Town of Salem, New Hampshire

Water System Master Plan

June 2008

June 30, 2008

Mr. Jonathan Sistare
Town Manager
Town Hall
33 Geremonty Drive
Salem, New Hampshire 03079

Subject: Water System Master Plan

Dear Mr. Sistare:

In accordance with our Agreement of December 12, 2007, CDM is pleased to submit this Water System Master Plan for the Town of Salem, New Hampshire.

In this letter, we briefly summarize the findings of our evaluation, referencing key figures and tables in the report.

Executive Summary of Master Plan Recommendations

The primary focus of CDM's assignment was Salem's present and future water distribution system. In addition, our assignment included brief reviews of the water conservation issues, the supply sources, water quality and the Canobie Lake water treatment plant (WTP), organizational issues, and financial management issues.

Section 11 of this report presents an overview of the water system improvements program. We particularly call your attention to Figure 11-1, which is a one-page chart showing the recommendations, their timing, and a cross-reference to their discussions in the report. This chart groups the recommendations into five major categories, listed below.

1. ***Water Conservation/Demand Management***
   Section 3.5 of this report details our review of Salem's water conservation and demand management program. The most fruitful areas for the Town's future focus are improvements in the annual water audit, leak detection and repair, and a water meter replacement and automatic meter reading (AMR) program. The meter/AMR work is a significant capital program, estimated at $1.9-2.3 million. It is intended to address the poor condition of many old Salem water meters, reduce unaccounted-for water, achieve equitability in consumer billings, and improve revenues. Regardless of the

future direction of the Town's water system, these and other water conservation and demand management efforts discussed herein will be expected by regulatory agencies and the public.

2. Supply Sources

The Town should continue to pursue the proposed transfer of Arlington Mill Pond water to Canobie Lake. In June 2008, the U.S. Environmental Protection Agency announced changes in a relevant federal permitting program that make this project appear more feasible from a regulatory standpoint. NHDES is preparing to implement changes in its permitting programs that may allow Salem to receive a formal review of a permit application in 2009.

A detailed review of the WTP was beyond the scope of this project. Nevertheless, our brief review as summarized at the end of Section 4 has identified several water quality issues for the Town's consideration. In addition, the current maximum day production of the WTP and its pumping systems exceeds the firm capacity of those facilities. The Town should prepare a comprehensive review of these issues at the WTP to ensure it will continue to provide sufficient quantities of high-quality water as the Town grows.

Section 8 of the report also includes information on other potential supply sources, such as groundwater supplies and the purchase of water from Methuen.

3. Storage Tanks

The most significant issue with the Town's three water storage tanks is the poor condition of the Howard Street Standpipe. This was documented in a 2007 tank inspection report and is discussed in Section 5.7. A rehabilitation program for this tank is warranted in the immediate future. The estimated cost is $640,000 in 2010 dollars.

4. Existing Water Distribution System

Salem's water distribution system performance with respect to fire flow capacity is especially good – one of the best CDM has seen in New England. Nevertheless, there are a number of issues that need to be addressed, such as the following:

- There are a few areas where fire flow and/or hydrant improvements are needed.

- Old, unlined cast iron mains are present in some areas, sometimes as parallel mains to newer pipes in good condition. Unlined cast iron mains are causing water quality complaints in some cases; these cases, and other cases where such mains cause hydraulic constrictions or develop structural problems, will grow with time.

- Construction of loops to eliminate dead-end mains would improve the system in several areas.

Table 11-2 lists a number of streets with mains that need to be addressed for the foregoing and other reasons.

As part of this effort, CDM reviewed the Town's current Capital Improvements Plan (CIP). A number of the needed water distribution system improvements are located in streets with roadway projects listed in the CIP, which will allow coordination of these efforts and reduced overall cost. These are listed in Table 11-1 and shown on Figure 11-1.

5. Future Water Distribution System Expansion
Salem's CIP calls out one expansion project, the Canobie Area Sewer/Water Construction program. Extensive additional areas in northern and southwest Salem are not currently served by the water system. Using the Town's hydraulic computer model, CDM developed two alternative means of extended water service throughout these two areas. One approach involves local water booster stations to achieve proper service pressures in high-elevation areas. The second approach instead creates one large high-service zone in North Salem with its own new storage tank, eliminating the need for many of the local booster stations. Both approaches are discussed and mapped in Section 6.

As noted earlier, this project included not only a review of the water system facilities, but also concise reviews of the "business side" of the water utility. The Utilities Division Organization Evaluation is presented in Section 9 of this report, and the Financial Management Evaluation in Section 10. Both sections contain summaries of the conclusions and recommendations from those reviews. Key elements of these two summaries are briefly noted below.

Utilities Division Organization Evaluation
The organizational review included interviews with Utilities Division staff and a questionnaire completed by all staff. CDM's review indicates that the current structure is effective and we do not recommend changes in structure or staffing. The

Utilities Manager position should be refilled after Mr. Daly's retirement. There is a need to increase awareness of the water system's importance and needs, in the minds of other Town officials and the general public. Establishment of an Advisory Committee may be one helpful step in this direction. Salem should seek to improve the use of technology in its water and sewer operations, and in utility management. In addition, there is a clear need for improving training and recognition opportunities for Utilities Division staff.

Financial Management Evaluation
This evaluation addressed not so much the cash position of the utility, but rather the financial policies and procedures by which the utility is managed. The Town has a multi-year rate model, which should be updated to incorporate the recommendations of this Master Plan. Several performance measures are identified for the Town's consideration, especially the goal of establishing a rainy-day fund equal to 15% of budgeted annual operating costs. A water meter replacement and automatic meter reading program should be instituted for reasons also described in the technical section of this report. Enterprise funds for water and sewer should be considered to assist in proper cost allocation. Planned moderate annual rate increases would be preferable to infrequent major increases. Salem could also consider either an increasing block or seasonal rate structure to more effectively encourage conservation and control peak demands, which drive capital investment.

This Water System Master Plan should be referenced each spring at the start of the Town's annual budgeting cycle, to make sure that needed water system projects are coordinated with other Town projects. A brief annual review of the key maps and tables in the Plan can be prepared by DPW at that time, to update the status of listed projects and to note other potential projects that are not currently anticipated. A more-rigorous update of the Plan through a revised or supplemental document prepared by DPW is suggested on a 5-year cycle.

Acknowledgements

CDM is indebted to the Town of Salem and its Public Works Department for invaluable assistance throughout this project. We especially thank Mr. Rick Russell, DPW Director, Mr. William Daly, Utilities Manager, and Mr. Glenn Burton, Distribution/Construction Foreman.

This Water System Master Plan was prepared under my general supervision. Mr. Jeffrey Diercks, P.E., served as project manager, and Mr. Benjamin Mosher, P.E., served as project engineer. Our key technical specialists included Mr. Peter Fairchild, management consultant, Ms. Carol Rego, P.E., water treatment specialist, and Mr. Joseph Ridge, financial specialist.

Very truly yours,

David G. Polcari, P.E.
Associate
Camp Dresser & McKee Inc.

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Section 2
Description of the Existing System

Portions of Salem have been served by a community water system since the late 1800s. In the early stages of the development of the water system, limited piping was installed to convey water by gravity from nearby Canobie Lake to the lower elevations of the rapidly developing community. Though the system gradually expanded, it was not until 1924 that significant service improvements were realized with the construction of a pumping station at Canobie Lake and a tank in the area of Howard Street. Since that time, the system has been gradually expanded and upgraded to include treatment, additional storage and piping facilities as well as a second source water reservoir and associated raw water transfer pumping station.

At present day, Salem's municipal water distribution system is supplied water from Canobie Lake or Arlington Mill Pond (depending on seasons and available water) which is treated by the Canobie Lake Water Treatment Plant. Water from the plant is supplied to the distribution system which currently consists of approximately 130 miles of piping ranging from 2 to 24 inches in diameter. Service pressure and available flow within the distribution system is further supported by three separate water storage facilities and two water booster stations. Figure 2-1 depicts the locations of the components within the Salem water system, the details of which are further discussed in this section.

2.1 Water Supply Sources

2.1.1 Canobie Lake

Canobie Lake, located in the Towns of Salem and Windham, has an estimated total water surface area of 373 acres and an estimated watershed area of approximately 1,490 acres (2.3 square miles). Until 1996, this reservoir served as the sole surface water supply to the Town, supplemented only by two groundwater wells, in the late 1970s and 1980s. Though historical water quality in Canobie Lake has not been a significant problem, the quantity of available water from this source has been the subject of extensive interest for some time.

In 1995, much of the Northeastern United States experienced mild to extreme drought conditions. During this time, the availability of the Town of Salem's water supply became a significant concern as the water level in Canobie Lake dropped to abnormally low levels, estimated to have been as low as 7.5 feet below spillway elevation. In response to this drought, the Town of Salem began evaluations as to the existing safe yield in Canobie Lake as well as potential future sources of supply. During one of the resulting studies ("Comprehensive Source Development and Conservation Plan for Water Supply for the Town of Salem, New Hampshire", September 1996, SEA Consultants, Inc.) it was estimated that Canobie Lake provided a safe yield of 1.33 million gallons per day (mgd). This yield estimate was defined at that time to be the available water on a continuous basis during a 3-year drought period with a 5 percent probability of recurrence (or a recurrence interval of once every 20 years). The September 1996 report further stated that the water available from Canobie Lake under "average" conditions was estimated to be 2.01 mgd. For comparison purposes, it should be noted that water demand in the distribution system has consistently exceeded 2 mgd over the past decade, with an average system demand of 2.5 mgd experienced in 2007.

It should also be noted that, though the Town of Salem does not have an official Source Water Protection Plan for Canobie Lake, there are protection measures in place which are administered by the Town of Salem Health Department. As part of their duties, a water protection overlay district is currently in place, in which a specific set of related ordinances are currently maintained. In addition, within the protection area, a list of Potential Contamination Sources (PCSs) is maintained and the associated sites are inspected by the Health Department at an average frequency of once every three years. Despite these efforts, it should be noted that a large portion of the Canobie Lake watershed is outside of the Town of Salem and therefore unprotected by the current Town regulations. Furthermore, it should be noted that Interstate 93 is located in close proximity to the reservoir and there are no special deicing limitations and/or hauling restrictions in place for the purpose of water supply protection. For these reasons, it is recommended that a thorough Source Water Protection Plan be developed which incorporates these and other potential Canobie Lake source water quality issues.

2.1.2 Arlington Mill Pond

As part of the 1996 investigations into supplemental water sources, it was determined that Arlington Mill Pond was the "largest, most economical water supply source" for the Town of Salem (SEA, 1996). As a result of these findings, the Town pursued the construction of the Arlington Mill Pond Raw Water Transfer Pump Station and associated raw water transfer pipeline which enabled conveyance of water from Arlington Mill Pond to the Canobie Lake Water Treatment Plant. The pumping system also has the ability to convey water from Arlington Mill Pond to Canobie Lake, though this option is not currently utilized for reasons discussed below.

Arlington Mill Pond

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Notes: Existing pipe information based on GIS data provided by the Town of Salem in October 2007.

Figure 2-1
Town of Salem, New Hampshire
Existing Water Supply and Distribution System
June 2008

The Town of Salem and the Arlington Pond Protective Association (APPA) executed an agreement regarding water transfers on March 14, 1996. Among its provisions are the following:

- The Town will not withdraw water for water supply purposes between April 30 and October 10 unless the water elevation in Arlington Mill Pond is above 161.712 feet mean sea level (MSL).
- The Town will strive to operate its control facilities in such a manner that the Pond reaches the above referenced elevation on or before April 30 each year.
- The Town will not withdraw water for water supply purposes between October 11 and April 29 unless the water elevation is above 154.5 feet MSL.
- The Town will take no action to change the recreational use of Arlington Mill Pond.
- The agreement is valid for 50 years.

The agreement between the Town of Salem and the APPA has been included herein as Appendix A. SEA also reports that NHDES requires a minimum release from Arlington Mill Pond of 0.304 cubic feet per second (cfs) when water is being diverted from the pond for water supply purposes.

According to previous studies and Town personnel, one of the primary benefits of utilizing Arlington Mill Pond as a source of supply is that it is considered to have a significantly greater safe yield than Canobie Lake. Though its surface area of 266 acres is less than that of Canobie Lake, its estimated recharge area of approximately 15,500 acres (24.2 square miles) is over ten times greater than that of Canobie Lake.

The primary reason that the Town has been thus far unable to obtain authorization for this water supply transfer authorization is that Arlington Mill Pond is currently classified as a “Class B” surface water while Canobie Lake is a “Class A” water source and the proposed transfer could theoretically reduce the quality of the water within Canobie Lake. Though this issue is beyond the scope of the current study, it should be noted that it continues to attract a high degree of interest within the Town and at the State of New Hampshire Department of Environmental Services (NHDES) and there are ongoing discussions between these parties to further determine the feasibility of this direct transfer. This issue is further discussed in Section 8 of this report.

Despite the current inability to utilize the Arlington Mill Pond supply system to directly recharge Canobie Lake, under current operations this source is utilized as the sole supply source to the Canobie Lake Water Treatment Plant from approximately mid-October to mid-April of each year. Based on Utility Department records, in recent years, its usage has equated to approximately 40 percent of the Town’s total annual water use. This supplemental source of supply has enabled Canobie Lake to more fully recharge during the winter months.

Finally, it was noted during this current study that there are no source water protection measures (overlay district, ordinances, PCS inventories, etc.) in place for Arlington Mill Pond. As a result of the highly developed nature of its immediate watershed, the significant recreational use which the water body receives, and the presence of densely located septic systems in close proximity to the reservoir, it is recommended that a Source Water Protection Plan be developed for this reservoir.

2.1.3 Inactive Groundwater Sources

The Town also owns two previously developed sources of groundwater, the Donigian Well and the Turner Well, neither of which is presently operated.

Donigian Well

The Donigian Well system is located in the southwestern portion of the Town in the vicinity of Commercial Drive. The wells at this site include the following:

- Well V-1: 6.5-inch bedrock well estimated to be 325 feet deep and contains a 10-stage, 50-hp submersible pump rated at 200 gpm at a total dynamic head of 440 feet;

- Well V-2: 6.5-inch bedrock well estimated to be 900 feet deep and contains a 10-stage, 15-hp submersible pump rated at 100 gpm at a total dynamic head of 415 feet; and

- The site also reportedly contains four 4-inch gravel packed wells approximately 24 feet deep. A 15-hp pump capable of pumping 100 gpm at a total dynamic head of 263 feet is currently installed to serve all four wells.

According to Town records, during the later years of this well field's operation, only well V-1 was utilized. Though previous studies had indicated the available yield from this well to be approximately 75 gpm (0.11 mgd) (Ground Water Associates, 1994), in the later years of its operation, excessive drawdown in local wetlands and other local wells were reported and unofficially attributed to the withdrawal from this municipal well. In addition to its limited yield, there are concerns as to the quality of its water supply. The water from the well reportedly contained manganese and radon well in excess of the current (or pending) Maximum Contaminant Level as required for municipal drinking water supplies, which further supported the decision to remove it from active operation.

Turner Well

The second inactive groundwater supply in Salem is the Turner Well (also known as well TP-2). This well is located in the vicinity of Delaware Drive, adjacent to a construction demolition landfill. This 12-inch bedrock well is estimated to be 533 feet deep and contains a 12-stage, 125-hp submersible pump rated at approximately 500 gpm at a total dynamic head of 52 feet. The available yield from this well has previously been estimated at 0.72 mgd (Ground Water Associates, 1994). Shortly after it was placed into operation in 1981, the well was removed from service as a result of a fire at the landfill in 1983 which reportedly introduced contamination into the well. According to the 1996 report from SEA Consultants, the most significant parameters of concern included benzene, methyl tertiary butyl ether (MTBE), radon, hardness, iron and manganese. SEA indicated at that time and again in a 2003 report that it would be feasible to install treatment systems and restore the well to use.

It should also be noted that the Town of Salem Health Department continues to enforce and inspect groundwater protection areas around the Donigian and Turner Well sites, which reportedly consumes significant person-hours each year. During the Town's continuing development of water supply alternatives which are outside of the scope of the current study, the efficacy of these efforts should be evaluated and a determination made as to whether these sites are worth protection given the current water quality issues.

2.2 Canobie Lake Water Treatment Plant

As previously noted, the Canobie Lake Water Pumping Station was first placed into operation in 1924. Though the pumping and treatment facilities received multiple upgrades over the succeeding decades, the largest upgrade was performed in 1995. The plant, which has been maintained in operations since 1995, utilizes a Trident Microfloc® upflow clarification treatment system and was designed with three 2-mgd modules for a peak treatment flow rate of 6.0 mgd. The "firm capacity" (the capacity with the largest unit out of service) is 4 mgd. A cursory review of the treatment process was completed during the current study and is summarized in Section 4 of this report. It should also be noted that the finished water pumping capacity was also evaluated during the current study and the related recommendations can be found in Section 5 of this report.

Canobie Lake Water Treatment Plant

2.3 Pumping Stations

2.3.1 Arlington Mill Pond Raw Water Transfer Station

As noted above, in 1996, the Town of Salem constructed the Arlington Mill Pond Raw Water Pump Station to enable use of Arlington Pond as a source of supply. This station currently contains a total of three pumps, each rated at 2 mgd. As further described in Section 5 of this report, according to state and industry regulations, the firm capacity of a pumping station is determined assuming any one pump can be out of service at any time. With this in mind, and as summarized in Table 2-1, the firm pumping capacity of the Arlington Mill Pond Water Transfer Station was therefore determined to be 4 mgd. It should also be noted that this station contains a water screening system intended to remove *Cabomba caroliniana* (common name Fanwort) and other invasive plants from the transfer flow stream as well as inactive chemical feed system. The station does not contain any provisions for standby power.

Arlington Mill Pond Raw Water Transfer Station

Pump Station	Installed Pumps	Firm Pumping Capacity[1]
Arlington Pond Raw Water Transfer Station	3 X 1,400 gpm @ 142 ft	2,800 gpm (4 mgd)
Canobie Lake Raw WaterTransfer Station	3 X 1,400 gpm @ 70 ft	2,800 gpm (4 mgd)
Canobie Lake Water Treatment Plant	3 X 1,400 gpm @ 165 ft	2,800 gpm (4 mgd)
Manor Parkway Booster Station	1 X 400 gpm (3-pump skid) 1 X 1,500 gpm fire pump	267 gpm (0.4 mgd) For non-fire demands
Nirvana Road Booster Station	2 X 84 gpm @ 112 ft 1 X 1,500 gpm fire pump	84 gpm (0.1 mgd) For non-fire demands

[1]Firm pumping capacity is considered to be capacity with largest non-fire pump out of service (per NHDES Env-Ws 370/Ten State Standards).

Table 2-1
Summary of Existing Pumping Facilities

2.3.2 Canobie Lake Water Treatment Plant Pumping Systems

There are currently two distinct pumping systems located at the Canobie Lake Water Treatment Plant which are critical to the supply of water to the Town, the first of which are the "low-lift" pumps located within the Raw Water Transfer Station. The Canobie Lake Raw Water Transfer Station is located adjacent to Canobie Lake, on the site of the Water Treatment Plant. The primary purpose of this station is to lift water from the Canobie Lake raw water intake to the treatment process located within the adjacent treatment building. Similar to the Arlington Mill Pond Station, the Canobie Lake station currently contains three pumps each rated at 2 mgd, for a total firm pumping capacity of 4 mgd.

Canobie Lake Raw Water Pump Station

The second, and arguably the most critical of pumping systems within the Town, is the finished water pumping system ("high-lift" pumps) located within the Water Treatment Plant. As noted in Table 2-1, this system also consists of three pumps each rated at 2 mgd, for a total firm pumping capacity of 4 mgd. It should also be noted that the entire Water Treatment Plant, including the low-lift and high-lift pumps, is currently connected to the on-site emergency generator. The adequacy of these pumps for current and future demands is further discussed in Section 5 of this report.

2.3.3 Manor Parkway Booster Station

The Manor Parkway Booster Station currently serves to boost pressures to a high elevation area of the distribution system in the vicinity of Industrial Way and Commercial Drive. Due to the fact that the current Manor Parkway High Service Zone does not contain a water storage tank, the associated booster station is required to supply all water demands to this area, including both peak instantaneous domestic water demands as well as fire flows.

The existing pumping station is equipped with 3-pump constant pressure "skid" system installed in 1984 that is capable of supplying 400 gpm (267-gpm firm capacity) to the domestic uses within the service area. Though the exact peak domestic demands within the industrial

Manor Parkway Booster Pump Station

park is not currently known, the Town has not experienced issues related to insufficient domestic pumping capacity as provided by the existing skid. Despite this, it is recommended that, depending on the phasing of the recommended expansion of this zone as further described in Section 6 of this report, the required domestic capacity of this system may need to be revisited.

In addition to the 3-pump skid, the station currently contains a single diesel powered fire pump rated at 1,500 gpm. As further described in Section 5, this pump is not adequate for the fire flow requirements of the industrial park, as determined by the Insurance Services Office (ISO). It should also be noted that this station does not currently contain a standby power system, but instead relies on the diesel powered fire pump to supply flows in the event of a loss of power from the local grid.

2.3.4 Nirvana Drive Booster Station

The recently installed Nirvana Drive Booster Station currently serves to boost pressures to a high elevation residential area on the south side of Spicket Hill. Though the current Nirvana Drive High Service area consists of a limited number of large residential homes, there are plans for expansion of this zone to include additional new homes on Nirvana Drive as well as a new extension to the Stanwood Road neighborhood. Though there is a water storage tank on Spicket Hill, it is not hydraulically connected (and not designed to be connected) to the Nirvana Drive Booster Station.

The existing Nirvana Drive station consists of two domestic pumps, each rated at 84 gpm, as well as a single diesel powered fire pump rated at 1,500 gpm. Though the exact peak domestic demands from the current and projected service area are not currently known, it is likely that the existing pumping system has been sufficiently sized to meet these demands. Similarly, though the required fire flow for this residential area would ultimately be determined by the closest spacing between structures, it is likely that the 1,500-gpm pump (as required by ISO for homes less than 11 feet apart) would be more than adequate to meet ISO requirements of this neighborhood.

As with the Manor Parkway Booster Station, this station does not currently contain a standby power system, but instead relies on the diesel powered fire pump to supply flows in the event of a loss of power from the local grid.

Nirvana Drive Booster Pump Station

2.4 Storage Tanks

There are three water storage tanks within the Main Service Zone of the Salem water distribution system which currently serve to meet demand fluctuations and fire flow volume within that zone. These tanks include the Howard Street Standpipe, the Lawrence Road Standpipe and the Spicket Hill Tank. The overflow elevation of all three tanks is 346.5 feet above mean sea level (USGS datum). The total storage capacity of all three tanks is approximately 4.5 million gallons (mg), the details of which are further described below.

2.4.1 Howard Street Standpipe

The Howard Street Standpipe is located near Town's commercial center, adjacent to Howard Street. The standpipe which exists today was constructed in 1980 and has a total storage capacity of 1.5 mg. As noted in Table 2-2, the standpipe is 48 feet in diameter and 117 feet high and has a volume per foot of approximately 13,500 gallons. The standpipe is constructed of welded steel plate with a steel roof.

