road and on Court Street, near Pine Street. The closed valve on Ashbrook Road was especially significant because the Town measures disinfectant residuals at this location. When the valve was closed, Ashbrook Road became the end of a long dead-end main. When the valve was opened, it became part of a 'loop' and water quality improved. The disinfection by-products measured at this location dropped markedly. During maintenance activities, the Town located a closed valve on Main Street that was assumed to have been closed during the Fire Department's flow testing. Also, there was a valve that was closed on Tan Lane during water main construction (in 2000 the existing 4-inch main on Tan Lane was replaced with an 8-inch ductile iron main to serve the new science building at Philips-Exeter Academy). However, simulating this valve closed in the model still did not accurately represent the field tests on Main Street.

These types of valve problems are not unusual. Numerous towns find closed or partially closed valves to be a problem, and have field crews identifying them on a continuous basis.

CDM and the Town were concerned about the discrepancies between the model and field test data on Main Street. The piping network in the Main Street area has a significant role in the conveyance of water within Exeter, as it connects the Epping Road Tank to the rest of the distribution system. This is particularly important in light of the operational problems with the tank, i.e., it does not fluctuate with the Hampton Road Tank. Therefore, it is important to correctly represent this area in the model. Additional hydrant flow tests were recommended to further identify potential areas of closed valves.

5.3.5 Additional Data Collection

Eight additional hydrant flow tests were conducted on May 23, 2001 after the model was initially calibrated. CDM and the Town performed these additional flow tests to identify remaining closed valves in the Main Street area. Originally, only one test was planned, however, when the results were checked against the model (in the field) the results still did not correlate. Therefore, six additional tests were performed in this area to verify system conditions. Different valves were closed during the testing in order to obtain as much information as possible. During each test, residual pressures were measured at four locations to obtain information about the system (typically residuals are taken at only one location). An additional test was also performed in the Epping Road High Service Zone to confirm the operation of the Epping Road Pump Station fire pump. Table 5-9 and Figure 5-2, provide a summary of the additional hydrant testing results. Appendix I contains the field data from the hydrant testing program. Generally, this hydrant flow testing data supported the initial model results indicating that there were additional closed valves in the Main Street area.

From the model, the areas along Epping Road and Main Street, near Harvard Street, were identified as locations of a suspected closed valve. The Town did an intensive check of all the valves in this area. A closed valve was found on Spruce Street, east of Columbus Avenue. There may still be an additional closed valve in the system, however, for the purpose of model calibration it was assumed that this valve will be found and opened.

Location	Static Pressure (psi)	Residual Pressure (psi)	Hydrant [1] Flow (gpm)	Flow Available [1] at 20 psi (gpm)
Main Service Zone:				
Main St. @ Lincoln St.	67	53	700	1,300
Park St. @ South Park St.	56	53	1,120	4,300
Main St. @ Cass St.	60	31	850	1,000
Main St. @ Cass (valve closed at Epping Rd. and Main St.)	60	24	800	900
Main St. @ Cass St. (valve closed on Main between Cass St. and Tan St.)	57	12	650	600
Main St. @ Cass St.	60	32	840	1,000
Main St. @ Cass St. (valve closed on Cass St.)	60	24	780	800
Epping Road High Service Zone:				
Epping Road @ Continental Rd.	72	66	1,280	4,100

[1] Hydrant flows obtained during testing program. Actual flows may be higher under optimized conditions, when all valves are opened.

Table 5-9
Additional Hydrant Flow Test Results

5.4 Analysis of Existing Facilities

CDM evaluated Exeter's piping, pumping, and storage facilities to determine the adequacy of the existing facilities to meet present and future water demand conditions and to provide fire protection. As a basis for this evaluation, system analysis criteria were established to set minimum requirements for service pressure and flow capacity. CDM assessed the system's capability to meet these system analysis criteria using the results of the field testing program (as described in the previous section), observations made during the field inspections of existing facilities, and the calibrated model of the distribution piping network.

5.4.1 Analysis Criteria

Water system facilities (i.e., piping, pumping, and storage) were evaluated to determine their ability to meet minimum system pressures under the following analysis conditions for the target year of 2020:

- Peak hour on the maximum day
- Fire flow requirements on the maximum day

- Nighttime tank refill on maximum day

The criteria for minimum system pressures for the Exeter water system were established based on discussions with Public Works staff, NHDES guidelines, and Ten State Standards. The water system should be capable of maintaining a minimum pressure of 35 psi during the peak hour demand period at ground elevation throughout the service area. During a maximum day demand with a coincidental fire flow, a minimum of 20 psi should be maintained throughout the system. The piping network should also be capable of refilling the storage fluctuation volume in about eight hours during the minimum (nighttime) demand period on the maximum day.

5.4.2 Distribution System Storage Analysis

5.4.2.1 Recommended System Storage

Storage is recommended within a distribution system for the following reasons:

- To dampen hourly demand fluctuations that otherwise would be met by supply sources, thereby reducing operating costs.
- To meet required fire flow, thus reducing pumping capacity (and costs) at supply sources, as well as reducing piping capacity requirements.
- To provide a volume of water for emergencies in case of pipeline breaks, mechanical equipment malfunctions, or power failure.

Additionally, storage helps to equalize pressure throughout the distribution system, to provide pressure surge relief, and to help control pumping operations.

In systems providing storage, water supply pumping facilities should be sized to provide maximum day demand. During periods when system demands are greater than maximum day (i.e., peak hour demand conditions), these demands are met by active storage (equalization storage). Storage facilities are also sized to provide fire protection volume.

The basis for these storage requirements is summarized below:

- ***Equalization Storage —*** The total volume required to meet hourly demand which exceed the maximum day demand. This volume is generally taken to be a percentage of the maximum day demand.
- ***Fire Protection Storage —*** The total volume of water to provide fire flows. To determine this volume, the maximum fire flow required is selected along with the appropriate duration (typically 2-3 hours).
- ***Emergency Storage —*** The volume of storage allocated in case of a power failure, pipeline breaks, or equipment malfunction. In most cases, if a community has an

adequate emergency standby power source at its water supplies, emergency storage is considered to be a lower priority requirement.

Distribution system storage facilities are considered adequate if the existing ***active*** storage volume meets equalization and fire protection requirements for the community. Active storage is determined by local topography and represents the volume of water in storage that provides a minimum acceptable pressure (e.g., 35 psi or 20 psi during fires) at the highest service elevation in the distribution system. This analysis is initially performed using static pressures and elevations but is verified under dynamic conditions using the computer model.

In addition to having adequate storage in a water system, it is important that the water system have adequate pumping and piping capacity to refill the system storage at night. Generally, total peak hour fluctuation volume must be refilled within approximately 8 hours during the nighttime period following maximum day demand.

5.4.2.2 Analysis of Existing Storage

Active storage required to meet the Town's current demands in the Main Service Zone (including storage requirements for the Epping Road High Service Zone) is 1.0 million gallons (mg). The active storage required in 2020 is 1.31 mg (Table 5-10). The active storage requirement for the Kingston Road High Service Zone is currently 0.26 mg. The active storage requirement will increase to 0.28 mg in 2020 (Table 5-11). Storage requirements are broken down as follows:

- ***Equalization Storage*** — The equalization storage component for the Main Service Zone and the Kingston Road High Service Zone were estimated based on typical values for similar systems. For the Main Service Area, 21% of maximum day demand is recommended for equalization storage. For the Kingston Road High Service Zone, 27% of maximum day demand is recommended for equalization storage. The percentage of maximum day demand required in storage increases as system demand decreases, because peak hour fluctuations are typically more pronounced in smaller systems.

- ***Fire Protection Storage*** — In the Main Service Zone the largest fire flow requirement is 3,500 gpm for a duration of three hours (based on ISO guidelines). In the Kingston Road High Service Zone, the largest fire flow requirement is 2,000 gpm for a duration of two hours.