Typical operations of the system currently produce approximately 8 to 12 feet of daily fluctuation of the water level in the tank (equating to approximately 9 percent of the total storage volume). An altitude valve is currently installed at the location of the tank to prevent the tank from overflowing in the event of an operational issue at the water treatment plant.

The Howard Street Standpipe was last inspected in September 2007, at which time significant deficiencies were noted including interior and exterior coating system failure and significant accumulation of sediment on the floor of the tank. As further described in Section 5, improvements to this tank are recommended.

Howard Street Standpipe

Storage Location	Type	Total Capacity (mg)	Overflow Elevation (Ft) [1]	Height (Ft)	Diameter (Ft)	Volume Per Foot (Gal)	Year of Construction
Lawrence Road	Steel Standpipe	1.5	346.5	135	45	11,900	1974
Howard Street	Steel Standpipe	1.5	346.5	117	48	13,500	1980
Spicket Hill	Concrete Tank	1.5	346.5	30	90	47,600	1998
Totals		**4.5**				**73,000**	

[1] Elevation above mean sea level

Table 2-2
Summary of Distribution Storage Facilities

2.4.2 Lawrence Road Standpipe

The Lawrence Road Standpipe is located adjacent to Eagles Nest Road, off of Lawrence Road. The standpipe was constructed in 1974 and has a total storage capacity of 1.5 mg. The standpipe is 45 feet in diameter and 135 feet high and has a volume per foot of approximately 11,900 gallons. The standpipe is constructed of welded steel plate with a steel roof. Typical operation of the system currently produce approximately 8 to 14 feet of daily fluctuation of the water level in the tank (equating to approximately 8 percent of the total storage volume). An altitude valve is currently installed at the location of the tank to prevent the tank from overflowing. The Lawrence Road Standpipe was last inspected in September 2007, at which time only very limited deficiencies were noted as further discussed in Section 5 of this report.

Lawrence Road Standpipe

2.4.3 Spicket Hill Tank

Spicket Hill Tank

Located off of Hitching Post Lane, the Spicket Hill Tank is situated at the easternmost extremity of the distribution system, a very short distance away from the Town boundary with Methuen, Massachusetts. Of particular note, it is also located in very close proximity to a 4 mg water storage tank atop Spicket Hill recently constructed by the City of Methuen to serve its water system. This issue will be further discussed later in this section.

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The Town of Salem's Spicket Hill Tank was constructed in 1998 and has a total storage capacity of 1.5 mg. The tank is 30 feet tall from the base elevation to overflow and 90 feet in diameter giving it a volume per foot of approximately 47,600 gallons. The storage tank is constructed of prestressed concrete. Typical operations of the system currently produce approximately 6 to 8 feet of daily fluctuation of the water level in the tank (equating to approximately 32 percent of the total storage volume). The tank does not currently have an altitude valve.

2.5 Distribution System Piping

According to the existing Geographic Information System (GIS) water system data layer, there are approximately 130 miles of water mains in the Salem water distribution system. These pipes range in size from 2 to 24 inches in diameter, with 6-, 8- and 12-inch pipes each accounting for approximately 30 percent of the system. Pipe materials consist of ductile iron, cast iron and asbestos cement pipe. Historically, the Town has aggressively replaced or cleaned and lined older mains, which has resulted in improved fire protection for the community. Though exact records as to the amount of remaining unlined mains are not readily available, it is estimated by the Town that only approximately 5 percent of the system is currently unlined.

Generally, the transmission piping system is hydraulically very strong, as is much of the local piping. This is clearly evidenced by the fact that 19 out of 21 ISO fire flow testing locations met or exceeded the required flow during the last testing in 2002, as further discussed in Section 5. However, it should be noted that in some of the outlying areas of the system, such as in the vicinity of Arlington Mill Pond, smaller diameter mains (2- and 4-inch) are still utilized to deliver water and provide limited fire protection benefits to these areas untested by ISO.

2.6 Distribution System Quality

2.6.1 Complaints

Consumer complaints regarding water quality and low pressure are presently recorded by the Salem Water Department. Generally, customer complaints focus on low pressures and colored water problems. Though customer complaints are relatively infrequent under normal conditions; customer complaints about poor water quality increase significantly in localized areas during water main breaks when hydrants are opened for street sweeping or flushing, or other similar situations.

2.6.2 Water Quality Testing

The Town conducts regular water quality testing in the distribution system to meet state regulations concerning monitoring for coliform bacteria, chlorine residual, trihalomethanes (TTHM's) and haloacetic acids (HAA's). Based on past sampling results, the Town has no major distribution system water quality problems related to these specific drinking water standards. Tap water testing in Salem for the EPA Lead/Copper Rule (LCR) indicated that Town water delivered to consumers is lower than the EPA action levels for lead and copper.

2.7 Distribution System Appurtenances

System appurtenances including hydrants, valves, and meters were reviewed for this report and a summary of the review is presented below. A review of the related Operation and Maintenance (O&M) programs associated with these appurtenances is included in Section 7 of this report.

2.7.1 Hydrants

Based on recent GIS data provided by Town of Salem, it is estimated that there are approximately 1,050 public and private hydrants throughout the water distribution system. Historically, the Town reports that broken or inoperable hydrants, encountered during daily routines or fires, are serviced or replaced as soon as possible. Furthermore, the Town performs an annual water main flushing program during which a large percentage of the hydrants are exercised and, if required, repaired.

2.7.2 Valves

There are approximately 1,900 valves in the Salem water distribution system. Broken valves encountered during the water main flushing program are repaired or replaced as soon as possible.

2.7.3 Meters

There are approximately 7,000 water meters in the Salem water distribution system. The majority of these are remote-read type meters allowing access to recorded flow measurements from outside the buildings. Though the Town replaces all meters in need of repair as a result of a customer complaint or due to any meter record inconsistencies or trends noted by Town personnel, there is no formal ongoing meter replacement program to replaced old, outdated meters. Recommendations related to consumer metering are included in Section 3 of this report.

2.8 Interconnections

There are no regularly-used interconnections between Salem and any neighboring community water systems. Interconnection piping does exist at three locations between the Town of Salem water distribution system and the Methuen, Massachusetts, water distribution system. The locations and details of these connections include the following:

Hitching Post Lane

As previously noted, Spicket Hill currently supports a 4-mg tank for the Methuen distribution system as well as a 1.5-mg tank within the Salem system. As part of the recent Methuen tank construction, a 12-inch metered interconnection was installed between the two tanks on Hitching Post Lane. The Methuen tank was designed to serve a new high service zone which has a maximum operating hydraulic gradeline of 375.0 feet, approximately 28.5 feet above the Salem Main Service Zone hydraulic gradeline.

As a result of these recent improvements, this interconnection is very well suited to supply emergency water from Methuen to Salem without the need for supplemental pumping. During the current study, CDM obtained the existing hydraulic computer model of the Methuen distribution system and performed simulations to determine the potential hydraulic transfer capacity from Methuen to Salem. At the new location of the new Hitching Post Lane connection, the model results indicated that, if activated, the transfer rate could be in excess of 9 mgd, as a result of the proximity and differing hydraulic grades of the two adjacent tanks on Spicket Hill.

However, it should be noted that the booster pump station which supplies the new Methuen High Service Zone is limited to a firm pumping capacity of approximately 1.5 mgd, much of which is required to meet the maximum day demands of its existing customers. Nevertheless, in the event this connection were needed for long-term supply to the Town of Salem, the design of the pump station included provisions for installation of an additional pump which could be installed for that purpose.

Main Street
Located in the vicinity of the intersection between Main Street and Hampstead Road, there is an additional 12-inch connection between the Salem and Methuen System which was initially intended to supply Salem in an emergency. A 1-mgd pumping system currently exists at this location and, prior to the development of the new high service zone in Methuen, was needed to transfer water into Salem. As a result of the new high service zone development, this connection now provides a hydraulic grade above that of the Salem system and, according to the hydraulic model, could hydraulically provide Salem with water in excess of 2 mgd. Despite this, as this particular connection is currently unmetered and in close proximity to the new Hitching Post Lane connection, it is likely that Hitching Post Lane would be activated in lieu of the Main Street connection.

Salem Street
There also exists a connection between the 8-inch pipe on Salem Street and the Methuen system in the vicinity of Silver Brook Road. This connection would effectively connect the Methuen Main Service Zone (maximum hydraulic grade of 328 feet) to the southern portion of the Salem Main Service Zone (maximum hydraulic grade of 346.5 feet). Due to the differing hydraulic gradelines, a small pumping system is currently maintained by the Town of Salem which consists of two “canned” inline booster pumps with a firm system pumping capacity of 0.25 mgd. According to the hydraulic model of the Methuen system, with upgrades to the pumping system, this connection has the potential to provide approximately 1 mgd while maintaining reasonable service pressures in the Methuen distribution system.

Section 1
Introduction

1.1 Background

The Town of Salem last completed an evaluation of its water system in 1992. The primary focus of long-term planning at that time centered around water supply and treatment alternatives rather than the water distribution system. A five-year Capital Improvements Plan (CIP) was developed which outlined a series of water supply, treatment and distribution system improvements for the Town. Since the time of that study, the Town has implemented many of the recommendations included in the CIP, the largest of which included the construction of the Canobie Lake Water Treatment Plant in 1995 and installation of a new water storage facility at Spicket Hill in 1998.

Since the last system evaluation, the Town's population and water demand has steadily increased while the remaining useful life of water system infrastructure has gradually decreased. Accordingly, the Town desired a comprehensive review of its water system to determine its existing deficiencies, and additional concerns that may develop as the Town continues to grow and expand its water system. As requested by the Town, this review emphasizes the water distribution system. Although evaluation of supply source alternatives is outside the scope of this assignment, we nevertheless offer some remarks on this topic within this report.

Additionally, the Town of Salem Utilities Division, as part of this project, requested a brief review of the department management structure, operations and maintenance practices, water treatment practices, customer outreach efforts and overall financial status of the department.

This report represents the culmination of the technical system evaluations and department reviews requested by the Town and presents an overall Capital Improvements Plan. It is intended that the prioritized program of capital improvements developed as part of this study will form a basis of financial and scheduling decisions regarding water system investment for many years to come.

1.2 Project Objectives

The major objectives of this study are to:

- Review all pertinent data, relevant plans, and past reports regarding the water system as provided by the Town;
- Perform a general assessment of the current water system which describes the existing infrastructure;
- Review past population and water demand information to develop historical trends and prepare demand projections for the 20-year planning period;

- Acquire a copy of the existing calibrated water distribution system model from the Town and extend the model to areas of likely system expansion. Run model scenarios to evaluate the system's ability to deliver water during peak demand periods and fire flow events during future design year conditions;
- Develop a prioritized capital improvement plan using information collected from the Town, the results of the system facility assessments and the hydraulic model simulations;
- Review the current procedures used by the town for capital improvement programming and discuss improving integration of Town projects;
- Review the current Operation and Maintenance practices of the department and offer suggestions for future actions such as hydrant, and valve inspection and replacement program enhancements;
- Offer suggestions for improvement in the area of customer communications and outreach;
- Prepare a general assessment of the existing conditions and practices relative to conservation and demand management, and offer recommendations for future efforts;
- Summarize current and pending water treatment regulations, actions taken or planned by the town and identify potential future impacts to the town;
- Comment on the current department management structure and present recommendations for improvement;
- Provide an assessment of the financial management of the department; and
- Summarize the findings of all tasks in a report.

1.3 Previous Reports

During the course of the current evaluation, CDM reviewed and, where appropriate, incorporated the results of past reports related to the Town of Salem water system. The most significant of these reports included the Water System Master Plan (January 1992), the Comprehensive Source Development and Conservation Plan (September 1996), Long Term Water Survey Needs Analysis (April 2003) the Lakes Area Infrastructure Study (December 1997) and the Corrosion Control and Chloramine Implementation Plan (April 2006), all prepared by SEA Consultants, Inc. The Salem Master Plan dated November 2001, prepared by Woodard Planning Consultants, Inc., was also obtained and utilized during the course of this evaluation. Along with these formally published documents, many additional documents (memos, budgets, inspection reports, etc.) were received from the Town and reviewed.

1.4 Report Organization

This Water System Master Plan is divided into eleven basic sections:

- ***Section 2, Description of Existing System.*** Overview of Salem's water distribution system and its major components.
- ***Section 3, Population and Water Consumption***. Discussion of future population and water consumption projections.
- ***Section 4, Water Quality and Treatment Review.*** Summarizes the current and pending water treatment regulations, actions taken or planned by the town and potential future impacts to the town;
- ***Section 5, Analysis of Existing Facilities***. Discussion of the evaluation of the distribution system and identification of existing and future deficiencies.
- ***Section 6, Alternatives for System Expansion.*** Presentation of alternatives for expansion of the existing distribution system for future supply of the currently unserved portions of Town, primarily located in North and South Salem.
- ***Section 7, Operation and Maintenance Practices.*** Provides a review of current O&M practices and provides recommendations for improvement to the existing programs.
- ***Section 8, Supply Source Issues.*** Provides general comment on the current status of Salem's existing and future potential supply sources;
- ***Section 9, Organization Evaluation.*** Provide comments on the current department management structure and present recommendations for improvement;
- ***Section 10, Financial Evaluation,*** Provides an assessment of the financial management of the department; and
- ***Section 11, Recommended Capital Improvements***. Presentation of the recommendations and a prioritized program for system capital improvements.

Section 3
Population and Water Consumption

3.1 Recent Population

Salem's population is counted every ten years during the U.S. Census. Interim estimates are prepared periodically by the New Hampshire Office of Energy and Planning (NHOEP). Recent data appear in Table 3-1.

The 2000 U.S. Census population for Salem was 28,112. The Town has experienced some growth since that time, as evidenced by the NHOEP estimates. The NHOEP estimate of 2005 population was 29,940, although the NHOEP estimate of 2006 was slightly lower, at 29,885.

Of interest in water system planning is another parameter, the "serviced population". Not all of Salem's population is serviced by the water system, as is evident from the water distribution system map in Figure 2-1. Using Salem's GIS, CDM counted the buildings in the water system service area, and the buildings outside that service area. By this method, we determined that the water system currently services 72 percent of the buildings in Salem. We have used 72 percent as the estimate of the portion of the Salem's current population served by the water system, as will be discussed further below.

3.2 Population Projections

Information about potential future population is available from two sources, both of which are summarized on Table 3-1.

The NHOEP document with the population estimates for 2005 also presents population projections for Salem for the years 2010 through 2030. As shown on Table 3-1, the population is projected to increase to 30,940 in 2010, and to continue increasing to 34,440 in 2030. This represents a growth projection of just under 1 percent per year in the first decade of the 21st century, decreasing to 0.6 percent per year in the second decade, and decreasing further to 0.5 percent per year in the third decade.

Although NHOEP's projections of 2006 population were slightly lower than those for 2005, the 2005 values are being utilized herein. This is for consistency with the population projections in that same document, which are the most recent available for Salem and thus are needed for this study.

A Town's population cannot increase indefinitely, but instead is ultimately constrained by the Town's zoning regulations. Salem has previously considered this effect in the 2001 Town of Salem Master Plan. The Master Plan evaluated the buildout population of Salem for two scenarios. In the first scenario, the existing zoning was assumed to remain constant. This led to a buildout projection of 35,780. In the second scenario, it was assumed that future sewer extensions would lead to rezoning of some land from Rural to Residential. Based on 1,862 acres being rezoned in this manner, the buildout population would be 37,426 instead of 35,780.

Year	***Total Population***
2000 (U.S. Census)	28,112
2005*	29,940
2006*	29,885
2010*	30,940
2015*	31,880
2020*	32,770
2025*	33,680
2030*	34,440
Buildout (Existing zoning)**	35,780
Buildout (Potential zoning)**	37,426

** Source: State of NH Office of Energy & Planning (2006, 2007)*
*** Source: Town of Salem Master Plan (2001)*

Table 3-1
Population Projections

It thus appears likely that Salem's population will approach, but not reach, the buildout population during the planning period of this report (through 2030).

The serviced population is difficult to project, given that it will depend upon future Town decisions regarding the degree of water main extensions to pursue. Two scenarios have been considered. The first is that the serviced population percentage would remain constant throughout the planning period. In theory, if there were no water main extensions whatsoever, it is possible the service population percentage would decline over time. This is because much of the expected growth of Salem may be in the less-populated areas outside the water system service area. But it seems likely that some degree of water main extensions to those areas will be pursued in the years to come; further, some of the future growth will occur within the existing service area. Therefore, as a lower-bound estimate for use in developing water demand projections, we held the serviced population percentage constant.

The upper-bound scenario assumes that water mains would be extended throughout Salem by 2030, resulting in the serviced population equaling the total population in 2030. This is a conservative assumption, from the point of view of water system planning. We assumed the serviced population percentage would increase linearly, from 76 percent in 2010 to 100 percent in 2030. These figures are shown on the population and water demand projection summary table, Table 3-2.

Year	Total Population	Lower-Bound Estimate (limited water main extension)				Upper-Bound Estimate (extension to all Salem)			
		Percent Served	Service Population	Average Day Demand	Max Day Demand	Percent Served	Service Population	Average Day Demand	Max Day Demand
2005	29,940	72%	21,557	2.39	4.07	72%	21,557	2.39	4.07
2010	30,940	72%	22,277	2.53	4.67	76%	23,406	2.66	4.91
2015	31,880	72%	22,954	2.61	4.81	82%	26,059	2.96	5.46
2020	32,770	72%	23,594	2.68	4.94	88%	28,782	3.27	6.03
2025	33,680	72%	24,250	2.75	5.08	94%	31,632	3.59	6.63
2030	34,440	72%	24,797	2.81	5.20	100%	34,440	3.91	7.22

Table 3-2
Population and Water Demand Projections

If the current general economic climate in New England were to continue for some years to come, one would not anticipate substantial and continuous investment in major extensions of the water system throughout Salem. The lower-bound estimate would thus be a better predictor of the future serviced population than the upper-bound estimate.

3.3 Recent Water Demands

Table 3-3 lists available water production and consumption data for the period 1999–2007. The "total pumped" column reflects the metered production records from Salem's Water Treatment Plant (WTP). Because of improvements in metering in recent years, Town officials believe that this 1999–2007 data are more accurate than data from prior years.

Also shown on the table are the metered consumption records. Salem tracks its residential water consumption and its commercial water consumption, as shown. The Town then subtracts these values from the total pumped, to derive the "unmetered water" figures shown in two columns of Table 3-3.

From the two most recent available years, the total pumpage averages about 2.4 to 2.5 million gallons per day (mgd). A little less than 80 percent of that value is metered as being utilized by consumers, while a little over 20 percent is unmetered.

We note in passing here that Salem's "unmetered use" parameter is not the same as the "unaccounted-for water" (UAW) parameter widely used in water system planning. This issue will be discussed later in this report section.

In addition to the average day demand, the maximum day demand is of significant interest in water system planning. Table 3-3 lists some recent maximum day demands for Salem—data from earlier years are not expected to be as reliable and are not shown. The maximum day demand has been in the range of 3.9 to 4.6 mgd. The higher values are the most recent values, and are considered the most reliable of the available information.

In both 2006 and 2007, the maximum day demand was 1.85 times the average day demand. Such "peaking factors" of around 2.0 often occur in water systems dominated by residential demands. Commercial water use, however, typically does not peak in the summer as much as residential use. In medium-to-large systems dominated by commercial and/or industrial demand, peaking factors may be 1.5 or less. In Salem's case, however, several major commercial areas (Canobie Lake Park and Rockingham Park) are seasonal in nature, and thus may keep Salem's overall peaking factor closer to a value more typically associated with a residential area.

Year	Total Pumped (mgd)	Residential Metered (mgd)	Commercial Metered (mgd)	Unmetered Water (mgd)	Unmetered Water (%)	Max. Day Pumped (mgd)
1999	2.38	1.14	0.93	0.31	13%	N/A
2000	2.19	1.05	0.84	0.30	14%	N/A
2001	2.38	1.15	0.85	0.38	16%	N/A
2002	2.24	1.09	0.82	0.32	14%	N/A
2003	2.25	1.08	0.77	0.41	18%	3.96
2004	2.37	1.08	0.79	0.50	21%	3.93
2005	2.39	1.13	0.82	0.44	19%	4.07
2006	2.41	1.07	0.79	0.55	23%	4.47
2007	2.50	1.15	0.78	0.56	22%	4.61

Table 3-3

Historical Water Demands, 1999-2007

3.4 Water Demand Projections

CDM has prepared water demand projections for both the "lower-bound" and "upper-bound" population projections described earlier. The lower-bound estimate assumed that the serviced population percentage would remain constant, while the upper-bound estimate assumed that the service population percentage would increase over time, reaching 100 percent in 2030.

The following assumptions were also employed:

- Commercial water use will increase proportionately to residential water use.
- The 2005 residential per-capita consumption (52.5 gallons per person per day) will remain constant.
- The 2006–2007 peaking factor of 1.85 will remain constant.
- The 2007 unmetered water of 22% will remain constant.

The water demand projections based on these assumptions are shown on Table 3-2 and Figure 3-1.

For the lower-bound estimate, the average day demand increases to about 2.5 mgd in 2010 and 2.8 mgd in 2030. The maximum day demand would be about 4.7 mgd in 2010 and 5.2 mgd in 2030.

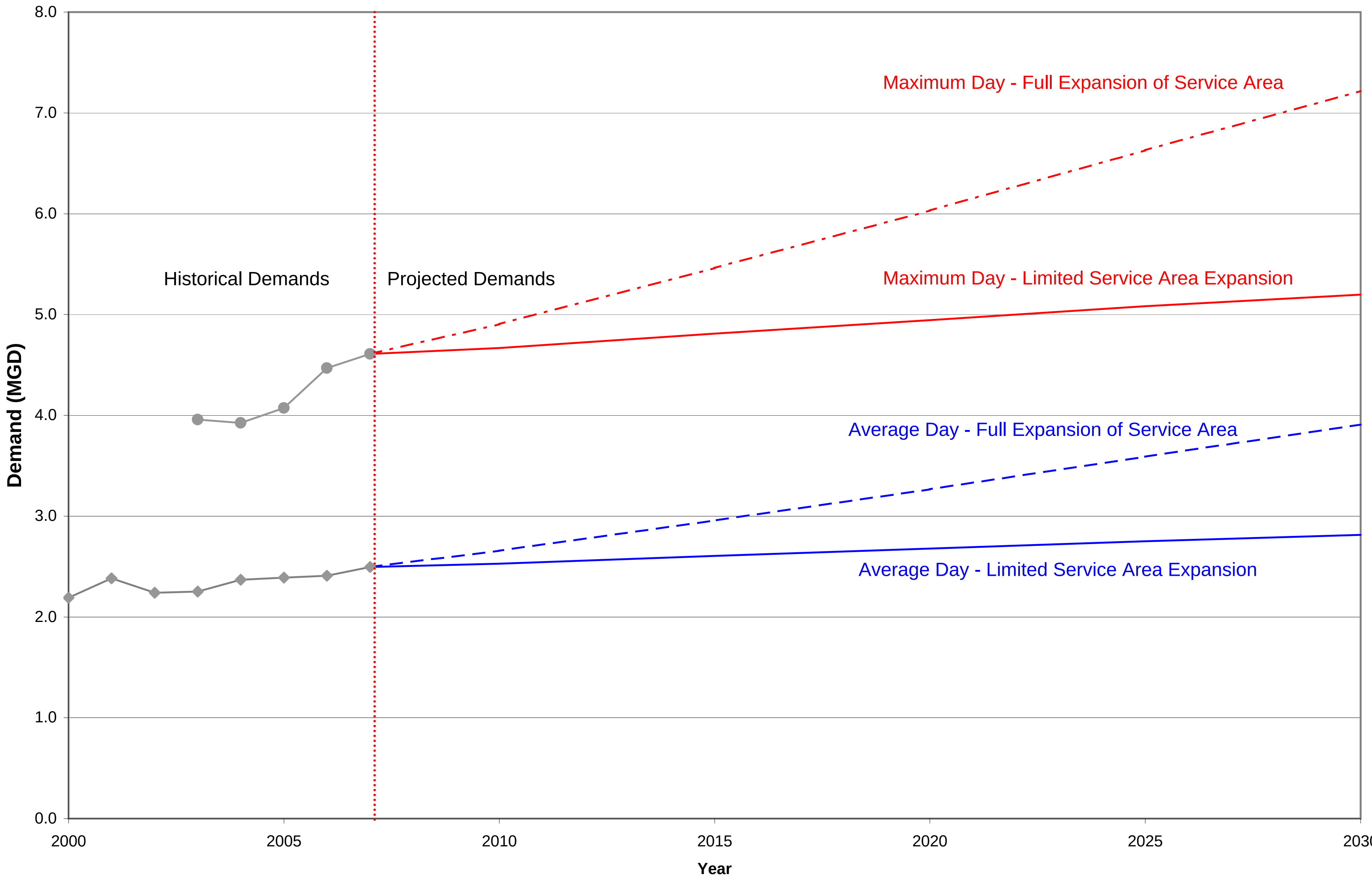

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Figure 3-1
Water Demand Projections

For the upper-bound estimate, which is based on extending water mains to serve all of Salem in 2030, the average day demand would increase from about 2.7 mgd in 2010 to 3.9 mgd in 2030. The maximum day demand would be about 4.9 mgd in 2010, and increase to 7.2 mgd in 2030.

As noted earlier, we anticipate that the lower-bound estimate may be a better predictor of future conditions. The upper-bound estimate approaches what one would expect for Salem's water demands when the Town is built out in the future, assuming current zoning.

3.5 Water Conservation and Demand Management

CDM has reviewed the status of Salem's water conservation and demand management efforts.

NHDES has published two documents that set forth various elements of a water conservation program. The first document is Fact Sheet No. WD-WSEB-26-9, and the second is the Water Conservation Rules (Env-Ws 390); both are available online from NHDES. The Water Conservation Rules, however, are only enforceable when a water purveyor is applying for NHDES approval of a new source of drinking water. Nevertheless, NHDES has stated that these rules can be used voluntarily by water purveyors as guidelines when developing water conservation programs.

In addition to the NHDES guidelines are various industry guidelines that can be utilized in water system planning. Some of these guidelines are from the American Water Works Association, while others reflect recommendations or requirements from other states.

In addition to these general guidelines, NHDES has made specific remarks about Salem's water conservation and demand management programs on various occasions during the Town's attempt to secure the ability to transfer water from Arlington Mill Pond to Canobie Lake. Examples include NHDES's recent letters of January 9 and April 21, 2008. NHDES states therein that certain water conservation and demand management measures will be required, should permits for the transfer project ultimately be issued.

In Table 3-4, which includes two fold-out pages, we have listed these various NHDES and industry guidelines, grouped into eight general categories. For each such guideline, we offer a comment on Salem's current efforts, state whether those efforts comply with the guidelines, and offer various recommendations for Salem. We refer the reader to Table 3-4 for the details, but we wish to highlight three key areas here in the report text that we believe merit the Town's immediate consideration. These three areas are, in the order listed, the typical high-priority items needing to be addressed to control unaccounted-for water and minimize associated revenue losses:

- Key Area 1 – Water Audit

- Key Area 2 – Leak Detection
- Key Area 3 – Consumer Metering

We also note that all three of these areas were mentioned in NHDES's April 21, 2008 letter. Each is described in detail below.

3.5.1 Key Area 1 -- Water Audit

As described earlier, the Town currently tracks its metered production at the WTP, its residential consumer consumption, and its commercial consumer consumption, to derive an estimate of "unmetered water". This is a necessary and helpful process, but we recommend that further review be pursued annually to develop a more-rigorous understanding of the Town's "unaccounted-for water" (UAW). The percent UAW will be less than the percent unmetered water, because various quantities, though not metered, can be confidently estimated and removed before calculating UAW.

We recommend the following:

1. The accuracy of the metered production records at the WTP is foundational for obtaining a reliable estimate of UAW. The Town has indicated, however, that there are reasons to be concerned about the validity of these metered production records. These records are based on venturi meters on the finished water pump discharge lines. Some meters are mounted closer to bends and fittings than is often recommended, and Town officials are concerned about the accuracy of these readings. A second concern reported is that the raw water pumps sometimes indicate smaller flows that the finished water pumps. Because water is actually lost during the treatment process (filter backwashing), this may indicate inaccuracies in one or more meters.

   Salem does currently perform annual calibration on its supply meters, but this has historically been focused more on calibration of the instrumentation and not necessarily of the meter itself. The testing performed would not be able to detect problems from the positioning of the meter with respect to nearby bends and fittings, nor would it detect any problems with the interior condition of the meter itself. We recommend the Town engage a meter testing specialist firm to test the raw and finished water meters, and to determine any needed adjustments to the metered records to improve accuracy. Different testing methods are available from the various firms, including: (1) velocity profiling in the discharge pipes, and (2) use of a known, high-accuracy meter in series with the existing meter.

   The Town can then adjust its metered production records based on the results of such testing. Based on the results of the first round of such testing, the Town can consider how often to repeat this process and/or whether any modifications to the master metering system are warranted.

	NHDES GUIDELINES FROM ENV-WS 390.05* & WD-WSEB-26-9**	ADDITIONAL INDUSTRY GUIDELINES	CURRENT SALEM EFFORTS	COMPLY WITH GUIDELINES?	RECOMMENDATIONS FOR SALEM
PLANNING	Submit report to NHDES every 3 years summarizing compliance with conservation standards (ENV-WS-390).*		Per notes below, this is not required unless applying for new source permit.	N/A	
		Develop a conservation plan in accordance with AWWA Manual M52.	Produced Draft Water Conservation Plan (2005), but have yet to approve or implement its recommendations.	No	Revise plan following completion of the current study and adopt as policy.
		Develop a drought emergency management plan.	Developed a drought management plan (1996).	Yes	
METERING	Meter all public sector water users except for fire fighting.*	Estimate and/or meter water use for all municipal uses including hydrant flushing programs, public irrigation and public buildings.	The Town meters municipal buildings & municipal irrigation systems but does not currently estimate hydrant flow volumes during flushing.	No	Estimate hydrant use on an ongoing basis, for use in annual calculation of unaccounted-for water.
	Meter all private water users.*		All private uses are currently metered	Yes	
	Meter all water sources.*		Raw water from each water source is currently metered.	Yes	
	Select and install meters in accordance with manufacturers recommendations and as described in Manual M6 produced by the American Water Works Association.*		Meters are selected and installed per all applicable guidelines.	Yes	
		All master meters and large use meters should be calibrated on a regular basis per manufacturer recommendations.	Currently calibrate master meters annually but perform no calibration of service connection meters.	Yes (Master) No (Large Use)	Perform more-rigorous check of master meters. After implementation of meter replacement program (below), consider periodic calibration of large-use meters.
		Should utilize ongoing meter repair and replacement program.	Currently replace meters on an as-needed basis and do not have a comprehensive meter replacement program. Estimated average age of system meters is 14 yrs while approximately 30% are greater than 20-yrs old.	No	Initiate comprehensive meter upgrade program to reduce unaccounted-for water and improve revenues.
	Read meter at a maximum interval of 30 days for all source meters and 90 days for all public and private use meters.*		Currently read commercial meters monthly and residential meters on a quarterly basis. Meters are read manually using digital read remotes. Town has reported that outside registers will often under-report water usage.	Yes	Initiate comprehensive meter upgrade program and consider Automatic Meter Reading system.
PRICING	Adopt a rate structure which promotes water conservation. Rate structure should be based on the unit price of water and the amount of water used from each connection. Unit rate should remain the same (flat rate) or increase (inclining block rate) along with the volume of water consumed.*		Currently utilize flat rate billing structure.	Yes	Salem could consider inclining block rate for additional conservation. (NHDES has recommended Salem consider this.)
		Full-cost pricing should be utilized so as to fully fund all ongoing operation and maintenance programs (meter replacement, leak detection, public outreach, etc.)	The Town is able to fully fund its water operations from the current water rate structure.	Yes	
WATER AUDIT & LEAK DETECTION	Implement a water audit and leak detection program in accordance with the recommendations of Manual M36 produced by the American Water Works Association. Repair all leaks discovered during the leak detection program within 60 days unless a waiver is obtained from the NHDES.*	Leak detection program should be performed on a regular basis by fully trained personnel and/or a company specializing in leak detection.	Have budgeted for the purchase of leak detection equipment (2008), and plan a 3-year survey. Last leak survey of the system was performed in 1995.	In Process	Perform leak detection and repair program on entire system. Repeat after 3-years, then determine long term frequency.
	Estimate the volume and percentage of unaccounted-for water once per year in accordance with AWWA M36. If the estimated unaccounted-for water rate is greater than 15%, submit a response plan to the NHDES within 60-days which identifies the plan of action to reduce the rate to less than 15% within 2-years.*		The Town does track unmetered consumption on an annual basis. The historical 5-year average unmetered water rate is approximately 21%.	No	Calculate unaccounted-for water annually, and prepare a plan to reduce UAW as needed.
	If feasible, implement a pressure reduction program.*		Not considered feasible.	N/A	

Table 3-4
Summary of Existing Water Conservation Efforts and Future Recommendations

	NHDES GUIDELINES FROM ENV-WS 390.05* & WD-WSEB-26-9**	ADDITIONAL INDUSTRY GUIDELINES	CURRENT SALEM EFFORTS	COMPLY WITH GUIDELINES?	RECOMMENDATIONS FOR SALEM
EDUCATION & OUTREACH	Implement a public notification and outreach program for customers to promote water conservation.*		Currently promote water conservation in billings, Consumer Confidence Reports and on the Town's website.	Yes	Update notices periodically to maintain public interest.
	Designate a person or office in charge of implementing the water conservation plan and associated outreach program.**		Water conservation initiatives are currently coordinated by the Utilities Manager.	Yes	Consider whether Utilities Manager has sufficient time to implement the desired Water Conservation Program. If not, consider a part time (one day/week) Water Conservation Coordinator. NEWWA has a Fact Sheet on this concept.
	Develop a conservation information and customer support center to disseminate conservation information.**		The Town does not currently maintain a conservation information center.	No	Consider as part of an enhanced public notification program. NEWWA has a fact sheet on such programs.
	Develop a public advertising campaign. This can be coordinated with local water fixture providers and installers.**	Produce media stories related to conservation success and failures.	A public advertising campaign is not currently in place.	No	Consider as part of an enhanced public notification program.
	Develop education program for area schools.**		The Town has not specifically coordinated conservation education with the local school system.	No	Consider as part of an enhanced public notification program.
	Develop and enforce water use ordinances and/or an outdoor water use restriction system.**		There are currently no conservation-related ordinances in place.	No	Consider as part of an enhanced public notification program.
		Provide a worksheet to users to estimate cost savings associated with conservation.	A cost savings worksheet has yet to be developed.	No	Consider as part of an enhanced public notification program.
RESIDENTIAL WATER USE	Offer water conservation kits to residential customers which could include low-flow faucet aerators and showerheads, toilet bladders, lawn care instructions with rain gauges and leak detection tablets.**		Do not currently offer water conservation kits.	No	Consider as part of an enhanced water conservation program.
	Offer rebates or billing credits for water saving devices.**	Promote water-efficient household appliances and consider offering rebates for associated purchases.	Do not offer conservation based rebates or incentives.	No	NHDES has recommended Salem pursue a water fixture replacement & retrofitting program, as well as requiring water-efficient fixtures and landscaping for new connections. (Would also apply to commercial, industrial and municipal uses.)
	Separate metering of irrigation system connections.**		When requested by property owner, the Town will install and bill irrigation meters separately from domestic service meters.	Yes	Consider <u>requiring</u> a separate meter for irrigation purposes.
	Offer water audits to customers.**		Currently offer water audits to all classes of customers. Audits are conducted by Energy New England, Inc.	Yes	
		Properly track and attempt to limit per capita residential water consumption to less than 65 gallons per capita per day (gpcd).	Do not track per capita water consumption.	No	Calculate this parameter on an annual basis.
INDUSTRIAL & COMMERCIAL WATER USE	Identify and properly meter all forms of water use at each facility.*		Currently offer water audits to all classes of customers. Audits are conducted by Energy New England, Inc.	Yes	
	Single-pass water cooling systems or other process discharge of unused water should be designed and operated so as to maximize water efficiency through the use of auto-shutoff devices, sensors, recirculation technique and/or other similar methods.*	Develop and enforce local ordinances regarding industrial water conservation.	Do not currently have or enforce industrial water conservation standards.	No	Discuss with large users and consider benefits to Town before deciding how to proceed.
		Encourage use of non-potable water for industrial uses where appropriate.	Do not currently have or enforce industrial water conservation standards.	No	
AGRICULTURAL WATER USE	Implement irrigation processes in accordance with the "Irrigation Best Management Practices for Agriculture in New Hampshire, published by the NH Department of Agriculture.*		The usage for this category is considered to be insignificant in the current system.	N/A	

Notes: * Env-Ws-390 (Water Conservation Rules) are only enforceable with water systems that are applying for a permit to develop a new water source but can be considered guidelines for any existing water system not applying for a new water source permit.

** The NHDES fact sheet titled "Implementing a Water Efficiency and Conservation Program for Public Water Utilities" (WD-WSEB-26-9) is generally intended to assist water utilities in managing water demands through the use of water efficiency practices. These guidelines are not enforceable.

Table 3-4
Summary of Existing Water Conservation Efforts and Future Recommendations

2. Salem should prepare estimates of various components of authorized-but-unmetered water, wherever practical. Possibilities include:

   - Estimating quantities used during hydrant flushing events.
   - Estimating water usage during fire events.
   - Estimating the volume lost during any tank overflow events.
   - Estimating water used by contractors from hydrants, during street-sweeping, and during various utility and roadway improvement projects. The Town could require contractors to use an approved Town meter and backflow device during all such operations.
   - Salem maintains two water system blowoffs for water quality control. One is metered, the other is not. The second blowoff could be metered to improve control and accounting.
   - Salem sometimes sells bulk water to private contractors operating tanker trucks. The quantities of these sales could be recorded and used in the calculations.
   - Quantify the water lost from leaks that have been fixed.

   Any quantities such as the above that can be confidently estimated may be subtracted from the unmetered water total during the annual water audit.

3. On an annual basis, calculate Salem's unaccounted-for water and compare the result to industry performance standards. Two such standards can be considered:

   - The only performance standard listed by NHDES is 15%, as stated in the Water Conservation Rules. Water purveyors who meet this performance standard may be considered to be doing a satisfactory job in controlling unaccounted-for water.
   - Experience elsewhere indicates that many communities can meet a stricter performance standard. For example, water purveyors in Massachusetts who withdraw their water from stressed river basins are expected to meet a performance standard of 10%, and many have done so.

   Salem's recent data indicate an unmetered use of 22 percent. It is not known at this time how that figure would change in response to master meter testing (it could go either up or down), nor whether Salem would meet the 15 percent UAW performance standard.

3.5.2 Key Area 2 – Leak Detection

Salem last conducted a leak detection survey of its distribution system in 1995. The Town currently plans to purchase leak detection equipment this year, train selected employees in the use of the equipment, and then proceed with a complete leak detection survey over a 3-year period. CDM concurs that this work should go forward as scheduled, given the long duration since the prior survey.

NHDES does not offer guidance on the expected frequency of these leak detection surveys in water systems of Salem's size. The results of the 2008–2010 survey may not provide a solid basis for assigning a recommended survey frequency, simply because of the long duration since the prior survey. We recommend that following completion of the first 3-year survey, the Town proceed with a second 3-year survey. The results of the second 3-year survey would allow Salem to establish a recommended survey frequency. This can be done by calculating the revenue being lost to repairable leaks during the second 3-year period, and comparing it to the cost of the leak detection survey.

For your information, many Massachusetts communities are required to perform these leak detection surveys on a 2-year cycle. This includes communities which draw water from the Massachusetts Water Resources Authority system (Greater Boston), and also various communities that have withdrawal permits but are not meeting the Massachusetts performance standards for unaccounted-for water. Other communities that do not have such a requirement imposed on them might perform surveys on a less frequent cycle such as every four years, depending on the expected cost effectiveness of the surveys.

Another option for Salem would be to contract out a system-wide leak detection survey, rather than performing it with in-house resources. This would allow rapid completion of a survey and repair program, which appears to be what NHDES had in mind in the recommendations contained in their April 21, 2008 letter to Salem.

3.5.3 Key Area 3 – Consumer Meters

Why Consider a Meter Replacement Program?
Most consumer meters lose accuracy over time. As a meter ages, it usually records less of the water passing through the meter. This results in increased unmetered use and decreased revenues for the utility. Many utilities have documented increasing amounts of unaccounted-for water as their meters age.

Salem officials have indicated that the average meter age in Salem is 14 years, while about 30 percent of Salem's meters exceed 20 years of age.

Neither NHDES nor AWWA have a requirement or policy on frequency of consumer meter replacement. A literature search by CDM for a recent project found numerous articles on this subject, with recommendations ranging from 7 years to more than 20 years for replacement frequency depending upon water quality, area of the country, and types of meters. A common frequency used for planning purposes in New England is 15 years. The fact that Salem has so many consumer meters of age greater than 15 years indicates a high-probability of revenue loss and of high unaccounted-for water. This situation will continue to deteriorate with time.

Residential Per-Capita Consumption

The Town's metered water use statistics may offer indirect evidence that consumer meters are currently under-registering, as can be seen by considering the Town's residential per-capita consumption (usually abbreviated as rgpcd, which stands for residential gallons per capita per day). NHDES does not have a performance standard for rgpcd, but this issue has been considered extensively in Massachusetts. The Massachusetts Water Resources Commission and the Massachusetts Department of Environmental Protection have utilized the following performance standard in water system permitting:

- Water systems that withdraw water from non-stressed river basins should achieve residential per capita consumption of 80 rgpcd or lower.
- Water systems that withdraw water from stressed river basins should achieve 65 rgpcd or lower.

Some Massachusetts water systems have been able to meet the 65 rgpcd performance standard, while others have found this to be challenging. In general, the more affluent suburban land uses that are served by the water system, the more difficult it is for that system to meet the performance standard because of outside watering and less sensitivity to price. In more-urban areas, this lower performance standard tends to be more achievable.

Using Salem's estimated 2005 service population and metered residential consumption in Table 3-2 one can estimate that Salem's residential per-capita consumption is about 52 rgpcd. At first glance, this appears excellent. However, it is so low that it raises the suspicion that the consumer meters may be affected by under-registration, as one would expect from their age. If so, then the actual rgpcd would be higher, and would be more in-line with typical values from other communities. We note, however, that further refinement of the data is likely needed before these performance standards can be used with confidence, as Salem's residential consumption data may be missing various residential water uses (apartment buildings, nursing homes) which are commonly classified as commercial use.

Meter Reading Systems

If Salem pursues a meter replacement program, Salem should also consider what type of meter reading system to implement. Currently, most Salem water meters have digital remote registers, which are read manually. Numerous problems have been reported regarding disagreements between the remote register and the actual meter register. In some cases, this may be caused by consumer tampering, while in other cases it may result from equipment problems. The Town is currently conducting a

Meter Validation Program to determine the extent of such problems and attempt to correct them.

Today's preferred technologies for automatic meter reading (AMR) include drive-by AMR systems and fixed-network AMR systems. In both systems, a radio transmitter is located at all residences and businesses, and broadcasts the meter reading. With a drive-by system, the meter reader carries a vehicle-mounted data collection unit which receives these signals, prepares the meter reading database, and interfaces with the Town's billing program. With a fixed-network system, no operator labor is involved. Instead, the radio signals are automatically conveyed from each radio device, through a fixed network of data collectors and repeaters, to a central computer which interfaces with the billing system. AMR systems offer substantial reductions in operating costs, improvements in accuracy, the potential for monthly billing based on actual readings, the potential for implementing seasonal water rates to control peak demands, and substantial additional information to the utility. For example, various AMR systems may offer tamper warnings, stuck meter warnings, leak detection capabilities, and profiling of individual consumer usage to allow flags for unusual usage.

Recommendations

Given the age of Salem's meters, CDM recommends that Salem plan for and implement a meter replacement program. Consideration could be given to whether this work would be contracted out or performed with in-house forces. In cases such as Salem's, where a large percentage of the meters would be scheduled for immediate replacement, it usually is more efficient to contract out the replacement program. There are three basic procurement approaches to these programs:

- A one-contract approach includes furnishing of new meters, furnishing of meter transmission units (MTUs, the radio devices on each house), furnishing the data collection units and central computer, and installation of all equipment.
- A two-contract approach typically includes an equipment procurement contract (meters, MTUs, and other AMR equipment), followed by an installation contract.
- A three-contract approach includes a contract for procuring the water meters, a contract for procuring MTUs and the AMR equipment, and an installation contract.

The single-contract approach is the simplest to implement and coordinate, but also includes the highest amount of subcontractor markups. More importantly in our opinion, the multiple contract approaches allow each water utility more flexibility in selecting the desired AMR system. CDM recommends that AMR systems <u>not</u> be procured by a bidding process, but rather by a proposal process, to allow Salem to select the best system for its needs even if that system is not the lowest-price system. The AMR systems on the market today have substantial differences in radio range, numbers of data collectors, communication protocols, software capability, and other factors.

The Town would need to decide the percent-coverage and duration of a meter replacement/AMR program, based on its needs and the expected costs. Based on recent prices of similar programs, and assuming for discussion that all 7,200 meters would be replaced by an installation contractor; the current cost for such a program may range between $1.9 and $2.3 million, depending upon the type of meter and AMR system chosen. Such an installation program could be completed within a one-year period.

Section 5
Analysis of Existing Distribution System

In this section, CDM analyzes the existing distribution system for its performance with respect to State regulations and other industry performance standards. Each time a deficiency is identified we discuss remedial measures and associated costs.