- ***Emergency Storage*** — Exeter's water treatment plant and Lary Lane Well both have emergency power to operate the pumps and treatment processes. The Epping Road Pump Station also has emergency power. Nevertheless, under current conditions, additional emergency storage would be beneficial because of the vulnerability of the WTP. If Exeter addresses the WTP vulnerability as discussed elsewhere herein, then no emergency storage for the distribution system is required.

Available Equalization Storage

Tank	Total Volume	Tank Overflow Elev. (ft)	Tank Base Elev. (ft)	System High Service Elev. (ft)	Tank Dia. (ft)	Tank Vol/ft	**Nominal Storage at 35 psi (mg)**	**Nominal Storage at 20 psi (mg)**
Epping Road	1,015,800	205	80	125	37	8,200	**0**	**0.28**
Hampton Road	1,056,200	205	120	125	46	12,500	**0**	**0.42**
Total	**2,072,000**					**20,700**	**0**	**0.70**

Required Active Storage

Equalization Component

	2000	2020
Maximum Day Demand (MDD) (mgd):	1.74	3.26
% of MDD recommended for storage:	21%	21%
Equalization Volume (mg):	**0.37**	**0.68**

Fire Flow Component

	2000	2020
Selected Fire Flow (gpm):	3,500	3,500
Duration:	3	3
Fire Flow Volume (mg):	**0.63**	**0.63**

	Required Storage at 35 psi (mg)		**Required Storage at 20 psi (mg)**	
	2000	**2020**	**2000**	**2020**
Total Storage Requirement	**0.37**	**0.68**	**1.00**	**1.31**

Table 5-10
Main Service Zone Storage Analysis

Available Equalization Storage								
Tank	Total Volume	Tank Overflow Elev. (ft)	Tank Base Elev. (ft)	System High Service Elev. (ft)	Tank Dia. (ft)	Tank Vol/ft	**Nominal Storage at 35 psi (mg)**	**Nominal Storage at 20 psi (mg)**
Cross Road	478,300	224	138	130	30.77	5,600	**0.07**	**0.27**

Required Active Storage						
Equalization Component						
	2000	2020				
Maximum Day Demand (MDD) (mgd):	0.08	0.13				
% of MDD recommended for storage:	27%	27%				
Equalization Volume (mg):	**0.02**	**0.04**				
Fire Flow Component						
Selected Fire Flow (gpm):	2,000	2,000				
Duration:	2	2	**Required Storage at 35 psi (mg)**		**Required Storage at 20 psi (mg)**	
Fire Flow Volume (mg):	**0.24**	**0.24**	**2000**	**2020**	**2000**	**2020**
Total Storage Requirement			**0.02**	**0.04**	**0.26**	**0.28**

Table 5-11
Kingston Road High Service Zone Storage Analysis

Main Service Zone - Available Active Storage

Exeter has two tanks to meet the storage requirements for the Main Service Zone and the Epping Road High Service Zone (which relies on the Main Service Zone for its storage). The Epping Road and Hampton Road tanks have overflow elevations of 205 feet (USGS) and a total capacity over 2 mg. In general, the high elevation areas along Hampton Road, up to approximately 125 feet, dictate the evaluation of active storage in Exeter. Due to the high elevations, it is not possible to maintain a minimum pressure of 35 psi at these locations, even when the tanks are at overflow. Therefore, based on the criteria adopted for this report, no active storage is available in the Main Service Zone to meet the system storage equalization requirements.

In practice, the Epping Road and Hampton Road tanks do help to meet the storage requirements of the water system. The tanks normally fluctuate up to 12 feet and provide storage to meet demands during periods when the water treatment plant is off-line (typically at night and on the weekends). In addition, there is storage within the tanks to help provide fire protection. However, under existing conditions, there are pressure deficiencies resulting from inadequate storage volume at the proper elevation.

Table 5-10 summarizes the available active storage for the Epping Road and Hampton Road Tanks.

Kingston Road Service Zone- Available Active Storage

Exeter has one tank available to meet the storage requirements for the Kingston Road High Service Zone. The Cross Road Tank has an overflow elevation of 224 feet (USGS) and a total capacity over 478,000 gallons.

The highest elevations served in the Kingston Road High Service Zone are approximately 130 feet (USGS). Under current operating conditions, the tank is allowed to fluctuate 15 feet. However, any fluctuations greater than 15 feet result in pressures lower than 35 psi at the highest elevations.

Cross Road Tank currently has adequate storage volume to provide the appropriate equalization and storage volume for the Kingston Road High Service Zone. However, by 2020 the storage requirements for this service zone will exceed the available storage volume in the Cross Road Tank. Therefore, under future conditions, there will be pressure deficiencies resulting from inadequate storage volume at the proper elevation.

Table 5-11 summarizes the available active storage for the Cross Road Tank.

5.4.3 Existing Pumping Station Analysis

5.4.3.1 Pumping Capacity Requirements

As mentioned above, when a distribution system relies on storage volume to meet peak hour demands, the total capacity of a pumping station should equal the maximum day demand of the service area with the largest pump out of service. If storage is not included in the system, the pumping capacity should meet system peak hour demands (with the largest pump out of service).

5.4.3.2 Analysis of Existing Pumping Facilities

Epping Road Pump Station

As mentioned above, the adequacy of pumping facilities is generally evaluated considering the largest pump is out of service. There is no storage available in the Epping Road High Service Zone, therefore, the pump station must be able to deliver peak hour flows. With the largest pump (315 gpm) out of service at the Epping Road pump station, the peak hour demands can still be met. The remaining pumps have a combined capacity of 450 gpm, which far exceeds the current peak hour demand of approximately 75 gpm.

The fire pump is powered by a diesel engine. When the pressure drops in the Epping Road High Service Zone (due to high demand, power outage, etc.) this pump will activate.

Kingston Road Pump Station

The two booster pumps at the Kingston Road pump station have a combined capacity of 280 gpm. There is also a smaller jockey pump located here, however, the design flow of this pump is unknown. The current maximum day demand in the Kingston Road High Service Zone is approximately 265 gpm. Therefore, when the largest pump is out of service, the remaining pumps are not adequate to meet maximum demands.

In addition, this station has no standby power capability.

5.4.4 Piping System Analysis

5.4.4.1 Piping System Requirements

Using the computer model, CDM analyzed Exeter's water distribution system, according to the design criteria discussed above. The conditions evaluated were:

- ***Maximum Day Demand Plus Fire Flow*** –This analysis evaluated the distribution system's ability to meet maximum day demands with a coincidental fire flow. Under these simulations, system demands equaled maximum day demands, the tank levels corresponded to those after 50% of the required equalization volume was withdrawn, the water treatment plant was providing maximum day flows, and Lary Lane Well was off.

- ***Peak Hour Demand*** – This analysis evaluated the distribution system's ability to meet peak hour demands. Under this simulation, system demands equaled peak hour demands, the tank levels corresponded to those after approximately 67% of the required equalization volume was withdrawn, the water treatment plant was providing maximum day flows, and Lary Lane Well was off.

- *Nighttime Refill* – This analysis evaluated the distribution system's ability to refill the tanks after a day of maximum demands. Under this simulation, system demands equaled 50% of maximum day demands, the tank levels corresponded to those after 50% of the required equalization volume was withdrawn, the water treatment plant was providing maximum day flows, and Lary Lane Well was off.

5.4.4.2 Analysis of Existing Piping System

Maximum Day plus Fire Flow

The capacity of the distribution system to provide adequate flow during fires is typically evaluated based on fire flow requirements established by the Insurance Services Office (ISO). The ISO is an association of insurance companies that compiles data used to establish rates for fire protection policies for both residential and commercial buildings. The ISO typically estimates fire flow requirements at several locations within a community. Locations are selected according to their relative representation of the overall fire flow requirements of the community. Therefore, only fire flow requirements for a small portion of the community are actually estimated by ISO.

Based on discussions with the Exeter Fire Department, the 1983 ISO Fire Flow requirements were used to analyze the water system facilities. The Fire Department does not have any requirements more stringent than ISO nor did they identify any locations were they thought additional fire flow analysis was warranted. Therefore, analyses were conducted to evaluate the distribution system's capacity to meet 2000 maximum day demands plus coincidental ISO fire flows. Fire flows were analyzed at each of the locations identified in the 1983 ISO report. Each simulation was evaluated based on the criteria established above, specifically; (1) the ability to provide the required fire flow under maximum day demand conditions, and (2) maintain a minimum residual system pressure of 20 psi. Fire flow deficiencies were noted at seven of the twelve ISO locations, as shown in Table 5-12 and Figure 5-2.

Peak Hour Demand

Simulations were conducted to evaluate the system's ability to meet 2000 peak hour demands. The analyses showed that the system cannot meet these demands while maintaining a residual system pressure of 35 psi or greater throughout the system. Many of the pressure deficiencies were noted along the eastern portion of Hampton Road. As noted previously, due to the high ground elevations in this area, it is not possible to maintain 35 psi based on the overflow elevation of the existing water storage tanks.

Location	ISO Required Fire Flow (gpm)	Available Fire Flow at 20 psi (gpm)	Adequate
Hampton Rd. & High St.	2,250	2,800	YES
Epping Rd. (north of Industrial Park)	2,500	3,700	YES
Main St. & Harvard St.	2,500	930	**NO**
Main St. & Center St.	2,000	3,780	YES
Lincoln St. (south of Daniel St.)	3,000	950	**NO**
Linden St. (south of Gill St.)	3,000	2,270	**NO**
Portsmouth Ave. (opposite Allen St.)	3,500	3,070	**NO**
Buzzel Ave. (at Hospital)	2,250	1,980	**NO**
High St. & Portsmouth Ave.	2,500	3,490	YES
Court St. & Maple St.	2,000	2,300	YES
Pine St. & Court St.	2,500	2,300	**NO**
Front St. & Parker St.	2,500	2,250	**NO**

Table 5-12
ISO Fire Flow Data and Deficiencies—Based on 2000 Conditions

Nighttime Refill

Under nighttime refill conditions, the system was unable to refill the Epping Road and Hampton Road tanks in an 8-hour period. Additionally, high headlosses along Main Street, Court Street, Front Street, and Epping Road caused unacceptably high simulated pressures (greater than 140 psi) at the water treatment plant. High headlosses typically result from inadequate piping capacity. To overcome the limited piping capacity, the model calls for supply sources to produce water at a higher pressure in order to 'force' it through the pipes. This analysis helped pinpoint the "bottleneck" in the pipeline network, which has prevented the two tanks from fluctuating properly together.

5.4.5 Summary of Existing System Deficiencies

Based on the analyses conducted on the existing pumping, piping, and storage facilities, the following conclusions were made regarding the adequacy of the existing system to meet current water system demands.

- The Kingston Road Pump Station has inadequate pumping capacity and does not meet current building code requirements.

- There is inadequate active storage in the Main Service Zone.
- Pressure deficiencies occur at the higher elevations along Hampton Road.
- Exeter's water distribution is not hydraulically well-connected. Inadequate piping capacity results in high headlosses in the downtown area, restricts flow to the Epping Road Tank; and complicates water treatment plant operations.
- Fire flow requirements are not met at seven of the twelve ISO fire flow locations.

Figure 5-2 summarizes the deficiencies in the existing distribution system.

As the existing distribution system is not able to able to meet the established performance criteria for 2000 demand conditions, recommendations were developed to address the existing distribution system deficiencies. The recommended improvements were then analyzed against 2020 demands to ensure that the distribution system would also meet future demands.

5.5 Results of System Hydraulic Analysis

The evaluation of Exeter's water distribution system, as presented above, identified four primary system goals that were the focus of the system recommendations:

- Increase active storage;
- Increase system pressures (i.e., maintain 35 psi throughout the system under normal operating conditions);
- Improve the hydraulic connection between the Epping Road Tank and the rest of the distribution system;
- Meet all ISO fire flows.

5.5.1 Summary of Results

5.5.1.1 Storage Improvements

Exeter has a significant active storage deficiency. As summarized in Table 5-10, the projected storage requirement for 2020 is 1.31 mg. Therefore, the cornerstone of the recommended improvements is a new 1.5 mg elevated storage tank.

In addition, the new tank will be used address the existing low pressure concerns in the Hampton Road area. By raising the overflow elevation of the new tank to 235 feet (compared to 205 feet currently), pressures along Hampton Road will increase by approximately 13 psi.

The increased tank overflow elevation will alleviate the low pressure (less than 35 psi) problems within the system, without creating a separate high pressure zone.

Historically, the Town has found the existing high service pump stations to be labor intensive. Therefore, they did not want to establish another high service pump station for the Hampton Road area. Raising the tank overflow will eliminate the need for an additional pressure zone in this area.

Three possible locations for a new tank were considered: a location on private property adjacent to the current Epping Road Tank, the existing Hampton Road Tank site, or at a Town-owned parcel near the Exeter Hospital complex. The existing Hampton Road Tank site is not considered a viable location because of site constraints. The lot is relatively small and highly visible. It would be difficult or impossible to construct a new tank on the site while keeping the existing tank in service. Therefore, this site was not given further consideration.

The parcel at the Hospital is already owned by the Town. While a tank could be erected on this site, it is a relatively small lot and is highly visible. In addition, the Hospital site is located close to the water treatment plant and there are hydraulic advantages to locating a tank further away from the supply source.

A lot adjacent to the Epping Road Tank is the third alternative. This site is located in the western portion of the system, therefore, it provides a good 'balance' with the water treatment plant located in the center of the system and the Hampton Road Tank located in the west. The abutters in this area are accustomed to having a water storage tank at this location, therefore, the siting approval process may be less difficult.

The lot adjacent to the existing Epping Road Tank site is considered the most viable alternative for a new tank. Therefore, the remaining analyses and piping recommendations were based on the assumption that a new 1.5 mg tank would be constructed at this location. If a different location were ultimately chosen by the Town, the piping recommendations should be reviewed and modified, if necessary.

Modification of Existing Facilities

Constructing a new tank with an overflow elevation of 235 feet will increase the hydraulic gradeline of the entire distribution system. Therefore, modifications to existing system facilities are necessary in order for these facilities to operate at the increased gradeline.

The existing Epping Road and Hampton Road Tanks will not be able to flow into the distribution system by gravity when the system hydraulic gradeline is increased. The existing Epping Road Tank should be removed, as it will no longer be needed when the new tank is constructed. The Hampton Road Tank, however, provides additional fire flow and equalization storage for the eastern portion of the system, therefore it is recommended to keep this tank in service. An in-ground booster pump station will be necessary to pump water from the Hampton Road Tank into the system. The "station" could be a submersible pump within a can, removable from the ground surface for maintenance. This station will pump into the system during high daytime demand periods and refill at night by gravity. Fire flow pumps will not be required with this pump station because if a major fire were to occur in this area, the hydraulic gradeline would drop below the overflow of the Hampton Road Tank and allow it to drain by gravity into the system.

The overflow of the Cross Road Tank in the Kingston Road High Service Zone is 224 feet. Currently, this tank overflow is 19 feet ***above*** the overflow elevation in the Main Pressure Zone. However, the Cross Road Tank overflow will be 11 feet ***below*** that of the new tank proposed on Epping Road. As the Cross Road Tank provides additional equalization and fire flow to the Kingston Road area it is recommended to remain in service. To keep this tank in service, it is recommended to phase-out the existing booster pump station on Kingston Road and replace it with a control valve. This control valve would open on a daily basis to allow flow from the Main Pressure Zone to fill the Cross Road Tank. The valve would then close and the Kingston Road area would continue to be fed from the Cross Road Tank.

The overflow elevation of the new tank would be adequate to maintain 35 psi in the Epping Road High Service Zone without booster pumping. However, as there is a significant amount of commercial development in this area accustomed to higher water pressures, booster pumping should be continued during high demand periods. But it may be possible to feed this zone by gravity during off-peak periods. The Town will be able to phase-out the fire pump at the Epping Road Pump Station because, as with the Hampton Road Tank, if a major fire were to occur in this area, water would be able to flow out of the new Epping Road Tank by gravity.