It is not our intent to establish priorities for the various recommended improvements in this Section. Priorities are discussed further in Section 11, where the Capital Improvements Program is presented.

5.1 Cost Estimating Procedures

Water main rehabilitation (or new construction) will constitute the majority of the projects to be addressed by Salem in the years to come. CDM developed generalized unit costs for future water main improvements based on recent prices and on the following assumptions:

- Projects will be contracted out rather than constructed by Town staff.
- 5-foot of cover in paved roadways, with trench paving included.
- No rock or unsuitable soils.
- Restrained-joint, ductile-iron pipe to be utilized.
- New Hampshire labor rates.
- Assumed hydrant assemblies every 500 feet, mainline or same-size sideline valves every 1,000 feet, and 15 services per 1,000 feet.
- Costs originally based on April 2008 prices (ENR index 8126) and then inflated to estimated 2010 prices (inflation rate of 7%/year), unless otherwise noted.
- Prices include all contractor indirect costs, and a 25% construction contingency.
- Engineering assumed to be by Town staff; costs not included.

On that basis, we utilized the following unit costs for water mains:

Diameter	Unit Cost
8-inch	$160/foot
10-inch	$175/foot
12-inch	$195/foot
16-inch	$250/foot

For booster pumping stations and water tank projects, we developed prices on a similar basis to the above. We did, however, include an allowance for engineering design in these costs. For generic water booster stations, we made the following additional assumptions:

- Prefabricated concrete building with brick finish.
- Pre-engineered package pumping system.
- Standby generator, outside station.
- 3-phase power available on street, and station no more than 30 feet back from street.
- Chain-link fence around station, with gate.
- No wetlands, no rock removal, no unsuitable soils, no land acquisition.

We developed costs for three general types of stations, as follows:

- Scenario 1 – Small service area station, with no fire pumps. Assume two pumps with variable-frequency drives (VFDs), 100 gpm at 100-foot head each. Planning budget for total project: $850,000.
- Scenario 2 – Small service area station, with fire pump. Same as above but add a 1,500 gpm, 150-foot head fire pump. Planning budget for total project: $960,000.
- Scenario 3 – Large station with no fire pump. Two pumps with VFDs, 1,000 gpm at 75-foot head each. Planning budget for total project: $1,100,000.

The water tank project costs are discussed in more detail as those projects arise in the text.

5.2 System Analysis Criteria

5.2.1 Regulatory Requirements

The hydraulic performance of a water distribution system is measured by its ability to provide a sufficient flow of water at a satisfactory pressure. State regulations and other industry standards establish quantitative goals for this performance.

The New Hampshire Department of Environmental Services (NHDES) has regulatory authority over the performance of water supply and distribution systems. In its regulations (Env-Ws 374.01), NHDES has adopted the 2003 version of the "Ten-State Standards" as the applicable standards for water distribution systems in New Hampshire. "Ten-State Standards" is the common nickname for the publication titled "Recommended Standards for Water Works", prepared by the Great Lakes—Upper

Mississippi River Board of State and Provincial Public Health and Environmental Managers.

Among the recommended standards for distribution system performance set forth in the 2003 version of the Ten-State Standards are the following, all of which can be relevant to water system master planning:

- "At least two pumping units shall be provided. With any pump out of service, the remaining pump or pumps shall be capable of providing the maximum pumping demand of the system." (Section 6.3) CDM also notes that a similar provision exists for rapid-rate WTP filtration units (Section 4.2.1.3) and, by logical extension, for other key facilities in a WTP.

- "Private booster pumps shall not be allowed for any individual residential service from the public water supply main." (Section 6.4.4) We also note, however, that NHDES has separately indicated that booster pumping is allowed in a multi-unit building such as a condominium or apartment complex.

- "Storage facilities should have sufficient capacity, as determined from engineering studies, to meet domestic demands, and … fire flow demands." (Section 7.0.1)

- "The minimum working pressure in the distribution system should be 35 psi." (Section 7.3.1, with similar statement in Section 8.2.1) We interpret this to refer to normal service conditions including peak hour demand conditions, but not to fire flow conditions.

- "The system shall be designed to maintain a minimum pressure of 20 psi at ground level at all points in the distribution system under all conditions of flow." (Section 8.2.1)

- "The minimum size of water main which provides for fire protection and serving fire hydrants shall be 6-inch diameter." (Section 8.2.2)

- "Where fire protection is to be provided, system design should be such that fire flows and facilities are in accordance with the requirements of the State Insurance Services Office." (Section 8.2.3)

- "Valves should be located at not more than 500-foot intervals in commercial districts … and at not more than one block or 800-foot intervals in other districts. Where systems serve widely scattered customers and where future development is not expected, the valve spacing should not exceed one mile." (Section 8.3)

- "Fire hydrants should be provided at each street intersection and at intermediate points between intersections as recommended by the State Insurance Services Office. Generally, fire hydrant spacing ranges from 350 to 600 feet depending on the area being served." (Section 8.4.1.a)

- "At high points in water mains where air can accumulate provisions shall be made to remove the air by means of air relief valves. Automatic air relief valves shall not be used in situations where flooding of the manhole or chamber may occur. … Use of manual air relief valves is recommended wherever possible." (Section 8.5)

Because NHDES has adopted the foregoing recommended standards into its regulations by reference, CDM is utilizing them in this evaluation.

5.2.2 Fire Flow Requirements

As noted above, NHDES refers to the Insurance Services Office (ISO) regarding establishment of fire flow requirements. ISO establishes these fire flow requirements for the purpose of evaluating water system performance as part of their process of establishing fire insurance rates.

ISO has established the following as the needed fire flow in residential areas, assuming one-family or two-family housing:

Separation Distance of Houses	Fire Flow (gallons per minute)
Less than 11 feet	1,500 gpm
11–30 feet	1,000 gpm
31–100 feet	750 gpm
Over 100 feet	500 gpm

ISO also has established a methodology for establishing the needed fire flow in larger buildings that are unsprinklered. A site-specific evaluation is required for each such building. The methodology includes such factors as building area, building occupancy, exposure to adjacent building, materials of construction, and more.

ISO cannot evaluate every building in a community for this purpose, but instead selects a small sample of buildings. The most recent ISO testing program in Salem was in 2002. The results of that program, which included 21 hydrant flow tests, are shown in Appendix B. As shown therein, Salem has many locations with needed fire flows above 3,500 gpm, including several locations in the 5,000–6,000 gpm range. The single highest needed fire flow was 6,000 gpm, at the intersection of South Broadway and Cumo Drive (ISO test no. 9). Another of the highest requirements was at the High School (5,000 gpm, ISO test no. 14).

ISO does not downgrade a water system's performance rating in a situation where a system can only provide 3,500 gpm at a location where there is a fire flow requirement over 3,500 gpm. ISO considers that fire flows above 3,500 gpm are the responsibility of the building owner, not the water system, for the purpose of setting insurance rates.

Based on ISO's distinction, many communities have adopted 3,500 gpm as the maximum required fire flow for water system planning purposes. Salem has done so for the purpose of this study. For the record, we note that a few other communities have adopted a higher fire flow requirement in cases where the subject building is a municipal property, but this has not been done here.

ISO also establishes the duration for which the needed fire flow must be available. For fire flows of less than 3,000 gpm, the duration is two hours. For fire flows of 3,000-3,500 gpm, the duration is three hours.

Thus, for Salem, the total required fire flow volume for planning purposes has been taken as 3,500 gpm for three hours, which equals 630,000 gallons.

5.3 Water Storage Analysis

As was discussed in Section 2, Salem's water system has three water storage tanks, all serving the same pressure zone. The three tanks are the Lawrence Road standpipe, the Howard Street standpipe, and the Spicket Hill tank. Each tank has a capacity of 1.5 million gallons (mg), for a total capacity of 4.5 mg.

5.3.1 Recommended System Storage

Water storage in water distribution systems is generally considered to have the following three components, which are illustrated in Figure 5-1.

Hourly Fluctuation Volume. This is the volume needed in storage for hourly demands which exceed the production rate of the water supply sources. During such periods on high-demand days, storage is depleted to help maintain pressures in the distribution system. As demands decline for the late evening and early morning hours, the supply sources refill the storage to be ready for the next day's demands. This component is sometimes also called "equalization storage", referring to its use to equalize pressures over the course of the day.

The hourly fluctuation volume is commonly expressed as a percentage of the maximum day demand. For systems of Salem's size, CDM recommends an hourly fluctuation volume of at least 18 percent of the maximum day demand. Using the midpoint of the 2030 water demand projections in Section 3, the required hourly fluctuation volume for Salem during the planning period of this report is 18 percent of 6.2 million gallons, or 1.12 million gallons.

This volume must be kept above an elevation high enough to assure compliance with the requirement to meet 35 psi minimum pressure in the distribution system.

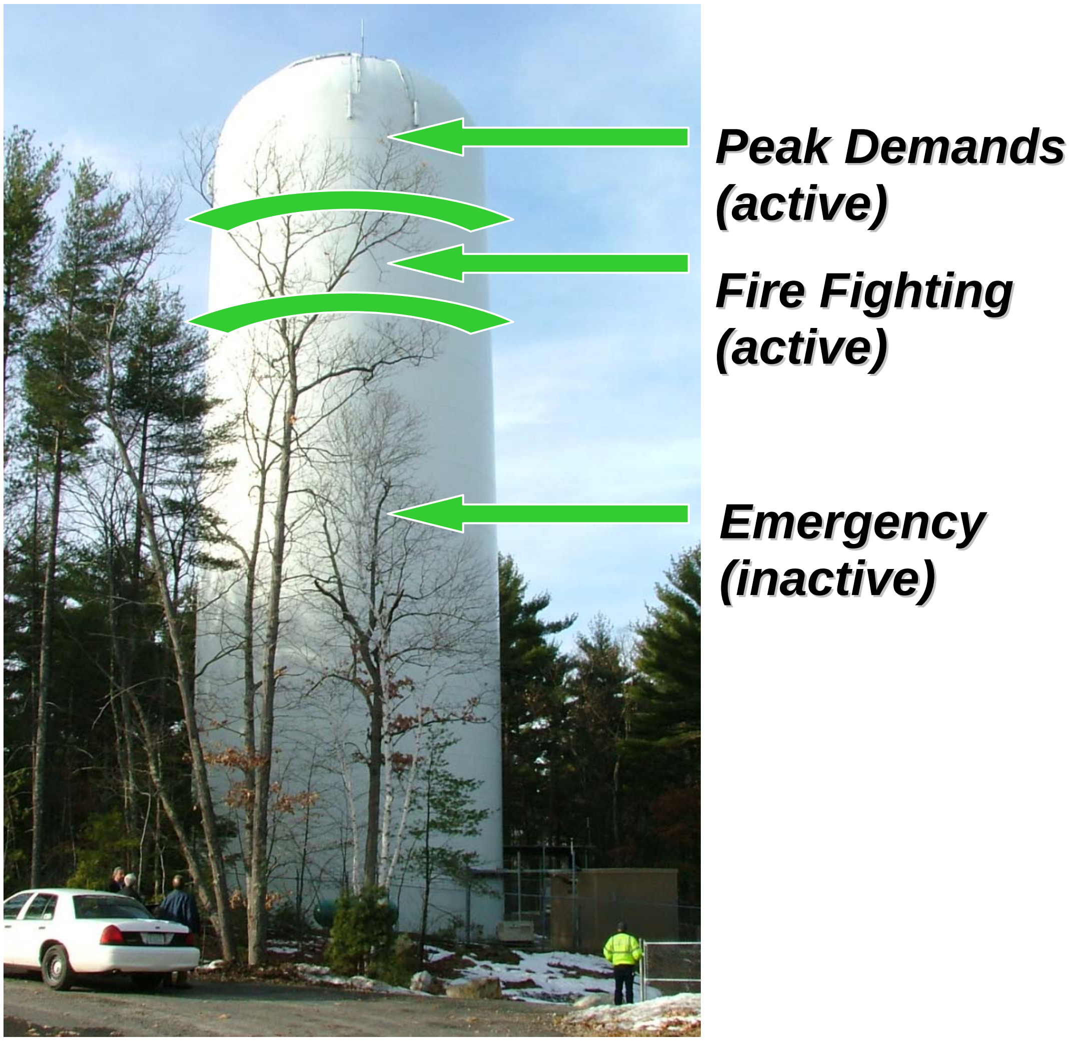

Figure 5-1

Components of Distribution Storage

Fire Flow Storage is water kept in storage tanks for fire fighting purposes. As noted earlier in this section, this volume is 630,000 gallons. This volume must be kept above an elevation high enough to assure compliance with the requirement to maintain 20 psi minimum pressure in the distribution system, even if the fire is on the highest-demand day of the year.

Emergency Storage may also be kept for any particular emergency scenario desired by the water utility. There are no regulatory requirements for emergency storage in Salem's case. Given the availability of standby power at the WTP, and the interconnections with Methuen, we have not assigned an emergency storage requirement for Salem.

Summarizing, the required storage volumes for Salem are a minimum of 1.12 million gallons at an elevation sufficient for 35 psi pressure, and a minimum of 1.75 million gallons at an elevation sufficient for 20 psi pressure.

5.3.2 Analysis of Existing Storage

Table 5-1 summarizes the analysis of the existing storage. Data for the three tanks are presented, showing that the three tanks together have 73,000 gallons in storage per foot of height. The table also lists the required storage volumes cited above.

A key parameter shown on the table is the highest serviced elevation in the system. Only those areas within the tanks' pressure zone are considered in this parameter. Thus, the high elevations serviced by the Manor Parkway and Nirvana Road booster stations are not considered, as those stations must provide the needed flows and pressures rather than the tanks. Salem has for many years maintained a policy that the highest elevation its main pressure zone can serve is 235 feet above mean sea level. This figure is carried on Table 5-1.

As shown on the table, Salem's existing storage is considered adequate for the planning period of this report, by the methodology described herein. At elevation 235, the tanks have 1.79 mg in available storage with 35 psi pressure, well above the required amount of 1.12 mg. Similarly, at elevation 235, the tanks have 2.21 mg in available storage, well above the required amount of 1.75 mg.

We also note the following:

- The foregoing assessment was based in part on the midpoint projection of 6.2 mgd for 2030 maximum day demand. Nevertheless, even if one were to use the upper end projection of 7.2 mgd, Salem's existing storage would still be considered adequate.

Available Equalization Storage								
Tank	Total Volume (M gal)	Tank Overflow Elev. (ft)	Tank Base Elev. (ft)	System High Service Elev. (ft)	Tank Diameter	Tank gal/ft	***Available Storage at 35 psi (mg)****	***Available Storage at 20 psi (mg)***
Lawrence Road Tank	1,577,000	346.5	214.0	235	45	11,900	0.36	0.78
Howard Street Tank	1,546,000	346.5	232.0	235	48	13,500	0.41	0.88
Spicket Hill Tank	1,428,000	346.5	316.5	235	90	47,600	1.43	1.43
Total	4,551,000					73,000	***1.79***	***2.21***
Required Active Storage								
Equalization Component								
Projected Maximum Day Demand (MDD) (mgd):		6.2						
Percent of MDD recommended for storage:		18%						
Equalization Volume (mg):		***1.12***						
Fire Flow Component								
Selected Fire Flow (gpm):		3,500						
Duration (hours):		3						
Fire Flow Volume (mg):		***0.63***					***Required Storage at 35 psi (mg)***	***Required Storage at 20 psi (mg)***
Total Storage Requirement							***1.12***	***1.75***

Table 5-1
Analysis of Existing Storage

- The foregoing assessment was based in part on the needed fire storage of 630,000 gallons (3,500 gpm for 3 hours). The total system storage is, however, adequate for some higher flows as well. For example, if one adopted a needed fire storage of either 960,000 gallons (4,000 gpm for 4 hours) or 1,080,000 gallons (4,500 gpm for 4 hours), then the existing storage would still be considered adequate. If the needed fire storage were assigned a higher value, then the total system storage may be considered marginal or slightly inadequate.

- Regarding the foregoing assessment, the existing storage would be considered adequate even for elevations higher than 235 feet, up to slightly over 240 feet.

- In actuality, a very small number of homes are connected to the existing main pressure zone at higher elevations than those cited above. Though not considered significant for the purpose of this analysis of the existing tanks, the pressures at these homes are considered later in this report in the assessment of the future distribution system.

5.4 Pumping System Capacity Analysis

Salem's distribution system is served by the three pumping stations at the WTP, Manor Parkway, and Nirvana Drive. A summary of these stations appeared in Section 2, including Table 2-1.

As noted earlier in this section, the performance standard for the pumping system at each station is, "With any pump out of service, the remaining pump or pumps shall be capable of providing the maximum pumping demand of the system." For pumps that supply systems without distribution storage, the fire pump must also be sufficient for the needed fire flow.

WTP Finished Water Pumps. As shown in Table 2-1, the WTP has three finished water pumps of 2 mgd capacity each. With one pump out of service, the firm capacity is 4 mgd. Salem has already experienced maximum day demands higher than this amount, such as 4.6 mgd in 2007, and the maximum day demand is projected to rise in the future. Therefore, the existing WTP finished water pumps do not meet the NHDES regulations in this respect. Addition of another pump, or replacement of the existing pumps with larger capacity pumps, would be needed for compliance. Detailed evaluation of the existing pumps, the clearwell, and available spacing would be needed to develop a specific project and cost.

For completeness, we note here that the raw water pumping station and the WTP itself have this same "firm capacity" issue as the finished water pumps.

Manor Parkway Booster Station. Salem has recognized the existing deficiency at this station for some time. Perhaps the simplest way to note the deficiency is to compare this station's fire pump capacity of 1,500 gpm (see Table 2-1) to the needed fire flows in the service zone which are up to 4,500 gpm. The deficiency is also illustrated by the results of one of the ISO fire flow tests (no. 5 as shown in Appendix B), which was located in the Manor Parkway high service zone and which demonstrated inadequate available fire flows.

This station has been the subject of much recent work by Salem. SEA Consultants has evaluated the station and has recommended an improvements program including replacement of the fire pump. The project appears in the Town's 2008 CIP, but the $150,000 in recommended funding for the program has not yet been appropriated.

It should also be noted that there have been discussions within the Town related to the installation of a water storage tank in the Manor Parkway High Service Zone. This improvement would be in lieu of the pump replacement discussed above and, if properly located and designed, would not only mitigate the fire flow deficiency within that zone, but would also facilitate operations of the Manor Parkway domestic pump system. However, with respect to cost-effectiveness, this alternative is likely to be significantly more expensive than replacement of the fire pump within the Manor Parkway Booster Station.

Nirvana Road Booster Station. This new station serves a small residential area but, as discussed in Section 2, was designed for a larger area with future expansion in mind. The fire pump capacity is 1,500 gpm, which is more than adequate for a low-density residential area.

5.5 Piping System Hydraulic Analysis

5.5.1 Distribution System Computer Model

To review the hydraulic performance of the existing water distribution system, CDM utilized Salem's existing hydraulic model.

History of Existing Computer Model

It is CDM's understanding that the original model was developed by SEA Consultants during the previous Master Planning Study in 1991. At that time, the model was developed for use within the KYPIPE modeling platform and was calibrated using a series of fire flow and "C-value" (pipe friction factor) tests. During a subsequent study in the late 1990s, the model was converted from KYPIPE into Cybernet, a more commonly used modeling platform at that time. The model was reportedly calibrated a second time following the conversion process.

More recently, during the completion of a "Modeling Study Plan" to be submitted to the NHDES in response to the requirements of the Stage 2 Disinfection Byproducts Rule, additional efforts were undertaken to calibrate the model. According to SEA's Model Study Plan dated September 28, 2007, 14 additional fire flow tests were conducted in 2005 to verify model results and extended period simulations were conducted to compare results to actual 2004 system tank level fluctuations.

The model file which CDM received during the current Water Master Plan contained approximately 108 miles (83% of total system) of Salem's water distribution system.

All three water storage tanks were included in the model along with representations of pumps at the Canobie Lake Water Treatment Plant and Manor Parkway Booster Station locations. The Nirvana Drive booster station was not represented.

During the initial review of the model input files, a few issues were noted and brought to the attention of the Town. These items include the following:

- Virtually all of the mains in the model were noted as having C-values of 100 or more. This fact was noted primarily because the results of C-value tests performed in 1991 and 1998 indicated that there were pipes within the system with C-values under 100, and even as low as 47.
- There were many mains within the model that contained entries in the "minor loss" column of the model input data. Though there are multiple ways to perform system modeling, typical industry practice does not use minor losses when system modeling is associated with distribution system planning.
- The altitude valves at both of the standpipes were noted as having flow/head loss curves associate with them. Typical operation of altitude valves does not induce significant enough (or predictable enough) head loss sufficient for assigning a curve to its operation.

Verification of Model Calibration

As a follow-up to these observations, CDM opted to complete simulations to verify the relative accuracy of the model based on the preexisting field data that was available. In order to perform these simulations, CDM requested and received existing field data which was collected as part of the 2005 field testing program. The flow data from each of these field tests was simulated in the model and the resulting pressure data was compared to that observed during the testing program. Though the exact status of the system facilities at the time of testing is not known, it was assumed that the Water Treatment Plant was supplying 4 mgd to the system, system demands totaled approximately 2.2 mgd (approximate average day) and the tanks were at approximately 10 feet below overflow elevation.

As shown in Table 5-2, the percent error between the model results and the field data ranged from 17 to 100 percent. Though the accuracy of desirable calibration results depends on the intended use of the model, it has been CDM’s experience that deviation between model and field results should be less than 10 percent. It should be noted however, that this percentage becomes increasingly difficult to meet when the pressure drop during a test is less than 10 psi. As shown in Table 5-2, many of the 2005 field tests experienced pressure drops less than this threshold which minimizes the relevance of comparing percent errors. It should also be noted that any significant deviations between the assumed and actual system conditions (status of pumps, tanks, etc.) at the time of the actual field testing could also account for the differences noted in Table 5-2.

Despite the uncertainties in the validity of the current verification simulations, these results do indicate that the model is not only functional, but also appears to yield results with a reasonable degree of accuracy when adequate pressure drops (greater than 10 psi) were observed in the field data. Given this, combined with the "big-picture" nature of the current effort and its associated system-wide analyses, the Town and CDM deemed the model usable for the purposes of the current study. It should be noted however that any current or future local area modeling (e.g., fire flow simulations) should be subject to model calibration and verification prior to reporting of any results.

Having established the model was satisfactory for the intended use in this project, CDM reviewed the existing distribution system's performance for two scenarios:

1. Peak hour demand (current and future), to determine areas with pressures below 35 psi.

2. Fire flow on the maximum demand day (current and future), to determine locations that cannot provide needed fire flows while maintaining 20 psi residual pressure.

5.5.2 Low Pressures During Peak Hour Demands

For the purpose of this evaluation, the peak hour demands in Salem were taken as 8 mgd for the existing system, 9 mgd for the future conditions with no system expansion, and 12.5 mgd for the future system with expansion. These figures were based on typical demand multiplying factors from other projects.