Modifications will also be required to the finished water pumps at the water treatment plant and to the Lary Lane Well pump. The head on these pumps will need to be increased to allow them to pump up to a higher tank elevation.

Impact of Increased System Pressures

The increased hydraulic gradeline will result in increased pressures throughout Exeter. The lowest points in Exeter's distribution system are approximately 10 feet above mean sea level. Therefore, a new tank with an overflow of 235 feet will result in static pressures of approximately 98 psi at these locations. While this pressure is higher than those currently experienced in Exeter, many other systems with the same pipe materials successfully operate at much higher pressures.

As previously noted, there are two PRVs located on Michael Avenue and Colcord Pond Drive in the Epping Road High Service Zone. These PRVs are necessary because some of the service pipes in this area are not able to withstand the current operating pressures. Accordingly, when these service pipes are replaced, the Town should de-activate the PRVs.

An increased tank overflow elevation will also result in an increased discharge pressure at the water treatment plant and the Lary Lane Well to account for the higher tank overflow. The highest discharge pressures are typically observed under nighttime tank refill conditions. When all the recommended piping improvements are implemented, the maximum discharge pressure will be approximately 110 psi. Currently, the water treatment plant operators do not operate at discharge pressures over 100 psi. However, based on discussions with the plant operators, this limitation is attributable to: plant capacity (currently the plant is unable to sustain the flows required to achieve the higher pressures) and the poorly connected piping network (water cannot be distributed throughout the system, which is especially problematic when the altitude valve on the Hampton Road Tank is closed). A plant discharge pressure of 110 psi is not considered excessive by standard waterworks practices, and with the construction of the new tank and related piping improvements (discussed below), the distribution system should be able to operate successfully at the higher pressures.

5.5.1.2 Piping Improvements

Piping improvements are required to improve the hydraulic connection between the new Epping Road Tank and the rest of the distribution system. In addition, piping improvements are required to increase available ISO fire flows. All the piping recommendations are based on the assumption that a new tank will be located on Epping Road. If a new tank location is selected by the Town, the piping recommendations should be reviewed.

Increasing the overflow elevation of the tank significantly improves available fire flows, however, three ISO fire flow locations are still deficient:

- Lincoln Street at the Lincoln Street School
- Harvard Street at Main Street
- Linden Street at the High School.

Therefore, piping recommendations were developed to meet the fire flow requirements at these locations.

To eliminate fire flow deficiencies, an 8-inch main on Lincoln Street, a 12-inch main on Main Street (from the existing 16-inch main on Water Street to Cass Street), and a 12-inch main on Cass Street are recommended. While an 8-inch main on Lincoln Street is adequate to meet the ISO fire flow requirements, a 12-inch main would provide increased benefits and could be considered by Exeter if desired. The new piping configuration will connect the existing 16-inch on Water Street to the existing 10-inch main on Park Street. This will provide the required fire flows at the Lincoln Street School and the High School and will improve the hydraulic connection between Epping Road Tank and the distribution system.

In order to meet the fire flow requirement on Harvard Street, a 12-inch main on Epping Road and Main Street (from Park Street to Harvard Street) is required. However, Harvard Street is primarily a residential area and the Fire Department does not know why a 2,500 gpm ISO fire flow is required at this location. It is possible that a fire flow of this magnitude is no longer required here. Therefore, it is recommended that the Town determine the current fire flow requirement for this location prior to constructing a new main on Epping Road and Main Street.

A new main in parallel with the existing 10-inch cast iron main on Epping Road (from Columbus Avenue to the tank) is recommended to further improve the connection of the Epping Road tank to the distribution system. This main will reduce the high headlosses that currently occur through the existing pipe.

The piping recommendations described above satisfy the maximum day demand plus fire flow, peak hour, and nighttime refill demand conditions for the year 2000 and for the year 2020. Figure 5-3 summarizes the recommended distribution system improvements.

5.5.1.3 Impact of Improvements on Plant Operations

The new water storage tank and associated water main improvements will improve plant operations by improving the hydraulic connection between the water treatment plant and system storage facilities. Currently, the two existing water tanks do not fluctuate together because of the poor hydraulic connection between the WTP and the Epping Road Tank. Therefore, the operators have to continually monitor and modify plant operations based on tank levels. For example, when the altitude valve on Hampton Road closes, plant flow needs to be reduced, even if the Epping Road Tank is still 10 feet below overflow. This occurs because the undersized mains in the central and western portions of the system are not able to convey high volumes of flow to the Epping Road Tank, i.e., the low tank level represents a system demand however, the distribution system is unable to deliver the flow to meet that demand.

Additionally, there are frequent low pressure complaints in Exeter when the water tank levels drop. A larger storage tank at a higher elevation will alleviate these complaints.

5.6 Recommended Improvements Program

The recommended improvements program, summarized in Table 5-13, is arranged in three categories: Immediate Recommendations, Phase I Capital Improvements, and Phase II Capital Improvements. Immediate Recommendations address hydrant and valve maintenance programs. Phase I Capital Improvements address the four primary deficiencies identified in the hydraulic analysis (storage, pressure, hydraulic connection within the distribution system, and fire flows). Phase II Capital Improvements address overall system reliability, looping, and pipe rehabilitation projects. Recommendations for system expansion and possible system interconnections are also included in this section.

RECOMMENDED SYSTEM IMPROVEMENTS

1) Increase 'active' storage
2) Raise hydraulic gradeline to improve pressures
   - Phase-out Kingston Road Booster Station
   - Phase-out Epping Road Fire Pump
3) Replace mains to meet fire flow requirements and better connect the Epping Rd. Tank to the System
4) Hydrant and valve maintenance programs
5) Pipe reliability [i.e., single main on Portsmouth Ave.; High St.]
6) Pipe rehabilitation [i.e.,CI mains >70 years old]
7) Pipe looping

CDM

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Figure 5-3

Recommended Water Distribution Improvements

Priority	Description of Improvement
Immediate	
Hydrant and valve maintenance program	Annual valve exercising and hydrant flushing programs
Phase I Capital Improvements	
Increase active storage and raise system pressures	New 1.5 mg elevated water storage tank; remove existing tank at Epping Road Site; increase head on WTP finished water pumps and Lary Lane well pump; new tank booster station at Hampton Road Tank; phase-out Kingston Road Booster Pump Station; phase-out Epping Road fire pumps.
Improve hydraulic connection of tank to the distribution system and improve ISO fire flows	Approx. 3800’ new 12” water main on Epping Rd. (tank to Park St.), Cass St., and Main St. (Cass St. to Water St.).
Improve ISO fire flows	Approx. 900’ new 12” water main on Epping Rd./Main St. (Park St. to Harvard St.); approx. 2200’ new 8”water main on Lincoln St.
Phase II Capital Improvements	
Improve system reliability	Provide redundancy in key areas where the integrity of the distribution system relies on a single water main.
Pipe rehabilitation	Replace/line old cast iron water mains.
Pipe looping	Loop dead end mains.

Table 5-13
Prioritized Summary of Recommended Distribution System Improvements

5.6.1 Immediate Recommendations

Hydrant and Valve Maintenance Program

There are many problems in the distribution system that can be resolved by implementation of a comprehensive valve and hydrant maintenance program. No program can deliver a better return on investment to Exeter than this, given the relatively limited costs and the benefits to fire flows and water system performance from such work. This is especially significant given the number of closed valves that were identified during the field testing program.

The Town is initiating a comprehensive valve exercising program in the fall of 2001. It is the Town’s goal to operate every valve once a year. This will ensure that no valves are inadvertently left closed after they were closed during construction, for a water main break or for other maintenance activities.

The Town is also initiating a more rigorous hydrant maintenance program in the fall of 2001. It is the Town's goal to operate every hydrant at least once a year. We recommend, that in addition to operating every hydrant, the hydrant flushing procedures be reviewed to ensure that appropriate flushing velocities are achieved. During hydrant flushing, valves should be closed to allow uni-directional flushing in the main being flushed. Such uni-directional flushing programs are considerably more effective than other approaches.

5.6.2 Phase I Capital Improvements

Phase I Capital Improvements include all the recommendations to improve the deficiencies noted during the hydraulic analyses. The four primary recommendations are: increase available storage, increase system pressures, improve the connection of the Epping Road Tank to the distribution system, and improve fire flows.

These recommendations were discussed in detail in Section 5.5 and are summarized in Table 5-14.

5.6.3 Phase II Capital Improvements

Phase II Capital Improvements include recommendations for general piping system rehabilitation, including replacing and/or cleaning and lining unlined cast iron mains, providing system redundancy, replacing under-sized mains, and minimizing dead end mains. Table 5-15 summarizes the Phase II capital improvements and the estimated cost.

5.6.3.1 Pipe Rehabilitation - Higher Priority

As discussed previously, a significant portion of Exeter's distribution system is unlined cast iron. Many of these mains are at least 75 years old and have experienced a reduction in carrying capacity due to tuberculation. The carrying capacity of these pipes will continue to be reduced as metallic salts continue to deposit on the interior walls of the pipe.

Structural integrity of very old pipes (100 years) is also questionable. Exterior corrosion can weaken the strength of the pipe wall, increasing the likelihood of a break, especially in areas of the system where the pressures are high. Leakage through joints and service connections is also more prevalent in older pipelines due to settlement over the years, especially in heavily traveled roadways. Systems with a high amount of old, unlined piping generally have a higher percentage of unaccounted-for water.

Location	Description of Improvement	Reason for Improvement	Planning Cost (Year 2003)
Increase Tank Elevation and System Pressures			
Epping Road Tank Site	1.5 mg elevated storage tank; remove existing tank.	Increase equalization and fire flow storage; improve system pressures.	$3,169,000
Kingston Road	Phase-out Kingston Road Booster Station. 8" control valve on Kingston Rd.	With increased pressure, a pump station will not be necessary at Kingston Road. A control valve will be used to fluctuate the Cross Road Tank.	$230,000
Water Treatment Plant and Lary Lane Well	New bowl assemblies and larger impellers for the finished water pumps. New pump at the well.	With the increased pressure, the finished water pumps will have to pump against a higher head.	$52,000
Hampton Road Tank	Tank booster pumps	With the increased pressure, the Hampton Road Tank will have to be pumped into the system. No booster pumping will be required under fire flow conditions.	$85,000
TOTAL			**$3,536,000**
Improve Hydraulic Connection Between Epping Road Tank and Distribution System and Improve ISO Fire Flows			
Epping Rd.	Approx. 1300' new 12" water main (tank access road to Park St.), existing main to remain in service.	Improve hydraulic connection of the tank to the distribution system.	$190,000
Cass St.	Approx. 800' new 12" water main (Park St. to Main St.), replace existing main.	Improve hydraulic connection of the tank to the distribution system.	$120,000
Main St.	Approx. 1700' new 12" water main (Cass St. to 16" main on Water St.), replace existing main.	Improve hydraulic connection of the tank to the distribution system.	$250,000
TOTAL			**$560,000**
Improve ISO Fire Flows (CDM considers these slightly lower in priority than the preceding recommendations)			
Lincoln St.	Approx. 2200' new 8" water main (Main St. to Front St.), replace existing main.	Improve fire flows at the Lincoln Street School (based on ISO requirements).	$290,000
Epping Rd./ Main St.[1]	Approx. 900' new 12" water main (Park St. to Harvard St.), replace existing main.	Improve fire flows at Main St. and Harvard St. (based on ISO requirements).	$130,000
TOTAL			**$420,000**

[1] The improvement on Epping Road is designed solely to meet this fire flow therefore the requirement should be further researched prior to implementing this recommendation. See text for additional discussion regarding the need for this main.

Note: Costs include allowances for engineering and contingencies but not for land acquisition, easements, or legal fees. Costs assume midpoint of construction in mid-2003 and do not include inflation beyond that time.

Table 5-14
Recommended Phase I Distribution Improvements

Location	Description of Improvement	Cost
Pipe Rehabilitation- Higher Priority		
Park St.	Clean and line approx. 3300' of existing 10" CI main (Epping Road- Water St.).	$280,000
Columbus Ave./ Railroad Ave.	Clean and line approx. 2700' of existing 10" CI main (Epping Rd.- Front St.).	$230,000
Cross-country transmission main	Clean and line approx. 2100' of existing 12" CI transmission main between Portsmouth Ave and the String Bridge.	$200,000
Water St.	Replace approx. 1200' of existing 6" CI/6" AC main with new 12" main (Main St.- Park St.)	$180,000
Court St.	Replace approximately 300' of existing 6" CI main with new 12" DI main (Front St. – Bow St.)	$42,000
Improve System Reliability		
Provide redundancy on Portsmouth Ave.	Approx. 1300' new 12-inch transmission main on Portsmouth Ave. (WTP to Hospital) or 5000' new 12-inch main on Holland Way (Portsmouth Ave.- Hampton Rd.)	$190,000/ $740,000
Replace 4-inch Cast Iron Mains		
Throughout distribution system	Replace all 4" unlined cast iron water mains with 8" water mains	Long-term program - see text
Pipe Looping		
Throughout distribution system	Provide pipe loops to minimize dead-end water mains	Long-term program - see text
Pipe Rehabilitation- Long Term		
Throughout distribution system	Replace (or line) all remaining unlined cast iron pipe	Long-term program - see text

Note: Costs include allowances for engineering and contingencies but not for land acquisition, easements, or legal fees. Costs assume midpoint of construction in mid-2003 and do not include inflation beyond that time.

Table 5-15
Recommended Phase II Distribution System Capital Improvements

Good waterworks practice suggests that a program to either clean and cement mortar line or to replace old, unlined piping with new, cement lined ductile iron pipe should be implemented. CDM has divided the existing unlined mains into three system rehabilitation programs.

While the reduction of pipe carrying capacity due to tuberculation is a significant problem for all unlined pipes, it is especially critical for unlined transmission pipes. Transmission pipes are the 'backbone' of the distribution system and a capacity reduction in these pipes can impair the systems ability to move water and meet customer demands. Accordingly, CDM has identified key unlined cast iron transmission mains in Exeter's system: the 10-inch main on Park Street, 10-inch on Columbus Avenue/Railroad Avenue, 12-inch cross-country main from Portsmouth Avenue to the String Bridge, and the 6-inch main on Water Street. To improve the carrying capacity of the distribution system, these mains should be either replaced or cleaned and lined, as suggested in Table 5-15. Additionally, a small segment of the Court Street water main is included in the program, as DPW reports it has been prone to breakage.

5.6.3.2 System Reliability

Good waterworks practice recommends that water distribution systems should contain redundancy, i.e., reliance on a single transmission main should be avoided. A critical main in Exeter's distribution system that has no redundancy is the transmission main on Portsmouth Avenue from the water plant to the hospital. If this main should break or otherwise be damaged, between the treatment plant and the Hospital, there is no alternative piping network to supply water to the rest of the distribution system. Therefore, a new 12-inch parallel pipe on Portsmouth Ave. or a 12-inch main on Holland Way (from Portsmouth Avenue to Hampton Road) is recommended. Either alternative would provide redundancy for the critical transmission main on Portsmouth Avenue. Additionally, a new main on Holland Way would provide service to any future development on this road and provide redundancy for the transmission main on High Street.

5.6.3.3 Undersized Mains

Cast Iron Mains

Exeter has a significant amount of 4-inch diameter unlined cast iron mains. These mains are heavily tuberculated and are undersized for serving the existing service area. Four-inch mains do not provide fire protection benefits and the Fire Department has stated that they are not able to use the hydrants located on these mains. Therefore, if a fire occurs on a street with a 4-inch main, they have to extend a hose to the nearest hydrant located on a main at least 6-inches in diameter. There are locations where this corresponds to an additional 1,200 feet of hose and hinders the Fire Department's ability to extinguish the fire. Therefore, an annual program should be established to replace these mains with 8-inch diameter ductile iron mains, in coordination with the Town's other sewer, utility, and road projects and as available funding allows.