For the existing system, there are two areas of pressures below 35 psi during peak hour demands:

1. An area along North Policy Street, south of the WTP. The highest elevation (and lowest pressure) point is between the intersections of North Policy Street with Veronica Avenue and Marianna Road.

2. A nearby area to the west, with a high point near the intersection of Brookdale Road and Northeastern Boulevard.

Simulations of future peak hour conditions demonstrated that no additional areas of the currently-existing system would become deficient with respect to peak hour pressures as demands grow. Methods of addressing the pressure deficiency in the two areas listed above will be presented in Section 6, and will include formation and/or extension of high service zones.

					FIELD			MODEL - PLANT ON			ERROR	
Test ID	Street Name	Flow Hydrant Node1	Obs Hydrant Node1	Measured Flow (gpm)	Static Pressure (psi)	Residual Pressure (psi)	Observed Pressure Drop (psi)	Static Pressure (psi)	Residual Pressure (psi)	Observed Pressure Drop (psi)	PSI	%
F4-2005	Garabedian Drive	538	784	1,404	95	86	9	95	83	12	-3	-33%
F14-2005	Budron Avenue	526	527	1,061	80	57	23	80	61	19	4	17%
F15-2005	Cypress Street	795	489	839	95	52	43	92	57	35	8	19%
F2A-2005	Old Coach Road	783	782	1,384	92	89	3	91	85	6	-3	-100%
F2B-2005	Old Coach Road	783	782	2,201	92	81	11	91	78	13	-2	-18%
F16-2005	Erin Street	427	780	957	58	48	10	57	43	14	-4	-40%
F22A-2005	Wheeler Avenue	794	793	1,186	77	74	3	70	68	2	1	33%
F22B-2005	Wheeler Avenue	794	793	1,807	77	71	6	70	65	5	1	17%
F19-2005	School Street	789	790	2,149	84	84	0	84	82	2	-2	-
F17-2005	Atkinson Road	781	875	2,251	90	78	12	88	71	17	-5	-42%
F6-2005	Bluff Street	549	785	964	77	52	25	77	58	19	6	24%
F12-2005	Main Street	732	733	1,244	76	76	0	81	79	2	-2	-
F8A-2005	Stiles Road	874	787	1,087	73	72	1	71	68	3	-2	-200%

Table 5-2
Calibration Verification of Existing Distribution System Model

5.5.3 Inadequate Fire Flows

The ISO fire flow testing results are included in Appendix B. Table 5-3 lists the 21 tests, the needed fire flow established for each site by ISO, and the available fire flow determined by ISO. For each location, CDM also utilized the hydraulic model to determine the available fire flow. The table notes the differences between the ISO-reported and model-reported available fire flows, and also indicates the adequacy of the available flow.

The differences between the two flow values are large in some cases. There are many factors that can cause such discrepancies, including the following:

1. The ISO results reflect the actual system demand conditions and tank water level conditions at the time of the test. The model results reflect current maximum day demand conditions, and an assumed tank water level of 12 feet below overflow. Differences in system demands and tank water levels will lead to differences in fire flow values.

2. Most water systems have partially-closed or fully-closed valves in the distribution system which can constrain flow to some hydrants during actual fire flow events. The model assumes that all valves are fully open.

3. The model makes various assumptions about the interior roughness of the pipes in the distribution system. Actual field conditions may vary from the assumed and modeled conditions.

More important, however, for the purpose of this Master Plan, is the determination of fire flow adequacy at each site. In this respect, the ISO results and model results are in full agreement. Adequacy is determined by comparing the available fire flows to ISO's needed fire flows, remembering that an available fire flow of 3,500 gpm or more is considered adequate even if the needed fire flow is higher. Only ISO tests nos. 5 and 11 have inadequate fire flows, and that is the case regardless of whether one utilizes the ISO results or the model results. We wish to call to the Town's attention that having adequate fire flows at over 90 percent of the ISO test sites is excellent water system performance, when compared to most cities and towns in New England.

ISO test no. 5 was located at the intersection of Industrial Way and Commercial Drive, in the high service zone served by the Manor Parkway Booster Station. As has been noted earlier in this Section, Salem has already developed a booster station improvement program to remedy this deficiency.

ISO test no. 11 was located at the intersection of Sand Hill Road and Pond Street, near the Granite State Christian School. A piping improvement in Pond Street to remedy this deficiency is discussed elsewhere herein.

NODE ID	ISO ID	REQUIRED FLOW	ISO REPORTED AVAILABLE FLOW	ISO REPORTED ADEQUACY	MODEL REPORTED AVAILABLE FLOW	MODEL REPORTED ADEQUACY	% DIFFERENCE
752	ISO01	3500	10,600	Adequate	14,444	Adequate	36%
408	ISO02	3500	6,300	Adequate	11,282	Adequate	79%
405	ISO03	3500	7,300	Adequate	6,032	Adequate	-17%
723	ISO04	3500	3,600	Adequate	5,882	Adequate	63%
722	ISO05	3500	2,100	Inadequate	291	Inadequate	-86%
531	ISO06	2000	9,400	Adequate	7,149	Adequate	-24%
756	ISO07	3500	Adeq.	Adequate	14,965	Adequate	-
497	ISO08	3500	7,500	Adequate	8,840	Adequate	18%
494	ISO09	3500	5,500	Adequate	7,569	Adequate	38%
719	ISO10	2000	4,100	Adequate	3,520	Adequate	-14%
624	ISO11	3500	1,500	Inadequate	2,070	Inadequate	38%
356	ISO12	3000	5,200	Adequate	9,022	Adequate	73%
687	ISO13	3500	5,600	Adequate	6,466	Adequate	15%
529	ISO14	3500	4,300	Adequate	3,527	Adequate	-18%
778	ISO15	3500	5,100	Adequate	9,987	Adequate	96%
577	ISO16	2250	9,400	Adequate	13,920	Adequate	48%
571	ISO17	750	1,400	Adequate	4,998	Adequate	257%
555	ISO18	750	6,400	Adequate	4,117	Adequate	-36%
612	ISO19	750	2,300	Adequate	3,301	Adequate	44%
638	ISO20	750	1,200	Adequate	9,083	Adequate	657%
764	ISO21	3500	5,900	Adequate	9,087	Adequate	54%

Table 5-3
Comparison of ISO Field Testing Results to Existing Model Results

CDM also examined fire flow adequacy at these same sites during future maximum day demand conditions. The results are presented in Table 5-4. With increasing system demands in the future, available fire flows will decrease. Only one location, however, is listed as becoming deficient for this reason, and in our opinion that deficiency can be considered negligible in magnitude (3,464 gpm vs. 3,500 gpm at the High School in ISO test no. 14). Nevertheless, if the Town would prefer to improve available flows to the High School, water main improvements in Geremonty Drive and Veterans Memorial Parkway would accomplish that goal and are discussed later herein.

The foregoing review of fire flow adequacy was based on the criterion of the piping system being able to deliver the needed fire flows at satisfactory residual pressures. Another factor which ISO addresses is whether there are sufficient hydrants at the test locations to deliver the needed flows from the piping system to the firefighting apparatus. In the right-hand column of ISO's test results sheet in Appendix B, ISO notes locations where additional hydrants are needed for this purpose. Considering only cases where the available flow is indicated as less than 3,500 gpm, there are eight such locations:

ISO Test No.	Location
1	Main Street at Broadway
2	Old Rockingham Road at Joseph Road
9	South Broadway at Cumo Drive
11	Sand Hill Road at Pond Street
13	Main Street at Henderson Circle
14	Geremonty Drive at High School
15	South Policy Street at Raymond Avenue
21	Northeastern Boulevard at North Policy Street

Additional hydrant assemblies could be constructed at these intersections during other roadway and/or water system improvement programs, or as part of a separate hydrant upgrade program. A suggested budget figure for planning purposes is $5,000/assembly, though this could vary up or down depending on whether the work is ancillary to another program or not.

NODE ID	ISO ID	REQUIRED FLOW	MODEL REPORTED AVAILABLE FLOW	MODEL REPORTED ADEQUACY
752	ISO01	3500	11,734	Adequate
408	ISO02	3500	10,965	Adequate
405	ISO03	3500	5,350	Adequate
723	ISO04	3500	5,239	Adequate
722	ISO05	3500	1,550	Inadequate
531	ISO06	2000	6,704	Adequate
756	ISO07	3500	12,400	Adequate
497	ISO08	3500	8,384	Adequate
494	ISO09	3500	6,919	Adequate
719	ISO10	2000	3,378	Adequate
624	ISO11	3500	1,968	Inadequate
356	ISO12	3000	8,626	Adequate
687	ISO13	3500	6,225	Adequate
529	ISO14	3500	3,464	Inadequate
778	ISO15	3500	8,412	Adequate
577	ISO16	2250	13,589	Adequate
571	ISO17	750	4,893	Adequate
555	ISO18	750	4,019	Adequate
612	ISO19	750	3,215	Adequate
638	ISO20	750	8,517	Adequate
764	ISO21	3500	7,743	Adequate

Notes:
1. ISO5 Correctable by pump replacement at Manor Parkway Station.
2. ISO11 Correctable by new 12-in pipe on Pond Street.

Table 5-4

Simulation of ISO Fire Flows
Under Future Max Day Demand Conditions

5.6 Other Piping System Issues

Various other distribution system problems and potential solutions have been noted by Salem in prior reviews. Distribution foreman Glenn Burton has tracked these items for the Town, and provided CDM with a prioritized list of about 35 issues and solutions. The reasons that various improvements appear on the list can be categorized as follows:

1. <u>Abandoning Old Parallel Mains.</u> Salem has a number of instances where old unlined cast iron pipe was kept in service, even after a newer, larger-diameter main was placed in the same street. In many cases, there are still service connections, hydrants, and/or side street mains connected to the old main instead of the newer one. Unlined cast iron mains can be sources of leakage, breakage, and impaired water quality. Their internal diameter is typically reduced by tuberculation (formation of iron hydroxide deposits), such that their hydraulic capacity may be very limited. In two cases, Salem operates bleeders (continuous waste of water) to control the water quality in these mains. Such mains are candidates to be abandoned, with their service connections, hydrants, and side-street connections switched over to the newer main.

2. <u>Replacing Other Old Mains.</u> Salem has other old unlined cast iron pipe which is still in service, but for which there is no parallel newer main. These can be replaced with new mains to eliminate the issues described above that are associated with unlined cast iron mains.

3. <u>Eliminating Undersized Mains.</u> Salem has several 4-inch mains in small residential areas. Mains of this size cannot provide any significant fire flows. Improved service results from replacing these undersized mains. Typically this is done with an 8-inch main to assure proper residential fire protection, although in some cases a 6-inch main may suffice.

4. <u>Accessibility.</u> Some old Salem mains are located in easements and/or at depths that make them almost inaccessible. Water mains should be in public rights-of-way or in dedicated and accessible easements, and should be buried at proper depths, to allow for long-term maintenance. Old mains in this situation can be abandoned and replaced with new mains in proper locations at conventional depths.

5. <u>Looping Projects.</u> All water systems have some dead-end mains. It is desirable, however, to minimize dead-end mains where possible. Dead-end mains can be associated with water quality deterioration. Looped mains generally improve water quality by providing better circulation, which also boosts available fire flows. Several locations in Salem appear to be candidates for looping projects which would eliminate dead-end mains in those areas.

In addition, there are a few projects on the list that are included for other, site-specific reasons.

CDM has reviewed the list, and with only one exception (Manor Parkway Storage Tank), concurs that each project should be included in the Town's master plan for water system upgrades. A reformatted version of the list with minor editing appears as Table 5-5. The table also lists the suggested improvements for each issue. These will be prioritized further in Section 11.

5.7 Condition of Water Tanks

In September 2007, Underwater Solutions Inc. of Mattapoisett, Massachusetts, performed inspections of the three Salem water tanks and issued reports to the Town. These reports are included in Appendix C. The purposes of their work were to remove accumulated sediment, to characterize the overall condition and integrity of the structure, and to make recommendations for any needed repairs. The findings are summarized below.

Howard Street Standpipe
This 1980 steel standpipe was in the worst condition of the three tanks. Among the problems identified were the following:

- Extensive scratches and chipping of the exterior surface.
- Numerous areas of external coating failure caused by installation of cellular communications equipment.
- Partial coating failure on the external ladder/safety cage.
- The end of the overflow pipe has no screen.
- Partial coating failure of external roof surfaces.
- Extensive interior sediment accumulation (11 to 17 inches in depth), not all of which could be removed in the time available to the inspector.
- Extensive coating failure of tank floor, in the areas visible.
- Extensive coating loss on interior walls, including corrosion pits and metal fatigue.
- Exterior welding of cellular communications equipment at the top of the tank caused coating system loss in numerous areas inside the tank.
- Complete failure of the cathodic protection system.

The inspection report recommends a complete coating rehabilitation, both interior and exterior, and replacement of the cathodic protection system. No cost estimate was provided.

The inspection report does not indicate whether the coating system is the original 1980 system or is from a subsequent repainting. If it is the original, which seems likely given its condition, then we note that the paint may be lead-bearing and would require special environmental protection controls during the removal of the existing coating system. Based on that assumption and on recent tank recoating project prices, we recommend a budget for this project of $600,000, assuming 2009 construction, or $640,000, assuming 2010 construction.

Lawrence Road Standpipe

This 1974 steel standpipe was in much better condition that the Howard Road Tank. About 2-3 inches of sediment had accumulated on the tank floor, and was removed. Four small areas of coating failure on the underside of the tank dome were believed to be from welding on the dome exterior. However, no needs for immediate work were identified in the inspection report.

Spicket Hill Tank

This 1998 concrete reservoir was found to be in very good condition. The sediment accumulation ranged up to 2 inches in thickness, and was removed. No needs for immediate work were identified in the inspection report.

Summary of Tank Condition

The improvements program developed later in this report carries a project for rehabilitation of the Howard Street Tank, as a high-priority item.

The other two tanks should be scheduled for future inspections, but do not require other work at this time. AWWA Standard G-200 and NHDES regulations (Env-Ws 361.08) call for water tank inspections to be performed at least every five years. Therefore, the next inspections for the Lawrence Road and Spicket Hill Tanks should be scheduled for no later than 2012, while the next inspection of the Howard Street Tank may depend upon the actual date of the rehabilitation program recommended herein.

5.8 Closing Remarks

It is noteworthy that all of the deficiencies discussed in this Section 5 are existing deficiencies. The assessment of the hydraulics of the existing system during future demand conditions did not identify other issues with the existing system that would be expected to arise with increased demands.

Figure 5-2 is a map identifying the projects discussed in this Section 5.

Section 11 of this report summarizes the recommended capital improvements to remedy these deficiencies, including a suggested prioritization of these projects.

Project No.	Street	Location	Problem	Required action	Budget
			FIRST TIER -- HIGHEST PRIORITY		
1-1	North Main St	Main St to Bluff St	Unlined, redundant, blow off running	Connect 40 services to 16" main, abandon 6"	$141,000
1-2	Main St	School St to N Main St	Unlined, redundant, blow off running	Connect 15 services to 16" main, abandon 6"	$53,000
1-3	North Policy St	Pump Station Rd to St. Mary's	Poor condition, undersized	Replace with est. 300' of 16" main	$75,000
1-4	North Policy St	WTP to Pumping Station Rd	Inadequate discharge connections	New 16" redundant WTP discharge	$575,000
1-5	Hampshire Rd	RR Xing to 300' into Methuen	Unlined, blow off running	Connect customers to Methuen Water Dept, abandon 6"	$80,000
1-6	St. Mary's Ln	North Policy to Old Rockingham Rd	Redundant, 4 mains connected to 1890 12", 9' deep.	Connect 12 services to new mains. Connect new 12" directly to new 16"	$42,000
			SECOND TIER -- NEXT HIGHEST PRIORITY		
2-1	Spencer Ave	at Joyce Heard Ave	No interconnection, poor flow, stagnation	Install <100' of 6" to connect dead ends	$16,000
2-2	Haigh Ave	at Streeter	No interconnection, poor flow, stagnation	Install <100' of 6" to connect dead ends	$16,000
2-3	Pond St	Lawrence Rd to Sandhill	Unlined, poor condition, undersized	Replace existing 6" with 1,600' of new 12"	$312,000
2-4	Spicket Hill Tank	to Nirvana Dr	Flow restrictions to storage tank	Install 1,800' of 12" main from tank to Bridge St.	$351,000
2-5	South Broadway	469 S B'way to 300 Lawrence Rd	Unlined, poor condition, cross country	connect 5- 3/4", 1- 1 1/2", 1- 2" and 1- 8" services over to existing 12" mains	$32,000
2-6	Willow St	All	Unlined, poor condition, undersized	Remove and replace existing 6" with est 350' of 8"	$56,000
			THIRD TIER		
3-1	Main St	N Policy to Sullivan Ave	Unlined, redundant	Connect 8 services to 12" main, abandon 6"	$28,000
3-2	North Policy St	St. Mary's to Veronica Ave.	Poor condition, undersized	Install 4,400' of 16" main	$1,100,000
3-3	Old Rockingham Rd	12" thru back yards	Stagnation, no access to piping through back yards, under decks, etc.	Install 5 services to main on Old Rock Rd, can couple with Catherine, Joseph, Helen problem	$18,000
3-4	Old Rockingham Rd	At Joseph, at Catherine, at Helen	No interconnection, poor flow, stagnation	Phone duct conflict, needs complicated plan	$42,000
3-5	Howard St	Charles St to Taylor St	Unlined, poor condition, undersized, needed to replace 1922 cross-country line	Replace existing lines with est. 675' of 12" main	$132,000
3-6	Taylor St	Lee Joy Lane to Howard St	Needed to replace 1922 cross-country line, dead ends, improve flow, bypass Depot piping	Install est. 400' of 12" main	$78,000
3-7	Cluff Crossing Rd	S Broadway to Lancelot Ct	Unlined, redundant	Connect exist services over to 16" main (1-3/4", 1-2", 2-6" add 3 hydrants)	$31,000
3-8	MacLaughlin Ave	North Main St to Oak Ave	Unlined, poor condition, undersized	Remove and replace existing 6" with est 750 of 8"	$120,000
3-9	Point A Rd	South Policy St to Fairmont Rd	Unlined, redundant	Connect 2 services to 16" main and remove 6" from service	$7,000
			FOURTH TIER		
4-1	Brady Ave	Cortland to #71 Brady Ave	Unlined, undersized	Replace with est. 3000' of 12" main	$585,000
4-2	Old Rockingham Rd	St. Mary's to Range Rd	Poor condition, undersized	Replace with est. 3000' of 12" main	$585,000
4-3	Franklin St	Howard St to Millville St	Unlined, poor condition	Remove and replace est. 1100' of existing 6" with new 8"	$176,000
4-4	Pond St	Sand Hill to Copper Beech	Unlined, poor condition, undersized	Remove and replace existing 4" with est. 1800' of new 8"	$288,000
4-5	Lawrence Rd	Senter to S Broadway	Unlined, redundant	Connect 21 3/4" services and 1 4" service to 12" main, abandon existing 6"	$78,000
4-6	South Broadway	Lawrence Rd to Mass. Line	Unlined, poor condition, undersized	Remove and replace existing 6" with est. 700' of new 8" (6, 3/4" services,1, 8" service)	$112,000
4-7	Lake St	Millville to Easy	Poor condition, undersized	Remove and replace existing 6" with est 2200' of new 12" main	$429,000
4-8	Veterans Parkway	Senior center to Freedom Dr	Dead ends, service interruptions, flows	Install est 1750' of 12" main to connect dead ends	$341,000
4-9	Geremonty Dr	Court House to Veterans Pkwy	Dead ends, service interruptions, flows	Install est 1000' of 12" main to connect dead ends	$195,000
4-10	Geremonty Dr	Main St to Meisner Dr	Dead ends, service interruptions, flows	Install est 500' of 8" main to connect dead ends	$80,000
4-11	Azarian Rd	to Future Rd connection	Single feed to area, dead end, flow	Require connection as part of subdivision approval of lot 135-8944	Privately Funded
4-12	Stone Post Rd	Jana Connection	Cross country feed	Install est 500' of 8" to connect to Jana, remove cross-country feed from service	$80,000
4-13	Fairmont Rd	South Policy to end	Unlined, poor condition, undersized	Remove and replace existing 6" with est 1400' of new 8"	$224,000

Notes:
Priorities were determined by DPW using the following factors, weighted in order:
1: effect on operating cost
2: risk of failure and severity of impact on operations
3: fire flows
4: water quality
5: overall customer benefit
Priorities are reconsidered by CDM later in this report's Capital Improvements Program.
Cost column added by CDM. See text for discussion of basis of costs.

Table 5-5
DPW List of Water System Improvements

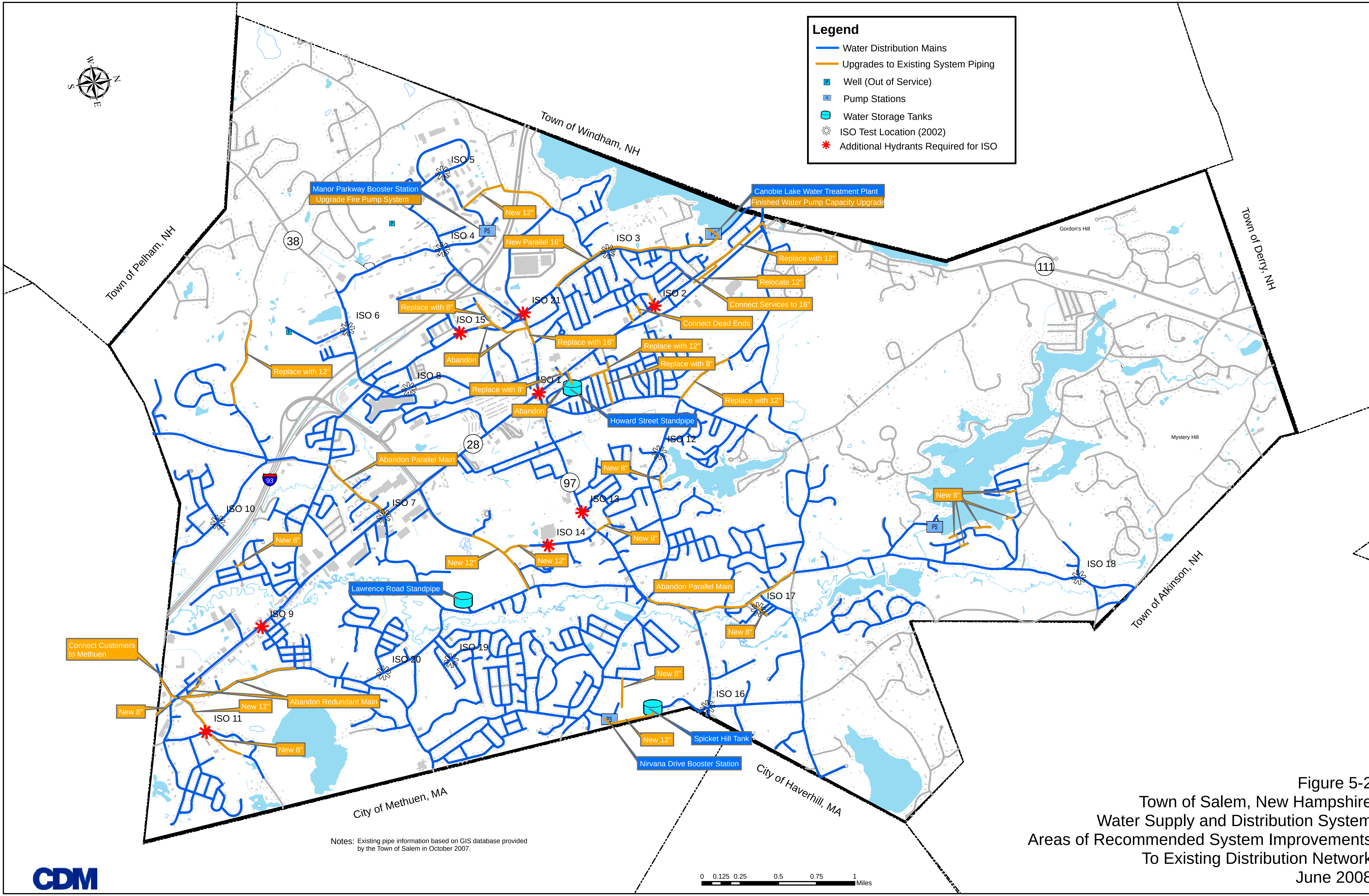

Figure 5-2
Town of Salem, New Hampshire
Water Supply and Distribution System
Areas of Recommended System Improvements
To Existing Distribution Network
June 2008

Section 4
Assessment of Water Quality and Treatment

4.1 Introduction and Scope

This Water System Master Plan focuses on the water distribution system but also includes reviews of organizational, financial and O&M issues. While not a major focus, the Master Plan includes a limited assessment of water quality and treatment. Specifically, our assignment is to "Summarize current and pending regulations, review the actions taken or planned by the town, and identify potential future impacts to the town."

CDM conducted a tour of the Canobie Lake Water Treatment Plant (WTP) on April 30, 2008, including discussions with the Utilities Manager and key treatment plant staff, and performed a cursory review of several documents and data summaries provided by the Utilities Division. These included pertinent sections of the O&M manual for the treatment plant, summary tabulations of disinfection byproduct data (3Q 2002 – 2Q 2008), TOC removal data (January 2005 – April 2008), MTBE monitoring data (2002 – 2007), 15-minute individual filtered water turbidity data (February 2008), and recent bench-scale (jar) testing results (January/February 2008).

4.2 Summary of Current and Pending Drinking Water Quality Regulations

4.2.1 Current Regulations

The drinking water quality regulations that affect the Salem Utilities Division water treatment facility are listed below in order of promulgation date:

- ***Surface Water Treatment Rule*** (SWTR; 54 FR 27486, June 29, 1989)—promulgated in 1989, the SWTR established treatment technique requirements to reduce exposure to pathogenic microorganisms. Specifically, it required (1) filtration of all surface water supplies; (2) maintenance of a disinfectant residual in the distribution system; (3) removal and/or inactivation of 3-log (99.9%) of *Giardia lamblia* and 4-log (99.99%) of viruses; and (4) maximum allowable turbidity in the combined filter effluent (CFE) of 5 nephelometric turbidity units (NTU) and 95th percentile CFE turbidity of 0.5 NTU or less for plants (like Salem) using conventional treatment.

- ***Stage 1 Disinfectants/Disinfection Byproducts Rule*** (S1DBPR; 63 FR 69389, December 16, 1998) —this rule replaced the 1979 Total Trihalomethane (TTHM) Rule and lowered the maximum contaminant level (MCL) for TTHMs from 100 parts per billion (ppb) to 80 ppb. It also established a new MCL of 60 ppb for haloacetic acids (HAA5s). Prior to this rule, HAA5s were not regulated. Compliance with these MCLs is defined on the basis of a running annual average of quarterly averages of all samples. It also established maximum residual disinfectant levels (MRDLs) at the point of entry. For free chlorine and chloramines, the MRDL was established at 4 parts per million (ppm). Also under S1DBPR, surface water systems that use conventional filtration treatment are required to remove specified percentages of organic materials, measured as total organic carbon (TOC), that may react with disinfectants to form DBPs. Removal is achieved through a "treatment technique" (enhanced coagulation) unless a system can meet one or more alternative compliance criteria.

- ***Interim Enhanced Surface Water Treatment Rule*** (IESWTR; 63 FR 69478, December 16, 1998) —this rule applies to public water systems serving at least 10,000 people that use surface water sources. Key provisions established by the IESWTR include: (1) *Cryptosporidium* removal requirements of 2-log (99 percent); (2) more stringent CFE turbidity performance standards of 1.0 NTU as a maximum and 0.3 NTU or less at the 95th percentile monthly for treatment plants using conventional treatment; and (3) requirements for individual filter turbidity monitoring. The IESWTR was developed in conjunction with the S1DBPR which reduced allowable levels of certain DBPs, including trihalomethanes and haloacetic acids, among others.

- ***Filter Backwash Recycling Rule*** (FBRR; 66 FR 31085, June 8, 2001) —requires public water systems, regardless of size, to consider the potential risks associated with recycling contaminants removed during the filtration process. The provisions of the FBRR require that recycle streams are returned to a point in the treatment process that is prior to primary coagulant addition (unless the State specifies an alternative location).

- ***Stage 2 Disinfectants/Disinfection Byproducts Rul***e (S2DBPR; 71 FR 388, January 4, 2006) —this rule builds upon the Stage 1 DBPR to address higher risk public water systems. Water systems are required to conduct an evaluation of their distribution systems, known as an Initial Distribution System Evaluation (IDSE), to characterize DBP levels and identify the locations with high DBP concentrations. These locations will then be used as sampling sites for S2DBPR compliance monitoring. The S2DBPR also revises the method of calculating compliance with the MCLs for TTHMs and HAA5s. The new calculation method—called a locational running annual average (LRAA)—differs from the S1DBPR requirements, which was based on calculating the running annual average of samples from all monitoring locations across the system. Under the LRAA method, site-specific compliance is determined for each monitoring location rather than for the entire system.

- ***Long Term 2 Enhanced Surface Water Treatment Rule*** (LT2ESWTR; 71 FR 654, January 5, 2006) —the LT2ESWTR is intended to protect public health from illness due to *Cryptosporidium* and other microbial pathogens in drinking water and to address risk-risk trade-offs with the control of disinfection byproducts. Key provisions in the LT2ESWTR include: (1) source water monitoring for *Cryptosporidium;* (2) risk-targeted *Cryptosporidium* treatment by systems with the highest source water *Cryptosporidium* levels; and (3) criteria for the use of *Cryptosporidium* treatment and control processes. Filtered water systems will be classified in one of four treatment categories (called "bins") based on their monitoring results. The majority of systems will be classified in the lowest treatment bin, which carries no additional treatment requirements. Systems classified in higher treatment bins must provide 90 to 99.7 percent (1.0 to 2.5-log) additional treatment for *Cryptosporidium*. This additional treatment must be selected from a wide range of treatment and management strategies in the "microbial toolbox" established by EPA.

In addition to the above, there are water quality/treatment regulations that govern other aspects of Salem's water system, including:

- ***Total Coliform Rule*** (TCR; 54 FR 27544, June 29, 1989) —the TCR applies to all public water systems and established a MCL for total coliform based on the percentage of positive samples collected during a compliance period. Coliforms are used as an indicator of fecal contamination and to determine the integrity of the water treatment process and distribution system. Under the TCR, no more than 5 percent of distribution system samples collected in any month may contain coliform bacteria.

- ***Lead and Copper Rule*** (LCR; June 7, 1991) —the LCR is aimed at reducing lead and copper levels at consumers' taps. It establishes requirements for water systems to optimize corrosion control and conduct periodic monitoring. Systems are required to perform public education when there are action level exceedances at more than 10 percent of the taps that are sampled, treat source water if it contributes significantly to lead and copper levels at the tap, and replace lead service lines in the distribution system if the lead level at the tap continues to exceed the action level after optimal corrosion control has been installed. Since the original 1991 rule, EPA has promulgated revisions to the LCR on two occasions. The first was termed "Minor Revisions" (LCRMR, 65 FR 1950, January 12, 2000), and addressed the areas of optimal corrosion control demonstration, lead service line replacement requirements, public education requirements, monitoring requirements, analytical methods, reporting and recordkeeping requirements, and special primacy considerations. The LCRMR did not change the action level, MCLG, or the rule's basic requirements. The second was the Lead and Copper Short-Term Regulatory Revisions and Clarifications (72 FR 57782, October 10, 2007). The Short-Term Revisions include seven targeted rule changes intended to strengthen the implementation of the LCR in the areas of monitoring, customer awareness, and lead service line replacement in the short-term.

In conducting our review, CDM considered the implications of the TCR and LCR; however, these regulations were not the primary focus of our review.

4.2.2 Pending and Future Regulations

Presently, there are no regulations affecting Salem's treatment requirements that we expect EPA to finalize (promulgate) in the next five years. The next likely regulation on the horizon will be the Revisions to the Total Coliform Rule, which EPA is tentatively targeting for a 2010 proposal and 2012 promulgation (these dates are likely to slip).

Looking beyond the next five years, EPA's Contaminant Candidate List (CCL) process will likely dictate the direction for future regulatory activity. The CCL process is dictated by the Safe Drinking Water Act (SDWA) as the means to identify and list unregulated contaminants that may require regulation in the future. EPA must periodically publish a list of contaminants and decide whether to regulate at least five or more contaminants on the list. The CCLs are also used to prioritize research and data collection efforts to allow EPA to determine whether specific contaminants should be regulated.

In February 2005, EPA published the second CCL (CCL2) of 51 contaminants for potential regulation. In May 2007, EPA published a preliminary notice of its CCL2 regulatory determination that no regulatory action is appropriate or necessary for 11 of the 51 contaminants (none of which would likely be problematic for Salem, even if they were to be regulated). A final regulatory determination for the remaining contaminants on the CCL2 is expected some time in 2008.

In addition, EPA proposed its third Contaminant Candidate List (CCL3) on February 21, 2008. The draft CCL3 list includes 93 chemicals or chemical groups and 11 microbiological contaminants which are known or anticipated to occur in public water systems. The list includes chemicals used in commerce, pesticides, biological toxins, disinfection byproducts, and waterborne pathogens. A final CCL3 list is expected to be published in 2009 and then a Regulatory Determination is expected to be proposed in 2010.

Some of the contaminants included on CCL3 that may have long-term impacts for Salem include MTBE, nitrosamines including NDMA (byproducts of chloramine disinfection), and a number of viruses and bacteria that might challenge present disinfection treatment adequacy. While the draft CCL3 did not include endocrine disruptors (EDCs), pharmaceuticals and personal care products (PPCPs), there is substantial public pressure to add these to the list.

4.3 Regulatory Review

4.3.1 Background – Source Water Quality

Salem's water supply sources include Arlington Mill Pond and Canobie Lake and, as such, Salem must meet the treatment requirements for surface water systems supplying a population of greater than 10,000.

The Arlington Mill Pond supply is used in the winter and the Canobie Lake supply is used in the summer. In some respects, the quality of the Arlington Mill Pond supply is more challenging from a treatment perspective, primarily because this supply can have episodes of elevated turbidity (the supply is often described as "flashy" by the plant staff). In other respects, the quality of Canobie Lake presents more of a treatment challenge because the nature of the natural organic material (which acts as precursors for formation of disinfection byproducts) in this supply is difficult to remove by chemical coagulation.

However, these issues notwithstanding, both supplies are considered overall as "high quality" from a source and treatment perspective.

4.3.2 Background – Treatment Process Description and Overview

The Canobie Lake Water Treatment Plant treats water from Arlington Mill Pond or Canobie Lake, seasonally. The plant includes chemical addition for coagulation (alum or polyaluminum chloride and a nonionic polymer) and pH adjustment (sodium hydroxide). The dosed water is conveyed to three "package" Trident Water Systems units. The system is commonly referred to as a "Microfloc" system. Each treatment unit has a rated capacity of 1,400 gallons per minute (~ 2 million gallons per day) and consists of an adsorption clarifier followed by a mixed-media filter. The adsorption clarifier contains buoyant media to increase the surface area for treatment and operates at a loading rate of 10 gallons per minute per square foot (gpm/sf). The filter is operated at a loading rate of 5 gpm/sf (it contains twice the treatment surface area as the clarifier) and consists of a three-layer granular media system.

The adsorption clarifier and mixed-media filter are "coupled" together such that they must be used together and there is no ability to make treatment process adjustments (hydraulically or chemically) in between the units. Both the clarifier and filter are cleaned by an upflow flow reversal process (for the clarifier, the cleaning cycle is called flushing and utilizes raw water; for the filter, it is called backwashing and uses finished water). Both also use auxiliary air to enhance cleaning. The spent water from the clarifier and filter cleaning process is collected in a holding tank. After a period of settling/clarification, a portion of the collected water (the "supernatant") is returned to the head of the treatment plant to the raw water line prior to the point of coagulant addition.

Following filtration, the water is treated with sodium hypochlorite just prior to the clearwell for disinfection. The contact time provided by the clearwell is used to meet primary disinfection requirements ("CT"). As the water leaves the clearwell, it is monitored for chlorine residual prior to the application of chemicals for corrosion control (carbon dioxide and sodium hydroxide), and chloramination (ammonium sulfate). The corrosion control treatment process being utilized is termed "carbonate passivation" with target end points of 9.2 – 9.4 for pH and 34 mg/L for alkalinity as $CaCO_3$.

The plant was recently upgraded in 2006/2007 to include the use of chloramines for secondary disinfection (was previously free chlorine) and carbon dioxide to increase the alkalinity for corrosion control.

The Canobie Lake treatment process is considered "conventional" treatment by the State of New Hampshire Department of Environmental Services (NHDES).

4.4 Summary of Findings

The remainder of this sub-section summarizes Salem's status relative to each of the current water quality/treatment regulations. A matrix approach was used to summarize CDM's findings in Table 4-1 on the following pages.

Table 4-1 Summary of Findings

Regulation	Key Provision(s) Applicable to Salem	Compliance Status for Canobie Lake WTF	Comments
Surface Water Treatment Rule (SWTR)	Combined filter effluent (CFE) turbidity <0.5 NTU (95th percentile) and 1.0 NTU (maximum)	In compliance	The turbidity requirements were superseded by more stringent criteria under the IESWTR, described below.
	Removal and/or inactivation of 3-log (99.9%) of *Giardia lamblia* and 4-log (99.99%) of viruses	In compliance	Chlorine contact time in the clearwell is utilized to achieve these requirements.
	Maintenance of a disinfectant residual in the distribution system	In compliance	Recent conversion to chloramines provides more consistent/persistent disinfectant residual in the system
Stage 1 Disinfectants/ Disinfection Byproducts Rule (S1DBPR)	Established DBP Maximum Contaminant Levels (MCLs) on System-wide Running Annual Average (RAA) Basis for: • TTHM at 80 ppb • HAA5 at 60 ppb Established Maximum Residual Disinfectant Residual Level at Point -of-Entry for: • Free chlorine at 4 ppm • Chloramine at 4 ppm	In compliance	Recent conversion to chloramines has decreased TTHM and HAA5 levels by ~ 50 percent.

Regulation	Key Provision(s) Applicable to Salem	Compliance Status for Canobie Lake WTF	Comments
	Established enhanced coagulation (EC) treatment technique. **Step 1** requires removal of specified percentages of total organic carbon (TOC) based on source water TOC and alkalinity levels. For Salem's supplies (alkalinity of both supplies is < 60 mg/L), required TOC removal is: • 35% if source TOC is > 2 – 4 mg/L • 45% if source TOC is > 4 – 8 mg/L **Step 2** sets an alternative TOC removal requirement (i.e., alternative percent removal of raw water TOC) for systems unable to meet Step 1 criteria. The Step 2 alternative TOC removal percentage is determined by performing jar tests in accordance with EPA procedures at least on a quarterly basis for one year. The jar test results are plotted as the TOC removal (mg/L) versus coagulant dose (mg/L). The Step 2 alternative TOC removal percentage is then set at the point of diminishing returns (PODR) identified on the plot.	Not in compliance. Salem is operating under a temporary waiver from NHDES until Stage 2 becomes effective (2013, with potential 2 year extension to 2015). The temporary waiver allows Salem to meet a TOC removal requirement of 25 percent, which is easier to achieve but still has not been met on a couple of occasions when using Canobie Lake water (April & May 2007).	Salem is unable to meet the Step 1 criteria when treating Canobie Lake water but has been able to meet the Step 1 criteria when treating Arlington Pond water on all but one occasion (out of 13) since January 2005. Jar tests have been conducted for Canobie Lake (and Arlington Pond) and were unable to demonstrate that the PODR could be reached. As such, Step 2 criteria were unable to be established and used for compliance. Salem continues to investigate alternatives to achieve higher levels of organics removal, and believes that advanced treatment processes (e.g., ozone/ biological filtration or nanofiltration) may be needed as part of a future plant upgrade.

Regulation	Key Provision(s) Applicable to Salem	Compliance Status for Canobie Lake WTF	Comments
	Provides alternative compliance criteria from the EC treatment technique requirements if certain conditions are met. Such alternative compliance criteria are separate and independent of the Step 2 enhanced coagulation procedure listed above, and includes: (1) source water TOC is <2.0 mg/L; (2) treated water TOC is <2.0 mg/L; (3) source water TOC <4.0 mg/L, source water alkalinity is >60 mg/L (as CaCO3), and the system is achieving TTHM <40mg/L and HAA5 <30mg/L (or the system has made a clear and irrevocable financial commitment to technologies that will meet the TTHM and HAA5 level); (4) TTHM is <40mg/L, HAA5 is <30mg/L, and only chlorine is used for primary disinfection and maintenance of a distribution system residual; (5) source water SUVA prior to any treatment is ≤ 2.0 L/mg–m; and (6) treated water SUVA is ≤ 2.0 L/mg–m.	Salem has not pursued use of alternative compliance criteria with NHDES.	Only Alternative compliance criteria #6 is likely to be met when using Canobie Lake water. Continuous compliance with this alternative criterion has not been demonstrated and may not be feasible. Some relatively minor treatment process improvements may increase the feasibility of meeting this alternative compliance criterion (see recommendations).

Regulation	Key Provision(s) Applicable to Salem	Compliance Status for Canobie Lake WTF	Comments
Interim Enhanced Surface Water Treatment Rule (IESWTR)	• 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	In compliance with all provisions listed at left; however, achieving compliance is challenging at times.	The treatment process employed at the WTF makes compliance with the filter effluent turbidity criteria challenging during the winter. This is a result of several factors – the cold water (which inhibits coagulation reactions), the occasional flashiness of the Arlington Pond supply, the limited contact time between the point of coagulant addition and the clarifier units, and the lack of flexibility inherent in the "package" treatment units – either alone or in combination. The plant staff often switches the primary coagulant between alum and polyaluminum chloride during the winter period, depending on which performs best. Jar testing is used to assist in this determination.
Filter Backwash Recycle Rule (FBRR)	All recycle flows required to be returned to a point prior to the rapid mix unit	In compliance	Recycle stream is returned to raw water line prior to addition of primary coagulant
	Conduct self assessment to identify direct recycle practices that exceed design capacity during recycle events	Not applicable	Only applicable to plants with ≥20 filters and recycling filter backwash or thickener supernatant without equalization or treatment
Stage 2 Disinfectants/ Disinfection Byproducts Rule (S2DBPR)	Conduct Initial Distribution System Evaluation (IDSE) to identify future TTHM and HAA5 compliance sampling locations.	In progress. Salem is defined as a "Schedule 3" system. The SSS study plan was submitted to NHDES prior to the regulatory deadline of 10/1/07. The next milestones are to complete the IDSE by 9/30/09 and submit the IDSE Report to NHDES by 1/1/10.	Salem is conducting the IDSE using t he System-Specific Study (SSS) approach. In order for the IDSE to be accepted by the state, the SSS must provide equivalent or better information that Standard Monitoring Program (SMP) approach for selecting sites having high TTHM and HAA5 levels.

Regulation	Key Provision(s) Applicable to Salem	Compliance Status for Canobie Lake WTF	Comments
	Compliance calculation method revised to Locational Running Annual Average (LRAA) for: • TTHM MCL at 80 ppb • HAA5 MCL at 60 ppb	Likely to be in compliance. Monitoring under the LRAA method to begin by 10/1/13.	If Salem continues with chloramines for secondary (residual) disinfection, compliance with the LRAA is likely to be achieved based on the current (Stage 1) sampling sites. Compliance may become difficult at future Stage 2 sampling sites, depending on the results of the IDSE.
Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)	• Conventional treatment is credited as providing 3.0-log *Cryptosporidium* treatment if filtered water turbidity levels are maintained below 0.3 NTU in 95% of samples (per IESWTR).	Current treatment is classified as “conventional” by NHDES. In compliance.	See comments above under IESWTR about periods when compliance is challenging due to source water quality fluctuations and limitations of the existing treatment process.
	• Systems must conduct two years of monthly source water monitoring for *Cryptosporidium*	In compliance	Salem has completed its source water monitoring

Regulation	Key Provision(s) Applicable to Salem	Compliance Status for Canobie Lake WTF	Comments
	• Based on concentration of *Cryptosporidium* detected during source water monitoring, systems will be classified into a bin with associated treatment requirements <u>beyond</u> conventional treatment, as follows: - Bin 1: <0.075 oocysts/L ; no additional treatment - Bin 2: ≥0.075 but <1.0 oocysts/L; 1-log additional treatment - Bin 3: ≥1.0 but <3.0 oocysts/L ; 2-log additional treatment - Bin 4: ≥3.0 oocysts/L ; 2.5-log additional treatment • Additional treatment must be selected from suite of "Microbial Toolbox" options	In compliance; monitoring has been completed and results place Salem in "Bin 1" with no additional treatment for *Cryptosporidium* required.	
Total Coliform Rule (TCR)	No greater than 5% total coliform (TC) positive in distribution system	In compliance	Recent conversion to chloramines provides more consistent/persistent disinfectant residual in the system

Regulation	Key Provision(s) Applicable to Salem	Compliance Status for Canobie Lake WTF	Comments
Lead and Copper Rule (LCR)	Lead Action Level of 0.015 mg/L and Copper Action Level of 1.3 mg/L at 90th percentile in first draw tap samples	In compliance	Recent addition of carbon dioxide to increase alkalinity in conjunction with pH adjustment provides more consistent pH levels in the system. pH/alkalinity adjustment also promotes formation and stability of monochloramine and assists in controlling chloramine decay, which could lead to nitrification.

Table 4-1

Summary of Findings

4.5 Conclusions and Recommendations

Based on the regulatory review presented above, CDM would like to suggest that Salem consider the following recommendations regarding continued and future compliance.