Table 5-16 summarizes and prioritizes the replacement of unlined 4-inch diameter pipes in Exeter. The priority for replacement is based on the length of the main, the material of the surrounding mains, and the proximity to fire protection. For example, a 'cluster' of unlined cast iron mains (e.g., the Oak Street area) is a higher priority for replacement than an area with a single cast iron main. Additionally, a long cast iron main or a main without an adjacent fire hydrant are also higher priorities. Accordingly, such mains were assigned as First Tier priorities, while the rest were assigned as Second Tier.

Also included in this table are the 4-inch diameter ductile iron mains in the Bow Street area. These mains were included in the table because these mains provide service and fire protection to a portion of the downtown commercial area.

Additional Undersized Mains

There are several areas within Exeter that are served by 1- and 2-inch diameter copper water main. If fire protection is desired in these areas, the existing main should be replaced with a minimum 8-inch diameter ductile iron main.

Street	Length of Pipe (feet)
1st Tier Recommendations	
Bow Street[1]	500
Clifford Street[1]	600
Forest Street	700
Garfield Court	300
Garfield Street	800
Hall Court	300
Hall Place	1,000
Kossuth Street	500
Oak Street	900
Pleasant Street	500
River Street	400
River Street[1]	300
Salem Street	200
School Street	700
Union Street	800
Walnut St.	1,000
TOTAL	**9,500**
2nd Tier Recommendations	
Chestnut St.	300
Cottage St.	400
Daniel St.	300
Elm St.	900
Grove St.	900
Maple St.	500
Marlboro St.	400
Spring St.	700
Tremont St.	400
Winter Street	700
TOTAL	**5,500**

[1] 4-inch ductile iron mains

Table 5-16
Summary of Unlined 4-inch Diameter Cast Iron Mains

5.6.3.4 Pipe Looping

In addition to the improvements discussed above, CDM recommends that the Town implement a program to install new 8-inch diameter mains to loop existing dead end mains. Eliminating dead end mains typically improves available fire flows and water quality.

Table 5-17 summarizes areas of pipe looping to eliminate dead end mains.

All the mains recommended for pipe looping are smaller distribution mains; therefore all the improvements are of equal priority. Many of the streets recommended for pipe looping are also included in the pipe rehabilitation recommendations. Therefore, these pipe looping projects can be combined with other pipe replacement projects.

5.6.3.5 Pipe Rehabilitation - Long Term

Exeter should eventually replace or clean and line the remaining 6- and 8-inch diameter unlined cast iron mains in the distribution system. These pipes play a less significant role in the distribution system than the transmission mains, however, replacement of these mains is still warranted as field testing indicated that tuberculation has occurred in these mains. The conditions of these mains will continue to deteriorate, therefore, an annual program should be established to replace these mains with an 8-inch diameter ductile iron main, in coordination with the Town's other sewer, utility, and road projects.

Table 5-18 summarizes and prioritizes the replacement of unlined cast iron mains in Exeter. The priority for replacement is based on the significance of the main in the distribution system (i.e., a transmission main versus a distribution main) and the length of the main. For example, a long cast iron transmission main (e.g., Court Street) is a higher priority than a shorter distribution main (e.g., Shady Lane). Any areas with water quality complaints related to unlined cast iron pipe should also be a higher priority.

5.6.4 Implementing Pipe Rehabilitation Programs

The total length of water main in the programs described above is over 72,000 feet, or about 28% of the Town's water system. These types of pipe rehabilitation programs can only be addressed over a period of time, which may involve several decades.

There are two basic strategies for implementing such programs. The first is to set aside a given amount of funds for the programs on an annual basis. The Town could elect to either perform some rehabilitation work each year or, alternatively, to collect two or more years of revenue to perform a larger rehabilitation project every few years, thereby realizing some economies of scale. Standard specifications, details, and bidding documents can be prepared for use by the DPW on a repeated basis over the years, accordingly the engineering effort associated with these programs will be minimized. For this strategy, the prioritizations suggested in this report would be followed.

Street From	Street To	Length of Pipe (feet)
Ann's Lane	Towle Avenue	100
Bittersweet Lane	Green Hill Road	300
Browns Court	River Street	250
Comings Court	Whitley Road	150
Downing Court	Leary Court	300
Folsom Court	Fox Chapel Court	300
Fox Chapel Court	Holly Court	400
Garfield Court	Lincoln Street	150
Granite Street	Ridgewood Terrace	250
Haven Lane	Bittersweet Lane	250
Haven Lane	Douglass Way	300
Holly Court	Laurel Court	300
Jady Hill Circle	Jady Hill Court	150
Locust Avenue	Walnut Street	150
Marlboro Street	Gardiner Street	400
Minuteman Lane	Boulder Rock Road	1,000
Robin Lane	Sleepy Hollow Road	100
Rocky Hill Lane	Sleepy Hollow Road	250
Scammon Lane	Westside Drive	150
Stevens Court	Leary Court	300
Tilton Avenue	Westside Drive	100
Vine Street	Carroll Street	50
Vine Street	Charter Avenue	50
Wadleigh Street	Salem Street	150
Webster Avenue	Douglass Way	300
Westside Drive	Leperle Lane	150
TOTAL		**6,350**

Table 5-17
Recommended Pipe Looping

Table 5-18: Long-Term Pipe Rehabilitation Projects

Street	Length of Pipe (feet)
1st Tier Recommendations	
Auburn Street	1,300
Bell Avenue	1,800
Buzzel Avenue	600
Court Street (Front Street to Bell Avenue)	3,300
Elliot Street	1,000
Epping Road (Park Street to Main Street)[1]	700
Epping Road (Tank to Park Street)	2,200
Front Street (Center Street to Railroad Avenue)	4,000
Jady Hill Avenue	2,200
Main Street (Harvard Street to Cass Street)[1]	1,500
McKinley Street	1,000
Pine Street	1,700
Ridgecrest Drive	1,100
Ridgewood Terrace	1,000
South Street	1,000
Summer Street	1,300
TOTAL	**25,700**
2nd Tier Recommendations	
Appledore Avenue	600
Arbor Court	300
Arbor Street	400
Blossom Lane	300
Carroll Street	600
Chestnut Street (Jady Hill to String Bridge)	900
Country Lane	300
Dartmouth Street	300
Franklin Street	600
Gil Street	900
Granite Street	500
Harvard Street	800
Langdon Avenue	700
Meadow Lane	600
Myrtle Street	500
Park Street (south)	400
Parker Street	400
Prospect Avenue	300
Prospect Street	700

Table 5-18: Long-Term Pipe Rehabilitation Projects

Street	Length of Pipe (feet)
River Street Extension	300
Rockingham Street	300
Salem Street (Oak Street to Summer Street)	600
Sanborn Street	700
Shady Lane	600
Star Avenue	200
Vine Street	500
Warren Avenue	500
Winter Street (Main Street to Railroad Avenue)	800
Whippoorwill Lane	500
Whitely Road	500
TOTAL	**15,600**

[1] If required, portions of these mains may be replaced as part of the ISO fire flow improvements

Table 5-18
Long-Term Pipe Rehabilitation Projects

A second basic strategy is to focus from year-to-year on streets which have other utility work being performed. Each year in Exeter there are certain streets which are scheduled to have sewer, drainage, gas, paving, or other infrastructure improvements performed. Whenever such a street also contains a water main identified in this report section, the rehabilitation of that pipe can be pursued at the same time as the other improvements to reduce the overall cost. In this strategy, the overall prioritization of programs suggested in this report is considered of less importance.

We recommend that Exeter consider a combination of these two strategies. We recommend an annual appropriation of funds to provide a regular rehabilitation program, with construction occurring either as an annual program or every 2-3 years. Based on its overall financial status, Exeter could either start this set-aside immediately, or wait until after the WTP improvements program. The projects which are included in each construction package may include some of the higher priority rehabilitation projects identified herein, or may include streets in which work is already being scheduled for other reasons, or a combination of both. This decision would have to be made at the time each construction package was being designed, based on DPW's sense of priorities at that time.