1. Achieving Stage 1 DBPR Compliance

The only regulation that Salem does not presently comply with is the Stage 1 DBPR, specifically the "treatment technique" requirements for TOC removal. TOC removal is important because naturally-occurring organic materials in the water (measured as TOC) can react with disinfectants to form DBPs.

Prior to the conversion to chloramines for secondary disinfection, Salem was not in compliance with the Stage 1 MCL for Total Trihalomethanes; however, the use of chloramines has allowed TTHM compliance to be achieved. Although the use of chloramines has allowed Salem to meet one component of the S1DBPR (the TTHM MCL), Salem still struggles with meeting the second major provision of the S1DBPR (organics removal) when using the Canobie Lake supply.

CDM understands that Salem has conducted extensive investigations, including a testing program conducted by the University of Massachusetts/Amherst, to understand the nature of the organic matter present in the Canobie Lake water, and why it is not amenable to removal by coagulation. Coagulation is the only process presently available to Salem at the WTP for organics removal. CDM also understands that these studies were unable to establish the point-of-diminishing returns (PODR) during jar testing conducted according to EPA protocols. Without being able to demonstrate that the PODR can be reached, Salem is not eligible to meet an alternative (Step 2) TOC removal percentage. The Step 2 removal percentage would be less than the primary Step 1 removal percentage and would have allowed Salem to comply with this provision of the S1DBPR.

Based on discussions with Salem staff, CDM learned that Salem has considered whether it could meet any of the six alternative compliance criteria (these were listed in the matrix above). Salem indicated that it might be possible to sometimes meet alternative compliance criteria #6 (treated water SUVA ≤ 2.0 L/mg–m). SUVA, an indicator of DBP precursor removal treatability, is defined as the UV–254 (measured in m-1) divided by the DOC concentration (measured as mg/L). Alternative compliance criteria #6 is determined based on monthly monitoring calculated quarterly as a running annual average of all measurements.

CDM recommends that Salem conduct testing of a preoxidant (likely candidates are ozone or chlorine dioxide) to determine if this may benefit the coagulation process. Some limited testing of ozone was conducted in the past, although the focus was ozone applied post-filtration. Testing of ozone applied to the raw water did show some benefit for the coagulation/flocculation process particularly under cold water conditions. The oxidant could be applied to the raw water at the pump station to take advantage of the contact time in the pipeline between the pump station and the treatment plant for oxidation to occur prior to the addition of the primary coagulant. Another possibility if ozone were used would be to use a side-stream injection method to introduce the ozone into the water, which would eliminate the expense and space requirements for ozone contactors. CDM has had good experience with preoxidation for the purpose of enhancing coagulation/flocculation (as well as for other purposes such as iron/manganese oxidation) and we generally include this provision in new plants and designs of plant upgrades.

It should also be noted that EPA stipulates Best Available Treatment (BAT) for controlling TTHMs (and HAA5s) as enhanced coagulation or GAC10 (both with chlorine as the primary and residual disinfectant). GAC10 is defined as granular activated carbon with an empty bed contact time (EBCT) of 10 minutes and reactivation frequency of no more than six months. This EBCT could not be met if the existing filters were to be retrofitted with GAC. However, one potential option that may be feasible and readily added to the existing plant (without a major upgrade) would be post-filtration GAC contactors. This may have a dual-purpose benefit for controlling taste and odor episodes, as discussed in the next item. Post-filtration GAC contactors would operate in an absorption mode, as particle removal will have taken place upstream in the primary filters. We would anticipate needing an EBCT of 10 to 15 minutes, subject to confirmation by bench-scale (RSSCT) or pilot testing. At the plant design flow of 4 mgd, this would require two 25-foot square basins with 4 to 5 feet of GAC. This option offers flexibility in plant operations in that the contactors can be taken off-line (bypassed) when not needed, which would help to extend the life of the carbon. Repumping may be necessary; however, more detailed hydraulic evaluations beyond the scope of this study would be needed to make that determination.

Another means of achieving additional organics removal would be to add pretreatment upstream of the existing adsorption clarifier. There are "package" clarification units offered in the Trident product line consisting of a two-stage high-rate clarification process—a tube clarifier with integral sludge recirculation followed by a buoyant absorption media clarifier (similar to the existing adsorption clarifier). This type of unit could be located at the head end of the plant to pre-treat all of the water for the existing three "package" Trident Water Systems. It could be operated only at times when the source water is difficult to treat (i.e., when using Arlington Pond water) and would allow for enhanced coagulation, greater TOC removal, and a greater degree of tolerance of "flashy" water. It would also provide some relief in terms of solids loading to the existing adsorption clarifiers and mixed media filters, thereby enhancing their overall performance. This type of process could likely be accommodated within the hydraulic grade line with minor modifications; however, a detailed evaluation is beyond the scope of this study.

2. Taste and Odor Control

Taste and odor (T&O) are aesthetic parameters that are not regulated as primary drinking water standards. However, they affect the palatability of the water and, more significantly, how the public perceives the quality of the water they are drinking. Water that is in full compliance with all regulations but exhibits taste and/or odor is often considered by the public as unsafe.

With regard to taste and odor, Salem has experienced algal blooms in the summer when Canobie Lake is used for water supply. The State does apply copper sulfate, but it is often too late to catch the bloom prior to its maximum growth phase. No T&O episodes occurred from the Canobie Lake supply in the last two years. The WTP does not have any capability within the process train such as a strong oxidant (e.g., ozone, potassium permanganate, chlorine dioxide, etc) or activated carbon for adsorption to address T&O in the source water. Powdered activated carbon (PAC) would be difficult for the adsorption clarifiers to handle (in terms of solids loading) and granular activated carbon (GAC) would have limited empty-bed contact time if placed in the existing filters as noted above. Given the seasonal nature of the problem, the most likely option for T&O control at the Salem WTP would be the use of a strong oxidant alone or perhaps combined with hydrogen peroxide to achieve advanced oxidation (e.g., ozone or UV combined with hydrogen peroxide to form the –OH radical). Post-filtration carbon contactors could provide the necessary EBCT for T&O removal, and might also remove (via adsorption) organics that are not amenable to removal by coagulation. If Salem were to consider GAC contactors for T&O control, a bypass could be installed so as to not exhaust the GAC during times when T&O is not a problem (the need for a bypass would depend on whether GAC would also be doing "double duty" for organics removal).

3. Filtered Water Turbidity

As noted above, the treatment process employed at the WTF makes compliance with the filter effluent turbidity criteria challenging during the winter. This is a result of several factors – the cold water (which inhibits coagulation reactions), the occasional flashiness of the Arlington Pond supply, the limited contact time between the point of coagulant addition and the clarifier units, and the lack of flexibility inherent in the "package" treatment units – either alone or in combination. Based on jar testing, the plant staff often switches the primary coagulant between alum and polyaluminum chloride during the winter period to achieve the best performance.

The nature of the treatment units (particularly the shallow filter bed depth of 30 inches) is such that there are limited options to improve turbidity removal performance. It is possible that decreasing the influent particle "load" on the units may improve performance. This could be evaluated full-scale through a limited testing program whereby incremental changes (decreases) in loading rates are tested and operating performance data collected. Each loading rate condition should be evaluated through at least two complete clarifier and filter run cycles. Data should be collected to evaluate both water quality (turbidity) and operating performance (e.g., ripening time, run length, headloss accumulation rate, etc.).

Another means of reducing the "load" on the existing treatment units would be installation of a "package" clarification unit as discussed above. This would consist of a two-stage high-rate clarification process—a tube clarifier with integral sludge recirculation followed by a buoyant absorption media clarifier (similar to the existing adsorption clarifier). This type of product is offered by the same manufacturer as the existing "package" treatment system.

Our experience is that a likely benefit of preoxidation (as suggested above for improved coagulation/organics removal) may be enhanced filter performance. CDM recommends that during testing of preoxidation, that the sampling program be extended to also evaluate the impact on filter performance. This would include monitoring of filtered water quality as well as filter operating parameters (e.g., ripening time, run length, headloss accumulation rate, etc.).

4. Chloramine Byproducts

Some studies have linked chloramine use with formation of N-nitrosodimethylamine (NDMA), a probable human carcinogen (USEPA 1993) that has been identified as a potential health risk in drinking water. NDMA is a potential disinfection byproduct from reactions of chlorine or chloramine with nitrogen containing organic matter and from some polymers used as coagulant aids. Research to date is not totally conclusive with respect to the extent of formation and the mechanism by which NDMA is formed.

Recent work by Schreiber and Mitch demonstrated monochloramine was not a significant precursor for nitrosamine formation during chloramination, which is contrary to previous research. They found that dichloramine reacts with secondary amine precursors to form an intermediate (dialkylhydrazine), which can then be oxidized by dissolved oxygen to form nitrosamines. The significance of this relates to the importance of controlling the chemistry of forming chloramines so that the formation of the dichloramine species is minimized (dichloramine formation can occur if excess chlorine is added above the stoichiometric 5:1 chlorine:ammonia ratio). Chen and Valentine found that NDMA formation in chloraminated river water was primarily attributed to reaction with humic substances. Humic substances are generally the bulk of what makes up natural organic matter (NOM). In this work, a linear correlation was found between NDMA formation and specific UV absorbance (SUVA). Recent research in Germany by Schmidt et al. found a good correlation for NDMA formation was the boron content in the water, suggesting a major anthropogenic influence. This research concluded that surface water supplies under the influence of wastewater are at higher risk for nitrosamine formation during chloramination than non-influenced supplies. Andrews found that NDMA concentrations within the distribution system appear to be related to the travel time or distance from the treatment plant, with increasing concentrations at higher water age.

In general, greater NDMA concentrations are found in chloraminated systems than systems using free chlorine for residual disinfection.

Salem recently (fall 2007) switched to chloramination for secondary (residual) disinfection. Monitoring conducted to date for NDMA and other nitrosamines has not detected these byproducts. CDM encourages Salem to continue with NDMA monitoring to determine if a future compliance problem could exist should EPA regulate this contaminant. A suggested monitoring program would include semi-annual sampling for NDMA, TOC, DOC, UV absorbance, boron (or other surrogate parameter to identify the extent of the anthropogenic source contribution), in addition to current monitoring of disinfectant residual, pH, temperature, etc. The DOC and UV absorbance parameters are suggested so that the SUVA parameter can be calculated. Sample locations should consider the effects of travel time through the distribution system. Because NDMA is not regulated, Salem should also develop a response plan in the event that levels of concern are detected. In the absence of regulations, one guideline that can be considered is adoption of California's NDMA "notification level" of 10 parts per trillion (ppt).

5. MTBE

MTBE or methyl-tertiary-butyl-ether is a gasoline additive that was formerly used to increase oxygen content and thereby reduce carbon monoxide and ozone levels caused by auto emissions. Releases into groundwater and surface water supplies are leaking underground storage tanks, spills, and emissions from marine engines. Concentrations at or below 20 – 40 ppb will avert unpleasant T&O effects, and will likely protect consumers from potential health effects. MTBE is currently on EPA's Second Contaminant Candidate List (CCL2) and included in the Unregulated Contaminant Monitoring Rule (UCMR).

NHDES established a state standard of 13 ppb for MTBE (source water). Salem has conducted monitoring for MTBE since 2002, with the highest levels detected in the source water of 2.5 ppb. CDM recommends continued monitoring to establish whether seasonal trends/patterns exist given the phasing out of the use of this additive in gasoline.

6. Water Quality Monitoring

A cursory review of Salem's current water quality monitoring capabilities was conducted. The recent addition of a full-time chemist position is an important step in providing focus to the detailed, highly-specialized nature of operating a water quality laboratory entrusted to protect public health.

Salem's overall water quality compliance monitoring program appears to meet all regulatory requirements. One area where monitoring should be focused relates to non-compliance or "diagnostic" monitoring focused on the distribution system. It is important to establish a long-term history of distribution system behavior given the recent chemistry changes related to chloramines and corrosion control. Although chloramines are relatively stable and less reactive (compared to free chlorine), they do exhibit a very slow, continual loss over extended periods of time. The primary mechanisms contributing to the decay of chloramines are autodecomposition and direct reduction by select reducing agents such as nitrite, natural organic matter (NOM), and iron.

Therefore, in addition to current monitoring for total chlorine and (free) ammonia, it is suggested that a chloramine diagnostic monitoring program include the following parameters: nitrite, nitrate, HPC - R2A, pH, temperature, dissolved oxygen (DO), and decay rate (calculated). Locations of concern should be targeted including stagnant/old water, unlined cast iron, and low velocity areas. The monitoring program should include "trigger" levels and associated operational responses for key parameters including those indicative of early signs of nitrification.

From a regulatory perspective, it appears that the only new federal initiative that will impact water quality monitoring in the next five years is the Revised Total Coliform Rule (RTCR). Once the regulatory framework is established (expected in late summer/early fall 2008), Salem should consider conducting TCR monitoring in accordance with the new requirements (e.g., use of fecal coliform will no longer be allowed and must be replaced by *E. Coli*) in parallel with current regulatory provisions in advance of the changes taking effect.

7. Comprehensive Long-Term Treatment Assessment

As noted above, this water quality and treatment process review was limited in nature. CDM recommends that Salem conduct a treatment review that would provide the Town with the same level of comprehensive recommendations as that being provided in this Master Plan for the distribution system. In that way, the CIP could be prioritized on an "apples to apples" basis to consider both treatment and distribution needs well into the future. The treatment assessment should take into account the results of water quality and water treatment studies currently being conducted as well as a through review of treatment capacity, in light of planned system expansion.

In such a review, the preceding water quality issues could be considered in more detail including the feasibility of the various treatment process modifications previously discussed (e.g., preoxidation, post-filtration carbon adsorption, two-stage high rate pretreatment, etc.). In addition, as noted elsewhere in this report, the production of the WTP on maximum days of demand already exceeds the "firm capacity" of the WTP. The comprehensive WTP review should include a review of reliability issues and means of expanding the WTP capacity to assure the ability to provide all Salem's water needs in future years.

4.6 References

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Section 6
Alternatives for System Expansion

6.1 General

Currently, Salem provides public water to approximately 70 percent of the Town. Despite the size of the distribution network which is currently in place, there exist significant areas within the northern and southwestern portions of town that are not currently served by the existing distribution system. In addition to evaluating the need for long term improvements to the existing system, the scope of this study included development of a plan for future service to these currently unserved areas of the community. As the topography in these areas is quite variable and contains elevations above the current maximum service elevation of 235 (as noted in Section 5), it was necessary to review the current service zone and delineate future service zones in order to properly serve these areas.

To determine the configuration of the future service zone(s) and the facilities needed to service these areas, CDM:

- Reviewed existing service zone boundaries;
- Reviewed ground surface elevations and determined the elevation ranges that can be served from the existing service zone;
- Established service criteria to determine future zone boundaries;
- Developed future service zone boundaries;
- Developed network of system facilities (pipes, pump stations, etc.) needed to serve areas while maintaining service goals; and
- Confirmed sizing of system facilities and service criteria using the hydraulic computer model.

6.2 Service Goals

6.2.1 Minimum/Maximum Pressure Goals

Since water pressure decreases with increased elevation, under normal system conditions, the topography of the land will generally dictate water pressure. Existing elevations within the existing Town of Salem water distribution system generally range from approximately 100 to 250 feet above mean sea level. Additionally, the elevations within the areas of Salem which are currently unserved by the water distribution system range from 150 to 370 feet. Because of the great range in elevation, it was necessary to divide the future distribution system into multiple service zones in an attempt to regulate system pressures. The variability of ground elevations can be seen Figure 6-1, where the red shaded areas indicate elevations above the current maximum service elevation of 235 feet.

As discussed in Section 5, per New Hampshire Department of Environmental Services regulations, minimum working pressures in the distribution system are required to be 35 psi or greater. In addition, the system is required to be designed to maintain a minimum pressure of 20 psi at ground level at all points in the distribution system under all conditions of flow. This standard helps to avoid potential cross-connections and negative pressures (vacuum) that could occur at service connections (at high elevations) during fire flows or other significant demand events.

General water works practice also suggests that the maximum desirable pressure in a water main be in the vicinity of 100 psi, and generally not greater than 130 psi. Even so, the State of New Hampshire building code requires that water main pressures in this range must be reduced to a maximum of 80 psi by means of a pressure reducing valve (PRV) for plumbing in buildings. Though not ideal, systems can be designed with pressures greater than 100 psi without any adverse effects. With these guidelines in mind, a pressure range of approximately 40 to 100 psi was used for the initial layout of the future distribution system.

6.2.2 Fire Flow Design Goals

General

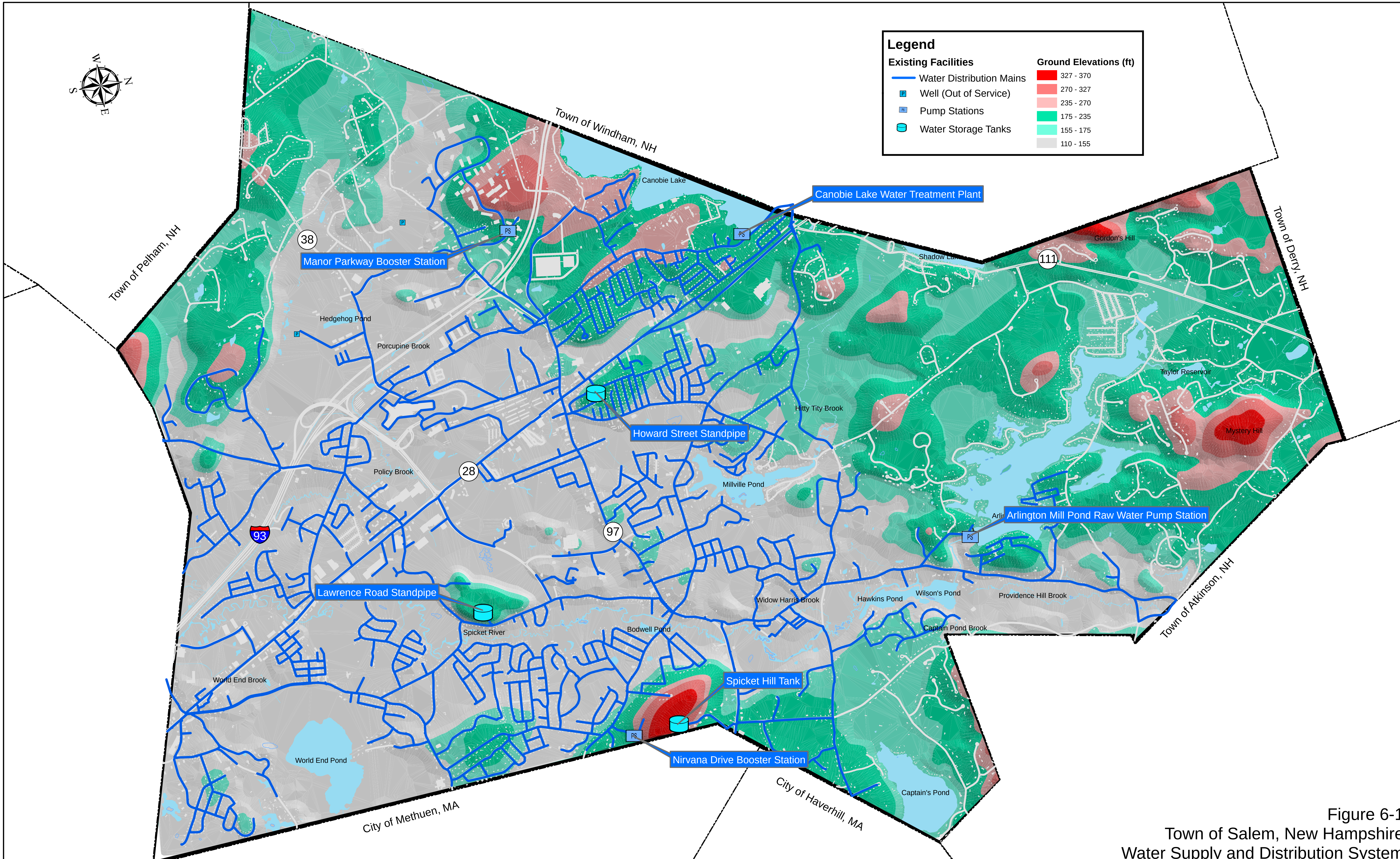
The ability of the distribution system to provide adequate flow during fires is generally evaluated based on fire flow requirements established by the Insurance Services Office (ISO). The ISO is an association of insurance companies that compiles data that are used to establish rates for fire protection policies for both residential and commercial buildings. ISO typically estimates fire flow requirements at several locations within a community.

In the case of Salem, the ISO last evaluated the community water system in 2002, at which time a total of 21 fire flow locations were used to determine the ability of the system to deliver fire flows. These fire flow locations were used to determine the adequacy of the existing system, as further discussed in Section 5. Since the ISO only determines fire flows for structures within the existing water distribution system service area, for the purposes of this study, it was necessary to estimate the required fire flows in the future distribution system area based on land use and known existing commercial and school buildings.

Following a review of the Town of Salem zoning maps, it was determined that the vast majority of the unserved areas of the Town consist of residential land-use. It should be noted however that, under current zoning, there is a limited area in the vicinity of Shadow Lake Road (Route 111) and Ermer Road that is classified as "Limited Community Shopping".

Residential

Fire flow requirements for residential areas are relatively simple to estimate using ISO guidelines. For 1- or 2-family dwellings not exceeding two stories in height, the requirements are dictated by the distance between structures, as outlined in Section 5.



Notes: Existing pipe information based on GIS database provided by the Town of Salem in October 2007.

0 0.125 0.25 0.5 0.75 1 Miles

Figure 6-1
Town of Salem, New Hampshire
Water Supply and Distribution System
Areas of High Elevation/Low Water Pressure
June 2008

Non-Residential

Estimates for fire flow requirements for non-residential buildings are based on a complex formula considering land use, building construction, occupancy characteristics, spacing between buildings, and the existence of individual building fire protection systems. Estimates of fire flow for specific commercial/industrial buildings are typically completed by a representative of ISO or a fire protection engineer.

Generally, the water system must deliver a fire flow up to a maximum of 3,500 gpm at a 20 psi residual pressure to obtain the best overall town-wide insurance rating. The provision of additional flow above 3,500 gpm, if needed, is generally considered by ISO as the responsibility of the owner of the building. A sprinkler system can be used to reduce the fire flow requirements for these larger existing buildings; sprinkler systems are generally required on new construction.

Estimated Fire Flow Requirements for Currently Unserved Areas of Salem

Based on the current zoning and estimates of spacing between existing homes, a general fire flow requirement of 750 gpm is likely to be required by the ISO in the currently unserved areas of Salem. In addition, based on experience with fire flow requirements in similar communities, it was estimated that a fire flow requirement of approximately 1,500 gpm would be necessary in the vicinity of the "limited community shopping" zone. It should be noted that these are planning level flow requirements and are subject to change based on site-specific evaluations.

6.3 Development of Distribution System Expansion

6.3.1 Delineation of Future Service Zone Boundaries

With these service goals in mind, CDM evaluated of existing service zones and the development of the proposed future service zone boundaries. This process took into consideration:

- Ground elevations;
- Desirable service pressures;
- Existing road network;
- Maintaining or expanding existing facilities, whenever possible;
- Minimizing the number and size of proposed facilities; and
- Optimizing locations of proposed facilities based on ownership and topography.