Based on the magnitude of work need, and assuming a 40-year time frame for completion, an annual appropriation of $200,000 is suggested, adjusted upward each year for inflation. Even if this level of funding cannot be achieved, it will be to the Town's advantage to make whatever annual appropriation is possible to begin to address the most serious rehabilitation projects.

5.6.5 Distribution System Expansion

Currently, Exeter's distribution system services about 75% of the Town's population. Service may ultimately be extended to all areas of Exeter and 2020 water demands, established in Section 2, are based on providing service to the entire Town. Therefore, possible piping alternatives to provide water service to the areas outside the existing service territory are summarized below.

North of Route 101

The area of Exeter north of Route 101 is an area where significant residential and commercial growth is anticipated to occur, particularly in the areas of Epping Road, Watson Road, and Beech Hill Roads. Service would be provided to this area from the existing 12-inch diameter main on Epping Road. A new 12-inch main is recommended to extend from the existing main in Epping Road, over Route 101, along Watson Road. A 12-inch main will also extend parallel to Route 101 to Old Town Farm Road. Twelve-inch diameter mains are also recommended for Old Town Farm Road, Beech Hill Road, and Oaklands Road because of the relatively long pipe runs and the associated high headlosses. A 12-inch diameter main is also recommended for Newfields Road. It may be possible to use the existing power line easement or future subdivisions to loop the proposed 12-inch main on Newfields Road to the 12-inch main on Watson Road.

The elevations north of Route 101 range from approximately 120 feet to 210 feet above mean sea level. The hydraulic gradeline of the Epping Road High Service Zone is approximately 258; therefore this high service zone will only be able to serve elevations up to about 180 feet (in order to maintain 35 psi minimum system pressure). The highest building elevation north of Route 101 is approximately 220 feet, off Watson Hill Road. However, with the exception of this limited area off Watson Hill Road, the highest point in this potential service area is only about 150 feet. Therefore, because the existing Epping Road Pump Station can only provide service up to 180 feet, it will be necessary to either increase the hydraulic gradeline of the entire Epping Road Booster Station (to about 300 feet) or create a new service zone to serve just the Watson Road area. As the high elevation area is very limited, and increasing the hydraulic gradeline of the entire service zone to 300 feet will result in several areas having operating pressures of 100 psi, it is recommended that a separate high service zone serve the area above 150 feet. The Epping Road Booster Station (at the current hydraulic gradeline) can serve the remaining areas north of Route 101.

A tank will be needed to provide equalization and fire flow for the service area north of Route 101. A potential site for a new tank is Oakland Hill, which is the local high point with an elevation of about 240 feet.

South of Route 101

Areas south of Route 101 that are not served by the existing distribution system are primarily located west of Kingston Road, along Brentwood Road, Dogtown Road, Kingston Road, Cross Road, and Pickpocket Road. The highest elevations in this area are about 125 feet. Therefore, the areas west of Kingston Road can be served from the Main Service Zone. Drinkwater Road, located south of High Street, can also be served from the Main Service Zone.

A 12-inch diameter main is recommended to extend along Brentwood Road to Dogtown Road. This main will dead end at the Exeter town line on Dogtown Road unless the main is extended in a large loop though Brentwood to Pickpocket Road. An 8-inch diameter main is also required on Drinkwater Road.

In order to provide adequate fire flow on Kingston Road, a 12-inch main is recommended to extend along Kingston Road to the town line. An 8-inch main is recommended along the unserviced portion of Cross Road. A 12-inch main is required on Pickpocket Road in order to provide adequate fire flow, if the main dead ends at the town line. However, if the main is looped to the existing 10-inch main on Cross Road (requiring about 700 feet in Brentwood), an 8-inch main would be adequate.

5.6.6 System Interconnections

An interconnection with an adjacent water system would provide significant benefits to Exeter because it would provide the Town with an additional source of supply during an emergencies. Also, the DES and other regulatory and funding agencies view interconnections favorably.

CDM performed an interconnection analysis for Hampton Water Works in September 2001. That report is included as Appendix J. CDM recommends that Exeter continue the on-going discussions with Hampton Water Works regarding the feasibility of establishing the interconnection proposed in the report.

Section 6
Implementation

6.1 Introduction

Town officials' review of this report will begin the process of implementing the report's various recommendations. Implementation includes considerations related to prioritization, schedule, and funding. This section is intended to summarize various information relevant to the implementation process for use by Town officials. It is recognized, however, that implementation strategies will continue to evolve over the coming months and years, and that this report can only provide a starting point for those discussions.

6.2 Prioritization

From the numerous discussions among DPW officials and CDM, it is clear that the construction of a new Water Treatment Plant is the highest-priority issue to arise from this study. As discussed in Section 4, the estimated cost range for this project is $16 to 20 million, in 2005 dollars. This cost range will be refined in upcoming work, as discussed below in Section 6.4.

From Table 5-15, the highest-priority distribution system improvements were those related to the proposed new water storage tank, and associated water mains:

Facilities to Increase Tank Elevation and System Pressures	$ 3,536,000
Facilities to Improve Hydraulic Connection to New Tank	$ 560,000
Total (2003 dollars)	$ 4,096,000
Total (2005 dollars)	$ 4,430,000

The decision on whether these distribution system improvements can be considered at the same time as the WTP program will depend in part on the Town's upcoming evaluation of the amount of indebtedness which can be incurred. If the Town can determine it to be financially feasible, CDM recommends that these high-priority distribution improvements be considered in the same funding package as the WTP program. The availability of the tank would greatly ease operation of the existing or future WTP, as sufficient storage capacity would be present to allow the WTP to continue to operate during off-peak hours to fill storage. This will smooth out the variations in WTP flow rates, and will eliminate the current need to shutdown the WTP on a near-daily basis when the Hampton Road tank fills.

Assuming the continued use of the Lary Lane Well, CDM would recommend that the safety-related improvements discussed in Section 3.8 also be included in the high-priority package. The estimated cost was $15,000. Because this amount is so small, it is not separately identified in the Capital Improvement Program discussed below.

The next-highest priority is the need for a long-term pipe rehabilitation program to address the many needs discussed earlier in this report. Such a program may require decades to address all the mains of concern. If, for example, the Town were to attempt to address all concerns listed in Section 5 over a 20-year period, an annual appropriation of $400,000 (2001 dollars) would be needed. If Exeter were to determine that this level of funding is not achievable, we would recommend an achievable annual appropriation be set aside for this purpose.

The above projects form the basis of a major Capital Improvement Program, as shown in Figure ES-1 in the Executive Summary.

6.3 External Financing

Exeter's implementation of the Capital Improvements Program would be greatly aided if external funding sources can be secured to cover part of the costs. CDM researched funding opportunities on the federal and state levels, and prepared a funding memorandum which is included in Appendix K. The review is summarized below:

- The New Hampshire Department of Environmental Services (NHDES) administers the federal State Revolving Loan Fund (SRF) for drinking water projects. No grant funds are available through this program, but low-interest loans can be secured. The current rate is 4.464% for a 20-year loan. We expect the WTP construction program would be eligible for this program. The water storage tank construction may not be eligible, as projects related to growth or fire flow improvements are excluded. Exeter should nevertheless discuss this issue further with NHDES; the lack of storage capacity affects WTP operability, thus providing a connection between the two projects in Exeter's case.

- "Disadvantaged systems" can receive 15-30% forgiveness of principal through the SRF program. The determination of a "disadvantaged system" is based on existing user costs, median community income, and projected water rate increases. Exeter should work with NHDES to determine its eligibility for this benefit.

- To help fund the 1993-94 WTP upgrade program, Exeter received a 20% construction grant from NHDES under the Water Filtration Grants Program (Env-Ws 382). According to NHDES, communities are eligible to use this program only once, hence it is currently not available to Exeter. With the continuing development of new federal regulations affecting filtration and disinfection of surface water sources, CDM expects that many New Hampshire communities will face additional WTP upgrades or replacements in the next 5-10 years. CDM recommends that Exeter, perhaps in consultation with similarly-affected communities, seek a modification to the 20% filtration grant program to allow communities to utilize the program a second time.

- CDM had further discussions with NHDES on regionalization and funding issues in December 2001. Statewide concerns over proposals for large commercial water withdrawals, the September 11, 2001 terrorist attacks, and the drought conditions of summer 2001, are pushing the Governor's Initiative for water supply regionalization, water conservation, and large groundwater withdrawals in New Hampshire to the forefront. Exeter's future capital improvements could be affected as follows:

  - NHDES plans to attempt to convene the Seacoast Water District (of which Exeter is allowed to be a member, per Chapter 42 of the Laws of 1995) to initiate discussions on regional water supply issues in the southern tier of the state, and particularly in the Seacoast region.

  - Quoting from a summary provided to CDM by NHDES, "Legislation will be proposed to expand eligibility for state-aid water supply grants to include projects with significant regional water benefit, and especially emergency interconnections to improve the state's preparedness for natural or manmade disasters such as terrorist attacks that impact public water supplies." This would certainly be applicable to a future Exeter-Hampton interconnection, and it may also apply to the proposed new WTP as a capacity/reliability benefit to regional users (i.e., Exeter and Hampton).

- There are several federal programs that have offered a very limited number of grants for waterworks programs to selected communities as part of the federal annual budget. Exeter could seek to have its U.S. Senators and Representative attempt to secure such funding. Appendix K has more information on these programs.

6.4 Implementation Schedule

In Section 4, a WTP implementation schedule was presented on Figure 4-7. The bottom half of that figure illustrated several issues that have led us to recommend immediate pursuit of this project:

- There is a continuing risk of flooding and WTP shutdown, given the WTP's vulnerable location. This is a concern to DPW during every major storm.

- The Stage 1 Disinfection Byproducts (DBP) Rule will come into effect in December 2001. Stricter standards for DBPs will be enacted, and Exeter will not be in compliance. Capital improvements to improve the plant processes are needed to achieve compliance. It is expected that NHDES would allow Exeter to delay full compliance, provided that a plan for WTP renovation or replacement is being pursued. Still-stricter DBP regulations under the proposed Stage 2 rule are expected in 2008.

- Additional monitoring for microbiological contaminants is expected to be required in 2003. Exeter has already decided to pursue such monitoring in 2002, starting a year ahead of the expected mandate, to provide information that ultimately will be needed for final design of process improvements.

- Exeter's maximum day demand already exceeds the capacity of existing WTP clarification process, based on the historical practice of 18 hour/day operation. Around 2007 the maximum day demand will exceed the clarification capacity even with 24 hour/day operation.

The top half of Figure 4-7 illustrates the schedule of the major project implementation activities, summarized below.

2002 – Preliminary Design Phase.
Before the final design can begin, a number of preliminary design issues must be resolved. These include selection of the WTP process train, final site selection, resolution of access issues, selection of basic site layout, building type and appearance, and more.

These preliminary design activities can be conducted in several phases, if preferred by the Town. The Town's current plan is to conduct a Phase 1 preliminary design starting this fall. This work is expected to include:

- Development of a topographic map of the probable WTP site, including mapping of wetlands.

- "Fatal flaw" analysis to determine if there are any siting, permitting, or access issues that would preclude the use of the site for a new WTP.

- Comparison of treatment process trains on a life cycle cost basis. This work would be based on operating experience and literature values of process costs. The results of this review would determine the need for, and cost of, any pilot treatment testing efforts.

Phase 2 preliminary design would include pilot testing of one or more processes, if needed. Once the process was selected, a building footprint and site layout would be developed. Issues related to building programming and exterior appearance would be addressed. One or more workshops with affected stakeholders would be helpful in the preliminary design process.

The microbiological sampling program referenced above would be initiated during 2002. Work related to refining cost estimates and securing funding would proceed throughout the preliminary and final design periods.

2003 – Final Design.
Following preliminary design, the final design phase can be initiated. Final design includes the preparation of plans, technical specifications, and contract documents for the construction of the project. Alternative project delivery arrangements could also

be discussed if desired by the Town. Arrangements for permitting and funding would be finalized. This phase, including the bidding, may take about a year.

2004-2005 – Construction.
The construction phase may require about one and a half years. Startup of the treatment plant would likely be in late 2005 or early 2006, as shown on Figure 4-7.

Assuming the Town determines to include the water storage tank and associated mains as part of the Capital Improvements Program, that work could be coordinated with the WTP improvements. Ideally, the tank would come on-line at about the same time as the new WTP.

If desired by the Town, it would be possible to construct the tank and associated mains at an earlier date. Assuming the proposed tank site is finalized shortly, these facilities could be designed in 2002 and constructed in 2003. Some work at the existing WTP and Lary Lane Well would be needed to make sure their pumps can produce water to the new, higher tank elevation. If instead the Town were to determine to pursue the tank project at a later date after the new WTP is constructed, then the WTP pumps should be selected with the future tank improvements in mind.

The small safety-related improvements recommended at the Lary Lane Well can be pursued at any time.

As shown in Figure ES-1, we have assumed that the long-term pipe rehabilitation program would begin in 2006, after the completion of the WTP program. Exeter could, of course, pursue some pipe rehabilitation projects earlier, if desired.

6.5 Other Recommendations

Among the other recommendations brought forward in the study are the following:

6.5.1 Former Groundwater Supplies

Exeter's two former groundwater supplies, the Stadium Well and Gilman Park Well, have not been used in many years and are in poor condition. Current water quality data do not exist, but it is likely that the water would require filtration to meet current and anticipated standards, and to provide water quality acceptable to Exeter's consumers. The Exeter River and Exeter Reservoir have sufficient yield to meet Exeter's demands during the planning period of this report. Therefore, the cost or reactivation of these wells does not appear warranted at this time. Exeter should nevertheless retain the ability to restore these wells in the future should circumstances change.

6.5.2 Safe Yield of Surface Water System

A rigorous hydrologic study of the surface water system to determine its safe yield has never been performed. Should Exeter wish to sell water outside its Town boundaries for extended periods, we recommend such a study be prepared to reliably quantify the yield of this system, and ensure that sufficient water is available. Such a study should also include assessment of the other uses of the Exeter River, how they affect the yield available for water supply withdrawals, and the feasibility of curtailing these other uses during drought conditions. If possible, agreements with other users to curtail water use during droughts should be developed.

6.5.3 NHDES Instream Flow Rule

At the present time, it appears that Town's water supply withdrawals will not be affected by the Instream Flow Rule which is currently under development. Exeter should monitor the development of this rule to be fully aware of any impacts upon its water supply sources. Possible impacts include the following:

- Should the designated reach of the Exeter River over which the rule has jurisdiction be extended farther downstream, the Town's water supplies could be affected.
- The Lary Lane Well is about 900 feet from the designed reach of the Exeter River. Should the separation distance from the river increase above the 500-foot value which has been considered previously by NHDES, then the Lary Lane Well withdrawals could be affected.
- The proposed rule could benefit Exeter, by requiring the operator of the Exeter River Hydro Dam in Brentwood to release water during low-flow periods. The status of these provisions of the rule should be monitored and encouraged by Exeter.

6.5.4 Valve and Hydrant Maintenance

A regular valve maintenance program is recommended to ensure that all valves are opened and stay open. A hydrant maintenance program should be coordinated with the valve maintenance program to ensure all hydrants are operating properly and that water mains are properly flushed. We understand DPW is currently initiating such programs.

6.5.5 Hampton Interconnection

CDM recommends that Exeter continue the ongoing discussions with Hampton Water Works, to determine the best means of establishing an interconnection with the Hampton water system. The preferred route is along Route 27. Such an interconnection would benefit both water systems, as discussed in the report on this interconnection which in included in Appendix J.