This process was aided by the use of GIS software and electronic elevation data for the town obtained from the USGS. This elevation data, known as a digital elevation model (DEM), made it possible to locate practical limits of service areas based on existing or proposed facility operations. For example, given an assumed overflow elevation of a tank or a discharge pressure of a pumping station, all areas of town within an elevation range that could be served by that facility at a reasonable pressure can be readily located. From these practical limits, each zone was compared with the existing road network and adjusted to maximize pipe looping within each zone. Pipe looping is important to maximize flows to each area and looping addresses issues of system reliability if one pipe in the system is out of service. Since it is unlikely that these zones will produce ideal pressures in all areas of town, this process becomes iterative in an attempt to minimize the number of zone and related facilities while attempting to meet the predetermined service goals.

6.3.2 Development of Expanded Piping Network Model

The existing model of the Salem distribution system (further discussed in Section 5) was expanded to include the area of future expansion in order to assist with the development and to verify the layout of the future service zones and associated facilities. Once developed, the expanded model yielded results which were then compared with known current operational conditions to verify the proposed layout.

In the case of the proposed piping facilities, a street centerline database of the town was manipulated and imported into the model to ensure that the future system model contained pipes on the majority of all streets in town. The sizes of the proposed pipes were modified during the planning of the future system. The Hazen-Williams C-value is a relative measure of the hydraulic capacity of a water main. For lined pipe materials, as would be installed in the future expansion of the Salem system, C-values were assumed to range from 110 to 130, depending on diameter and based on known empirical values.

The two primary data points contained in the junction database of the model are elevation and demand at each respective point. To develop the expanded Salem model, CDM used GIS software to automatically assign elevation data to each future junction using the digital elevation model (DEM) database obtained from the USGS. This method ensures relative accuracy of elevation information in the model and minimizes sources of potential error in the model.

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 system flows (which are distributed across the system) under typical daily demand conditions 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 requirements, which stress the system at discrete locations and create significant headlosses, generally govern the selection of required pipe diameter.

Since maximum day demands are typically used to size distribution system facilities, the estimated future maximum day demands (as discussed in Section 3) were used as the basis for assigning average demands to the model. For simulations of the future expansion of the service area, the increases in system demands were assumed to primarily occur in the expanded area and were therefore allocated evenly across the model junctions in the areas of system expansion. Fire flow demands were also assigned to each junction based on land-use and individually simulated to determine pipe sizes required for the flow rate. This was done by placing the 750 gpm residential fire flow demand at each junction and then selectively replacing this demand with a 1,500 gpm demand in the vicinity of the area of limited community shopping noted above.

Once the model development was complete, it was then used to:

- Verify and/or adjust boundaries of proposed service zones;
- Locate and size future distribution facilities to serve maximum day demands; and
- Size water mains and facilities to deliver estimated required fire flow demands.

6.4 Alternatives for Expansion

As previously noted the areas of future expansion within Salem are topographically diverse and frequently exceed the maximum service elevation of the existing system. As shown on Figure 6-1, these areas are scattered throughout the future service area and create the need for additional system pumping stations as further described below. In addition, there are some limited areas within the existing Main Service Zone which also exceed 235 feet and do not currently meet the NHDES requirements for minimum service pressure. Alternatives for mitigating these pressure deficiencies are also included in the following discussion.

6.4.1 Mitigation of Pressure Deficiencies in the Existing System

High Elevation Areas

As discussed in Section 2, there are currently two booster pump stations located in the distribution system which boost water from the Main Service Zone to high elevation areas. These stations include:

- Manor Parkway Booster Station: Supplies high elevation area in the vicinity of Industrial Way and Commercial Drive; and
- Nirvana Road Booster Station: Supplies residential development in the area of Nirvana Drive and is currently being expanded to include high elevation areas of Stanwood Drive.

In addition to these high elevation areas of the existing system, the evaluation of the existing service area yielded the following locations which also exceed elevation 235 feet and are currently connected to the Main Service Zone. It should be noted that, under ideal conditions (low system demands and full distribution tanks), the existing Main Service Zone has the potential to supply elevations up to 265 feet with a minimum service pressure of 35 psi. For this reason, the Ticklefancy Lane area noted below was not identified during peak hour system modeling as discussed in Section 5. However, the maximum service elevation of 235 feet which has been used by the Town of Salem for many years was used here to determine areas of potential low pressure concerns and is thought to be appropriate.

The areas of the existing Main Service Zone which currently exceed 235 feet include the following:

- Ticklefancy Lane: The northern extremity of Ticklefancy Lane currently exceeds an elevation of 250 feet;

- North Policy Street: The area of North Policy Street approximately between Orchard Terrace and Veronica Avenue exceed elevations of 235 feet, up to an approximate elevation of 260 feet; and

- Brookdale Road: Brookdale and adjoining streets to the southeast of Canobie Lake (Canobie Avenue, Lakeshore Road, etc.) currently have water mains servicing elevations in excess of 27 feet. It should be noted that this area is located across Interstate 93 from high elevation areas currently served by the Manor Parkway Booster Station.

Mitigation of Existing Elevation Issues

Alternatives for mitigating these existing pressure deficiencies include installation of additional local booster pumping stations or adjusting the hydraulic gradeline of the entire distribution system. Since there are already significant facilities in place (multiple storage tanks and finished water pumps at the WTP) which would need to be modified in order to adjust the grade of the entire system, this option was deemed not to be a cost effective alternative and was removed from further consideration. Accordingly, the remaining method for addressing the pressure deficiencies was the creation of new high service zones or modification to the extents of existing high service zones.

The high elevation area of Ticklefancy Lane is located at an extremity of the existing system and is not in close proximity to either of the existing high service zones. For this reason, the only feasible alternative to increase pressures is the installation of a booster pump station for this location. The suggested area this station is shown in Figure 6-2. It should also be noted that, based on hydraulic modeling of the proposed high service zone at this location, it is likely that a fire pump would not be required. Though minimum "working" pressures are unable to be maintained at this location, the model results indicated that the installation of a check valve around the booster station would enable adequate fire flows (up to the assumed 750 gpm residential ISO requirements) would be capable of being supplied at a minimum residual pressure of 20 psi by the existing system.

Figure 6-2
Town of Salem, New Hampshire
Water Supply and Distribution System
Areas of Recommended System Improvements
Using Multiple North High Service Zones
June 2008

Notes:
- Existing pipe information based on hydraulic model provided by the Town of Salem in October 2007.
- Proposed pipe diameters based on hydraulic simulations of full build-out conditions. Prior to implementation of individual improvements, separate evaluations should be made to determine adequacy of proposed improvements based on preexisting facilities.

CDM

Though new individual high service zones are potential alternatives to mitigate the pressure deficiencies in the area of North Policy Street and Brookdale Road, the proximity of this area to the existing Manor Parkway High Service Zone yields an attractive alternative. In the event a new water main were to be extended from Manor Parkway cross-country to Brookdale Road and then east on Brookdale Road to the existing 8-inch water main on the east side of Interstate 93, both of these areas could be effectively connected to the Manor Parkway High Service Zone. It should be noted that the opportunity presents itself under this alternative to coordinate this improvement with the proposed 16-inch pipe on North Policy Street presented in Section 5. In the event the 16-inch North Policy Street pipe were to be installed prior to or in conjunction with this improvement, the existing 12-inch main on North Policy could then be reused as a high service pipe which would mitigate the North Policy deficiencies.

6.4.2 Alternatives for High Elevation Areas of the Expanded System

As shown on Figure 6-1, the areas of the future expanded system which contain ground elevations which exceed 235 feet include the following:

- West of Route 111: There are a number of streets located west of Shadow Lake Road (Route 111) which have limited areas which approach elevation 250 feet. These streets include Gordon Avenue, Elizabeth Lane, Partridge Circle, Halk Drive and Green Haven Road;

- Mystery Hill: Multiple streets adjacent to Mystery Hill support homes at elevations greater than 235 feet. Though Mystery Hill itself (which is assumed to be undevelopable for the purpose of this evaluation) exceeds an elevation of 360 feet, the homes in that area are located at approximate elevations of 300 feet or below;

- Briarwood Drive: In the event there were homes on this street which required connection to the distribution system, a booster station would likely be required to serve the elevations in this area which approach 280 feet. It should also be noted that there are areas of Hunt Street, located immediately north of Briarwood Drive, which also slightly exceed 235 feet;

- Samoset Drive: Located adjacent to Lake Street, portions of this neighborhood exceed elevations of 250 feet;

- Zion Hill Road: The area of Zion Hill Road in the vicinity of Tudor Drive is located at elevations up to approximately 270 feet;

- Carriage Lane: The northern extremities of Carriage Lane and Fieldstone Lane support homes which are located at elevations approaching 270 feet; and

- Lowell Road: Located in the southwestern extremity of Salem, portions of Lowell Road near Lancaster Crossing have areas which approach elevations of 250 feet.

6.4.2.1 Multiple Booster Pump Station Alternative

As previously noted, these areas of high elevation within the currently unserved area of the Town are scattered and generally not located in close proximity to one another. As a result, one option would be to install individual booster pump stations at each of these locations in order to create individual high service zones. Potential locations for the individual booster pump stations are shown on Figure 6-2. Some notes on each of these high service zones include the following:

- Zachary's Crossing Road High Service Zone: In the event a new station were installed near the intersection of Zachary's Crossing Road and Route 111, a new high service zone could be created to serve the streets west of Route 111. In addition to the pipes required for service connections, a parallel high service pipe on Route 111 could be installed to supply the area of Gordon Avenue without the need for a separate station.

- Independence Drive High Service Zone: A station could be installed in the vicinity of Independence Drive to serve the high elevations around Mystery Hill. In addition to the pipes required for service connections, cross country pipes between Pawtucket Lane and Haverhill Road and between Norwood Road and Lazarus Way should be installed to create a fully looped zone around Mystery Hill.

- Briarwood Drive High Service Zone: As noted, in the event there were homes on this street which required connection to the distribution system, a booster station would likely be required in the vicinity of Briarwood Drive;

- Samoset Drive High Service Zone: A new booster station near the intersection of Samoset Drive and Lake Street would serve the neighborhood of Samoset Drive, Penobscot Avenue, Mascoma Road and Kiowa Road.

- Zion Hill High Service Zone: As shown on Figure 6-2, a pump station in the vicinity of Arcadia Lane would serve the high elevations in this area. Though it would be possible to install a single pipe in Zion Hill Road to serve this area, it is suggested that the high service area pipeline parallel a Main Service Zone pipeline so as to not create significant lengths of dead-end piping in the system.

- Carriage Lane: A new booster station near the intersection of Carriage Lane and Hooker Farm Road would address this pressure concern; and

- Lowell Road: A new station in the vicinity of Lancaster Crossing could be installed to boost pressures on the south end of Lowell Road and adjoining streets.

Table 6-1 below summarizes the individual booster pump station that would be required to boost pressures to the high elevation areas. It should also be noted that, due to the lack of distribution storage within these new high service zones, each of these pump stations would be required to supply up to peak hour flows, the magnitude of which would need to be evaluated on a case-by-case basis prior to design of the station. Table 6-1 also notes whether the hydraulic modeling of the proposed system indicated the need for a separate pump to supply fire flows to each high service area.

Zone	Location *(see Figure 6-2)*	Pumping Requirement
Ticklefancy Lane	Ticklefancy Lane @ Courtland Drive	Peak Hour Flows
Lowell Road	Lowell Road @ Lancaster Crossing Road	Peak Hour Flows
Carriage Lane	Carriage Lane @ Hooker Farm Road	Peak Hour Flows
Samoset Drive	Samoset Drive @ Lake Street	Peak Hour Flows
Zion Hill Road	Zion Hill Road @ Arcadia Lane	Peak Hour Flows
Briarwood Drive	Briarwood Drive @ Elsie Avenue	Peak Hour Flows
Zachary's Crossing Road	Zachary's Crossing Road @ Route 111	Peak Hour & Fire Flow
Independence Drive	Independence Drive @ Tilton Terrace	Peak Hour & Fire Flow

Table 6-1
Locations of Individual High Service Zones
In Areas of Future System Expansion

6.4.2.2 Consolidated North High Service Zone Alternative

In the event the multiple pump station option was utilized during expansion of the Salem distribution system, the resulting system would include a total of ten separate booster pump stations within the distribution system. Even for larger systems with staffing levels above that of Salem's, ten separate stations could be considered extreme and is likely to require significant operation and maintenance expenditures and copious amount of person-hours in order to properly maintain. For this reason, a second alternative was developed as part of the current study in an attempt to minimize the number of proposed pump stations.

Consolidated Northern High Service Zone Pump Station

With this issue in mind, after a review of system configuration options and service elevations, it was determined that it is possible to consolidate the majority of the northern portions of the Town into a single high service zone. As shown on Figure 6-3, this zone would be served by a single new high service zone pump station to be installed at (or in the vicinity of) the Canobie Lake WTP. It should also be noted that, in the event the new Northern High Service Zone Pump Station were installed so as to not rely on the existing high-lift pumps (e.g., draw directly from the WTP clearwell), it is possible that the high-lift pumping system deficiency identified in Section 5 may be mitigated by the inherent increase in overall finished water pumping capacity of the WTP.

Recommended Northern High Service Zone Storage

Though it is technically possible to supply this consolidated zone from a single new high service zone pump station without the use of system storage, doing so on a large system such as this is not recommended. The operational complexity and lack of flexibility for future operations would be reduced by relying on a single pumping system which would be required to operate continuously in an attempt to maintain constant system pressures. Accordingly, it is recommended that a storage tank be provided for the following reasons:

- Dampen hourly demand fluctuations that otherwise would be met by the supply source, thereby reducing operating costs;
- Meet required fire flow, thus reducing pumping capacity (and costs) at supply sources, as well as reducing piping capacity requirements;
- Provide a volume of water for emergencies in case of pipeline breaks, mechanical equipment malfunctions, or power failures; and
- Help to equalize pressure throughout the consolidated High Service Zone to provide surge relief, and to help control pumping operations.

As further detailed in Section 5, the three components of distribution system storage include hourly fluctuation volume, fire flow storage and emergency storage. In the case of the proposed Northern High Service Zone Tank, the requirements for each of these components would include the following:

- Equalization Storage: The equalization storage component, based on typical values for similar systems, would be approximately 20 percent of the maximum day demand. Based on an estimate of the future max day demand of this area, the future equalization storage volume requirement would be about 0.30 mg.
- Fire Flow Storage: Though the maximum ISO required fire flow for this zone has yet to be determined, for the purpose of the storage evaluation it was assumed to be 2,000 gpm. Though this is slightly greater than the flow assumed earlier in this section as used for the piping system analysis, it is considered to be conservative and appropriate for the purpose of the storage system analysis. Thus, the fire flow storage component is 0.24 MG based on providing a 2,000 gpm fire flow for two hours.

Emergency Storage: As this new storage is above and beyond the existing storage tanks that support the main service zone, the inclusion of emergency storage in this new tank is likely unnecessary, unless deemed otherwise by the Town.

Figure 6-3
Town of Salem, New Hampshire
Water Supply and Distribution System
Areas of Recommended System Improvements
Using Consolidated North High Service Zone
June 2008

Notes:
- Existing pipe information based on hydraulic model provided by the Town of Salem in October 2007.
- Proposed pipe diameters based on hydraulic simulations of full build-out conditions. Prior to implementation of individual improvements, separate evaluations should be made to determine adequacy of proposed improvements based on preexisting facilities.

The location of a proposed storage tank is primarily dictated by ground elevations in addition to physical location within the distribution system. Upon review of the topographical high points within the Northern High Service Zone, it was determined that the two highest and most appropriately situated locations for a tank included Gordon's Hill (approximate elevation of 370 feet) or Mystery Hill (approximate elevation of 360 feet). Since land acquisition at the latter site is unlikely due to its reported archeological significance, it was assumed for the purposes of this study that Gordon's Hill would be the most appropriate location for the proposed tank.

The following is a summary of the design characteristics related to the proposed tank.

- Maximum Day Demands for North Salem: .... 1.5 mgd
- Equalization Volume (20% of Max Day):............................0.30 mg
- Fire Flow Volume (2,000 gpm @ 2hrs): ....0.24 mg
- Total Volume: ....0.6 mg
- Assumed Max High Service Elevation:...............................270 feet
- Proposed Overflow Elevation: ....381.5 feet
- Base Elevation (Gordon's Hill):...360 feet
- Height: ....20 feet
- Diameter: ....71 feet

Assuming prestressed concrete construction is used for this tank, based on recent similar installations, it is estimated that this new tank would cost approximately $1.4 million

6.5 Piping System Analysis

6.5.1 Piping System Requirements

Using the computer model of the future service zones and storage and pumping facilities, CDM analyzed and sized Salem's water distribution system piping. 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 percent of the required equalization and fire flow volume was withdrawn, and the supply source was providing maximum day flows.

6.5.2 Piping System Sizing

Fire flows were simulated at each junction in the areas of future expansion of the system to ensure that a minimum acceptable residual pressure of 20 psi was maintained throughout the system during each flow simulation. In the event that a particular simulation resulted in pressures below 20 psi anywhere in the system, modification to the pipe size and/or piping facilities were made until the fire flow was met. This evaluation was performed for both the multiple pump station and the consolidated Northern High Service Zone options.

Under fire flow conditions, small diameter mains can only convey flows for a limited distance before the friction between the wall of the pipe and the water will result in less than adequate flows and pressures at the hydrant. Accordingly, NHDES requires that a minimum pipe diameter of 6 inches be used in systems designed for fire flow purposes. As a result of the sprawling nature of the road network, in combination with standard water works practice used in similar communities (and required by many states), a minimum pipe size of 8 inches in diameter was used in the layout of the future Salem distribution system.

As shown in Figure 6-2 and Figure 6-3, the resultant distribution system pipes ranged from 8 inches in diameter to 16 inches in diameter. Table 6-2 summarizes the proposed piping facilities for each expansion alternative.

It is important to note that the proposed water system piping layout was generally dictated by the location of existing roadways. In order to minimize future water quality issues, the Town should attempt to maximize the use of pipe loops at locations where easements are thought to be obtainable. In addition, it is important to note that the pipe sizing included in this report was analyzed and designed based on full system build out conditions. Since it is not possible to predict how the system will be expanded over time, it is critical that prior to implementation of any incremental piping system improvement, each proposed improvement be evaluated with respect to fire flow availability and service goals prior to full build out of the distribution system.

	Diameter	Multiple North High Zones		Consolidated North High Zone	
	(in)	Length (ft)	Length (mi)	Length (ft)	Length (mi)
North Expansion	8	186,000	35.2	176,100	33.4
	10	2,300	0.4	-	-
	12	66,200	12.5	79,300	15.0
	16	-	-	2,100	0.4
	Subtotal	**254,400**	**48.2**	**257,600**	**48.8**
South Expansion	8	43,100	8.2	43,100	8.2
	10	14,200	2.7	14,200	2.7
	12	13,900	2.6	13,900	2.6
	Subtotal	**71,200**	**13.5**	**71,200**	**13.5**
Total Piping		**325,600**	**61.7**	**328,800**	**62.3**

Table 6-2
Inventory of Proposed System Expansion Piping

6.6 Estimated Cost of System Expansion

In summary, based on the expansion analysis described in this section, it was determined that the infrastructure required to support full expansion of the distribution system would include the following:

Multiple North High Service Zone Alternative

- Seven new booster pump stations (exclusive of upgrades required for the existing distribution system); and
- Sixty-two miles of new distribution main.

Consolidated Northern High Service Zone Alternative

- One new high-lift service zone pump station at the WTP;
- One new 0.6-mg storage tank;
- Two new booster pump stations; and
- Sixty-two miles of distribution main.

Based on the project cost estimates outlined in Section 5 and within this section, it is estimated that the overall implementation cost of this expansion would be roughly $61.3 million (in 2010 dollars) for the Multiple North High Service Zone Alternative and $60.5 million for the Consolidated Northern High Service Zone Alternative.

Section 11
Capital Improvement Planning

11.1 Introduction

Most of the prior sections of this report have offered recommendations on facilities and issues affecting the Town's water system. The primary purpose of this Section is to collect all recommendations regarding facilities, and include them in a single section for the Town's future reference. Recommendations which appeared in Sections 2 through 8 are reiterated or referenced herein. Other sections include recommendations on other types of issues, and the reader should refer to those sections for those issues including Section 7.9 (information systems), Section 9 (organizational evaluation) and Section 10 (financial evaluation).

In this section, we review issues related to integration of water system work with other Town efforts, such as the roadway reconstruction program. We then offer suggestions on the prioritization of the various improvements to the existing system that were presented in Section 5. Projects are then grouped and presented in 5-year phases.

11.2 Integration of Water System Work with Other Town Programs

Salem's fiscal year is aligned with the calendar year. Salem's annual municipal budgeting cycle begins in the late spring, when officials develop and/or modify their recommendations for capital improvements. In late June, the Engineering Department brings projects and budgets to the Town Manager, followed by a presentation in July to the Board of Selectmen. The Capital Improvements Committee review is in August. In the fall, warrant articles are developed for Town Meeting. After the start of the fiscal year in January, the warrant is issued in February, for Town Meeting action in March.

Salem maintains a ten-year Capital Improvements Plan (CIP) which is updated annually through this process. The current version of Salem's CIP was developed in September 2007 and was provided to CDM for use in this project.

The annual budgeting cycle and the ten-year CIP provide opportunities for integration of the needed water system work into the Town's overall financial planning. We offer the following remarks:

- The ten-year CIP contains numerous roadway projects which will be conducted in areas that also have water system needs. Combining utility projects into a single coordinated program typically results in cost savings for the community, and should be done whenever possible. For example, if a repaving project is planned on a certain street, it is cost-effective to coordinate any needed water main work on that street with the roadway program. This reduces mobilization costs, avoids the need to cut pavement that has been placed relatively recently, and minimizes the inconvenience of construction projects to the public.

- The key time for coordination of projects is late spring, when the Engineering Department develops recommendations for the Town Manager. Mid to late spring is thus the ideal time each year for the Engineering Director, DPW Director, Utilities Manager and others to review overall capital needs associated with Public Works. This Water System Master Plan will provide a document that can be utilized immediately for this purpose. The Town is considering future performance of a Sewer Master Plan which, if pursued, would do the same for that utility. The needs of other utilities—such as gas, electric and communications—should also be factored in during these mid-to-late spring reviews.

- Over time, any utility planning document will show its age. Certain projects will have been completed, others deferred, and issues will arise that could not have been anticipated in the planning document. Therefore, there is a need for a mechanism to regularly update a utility plan such as this Water System Master Plan. In the early years after the plan's development, this can be done fairly simply. Issues and ideas can be noted throughout the year on hard copies or e-copies of the key maps and tables in this document, and then reviewed as part of the annual coordination process. This will facilitate continued coordination with other programs.

- After some years, a utility plan may need to be updated. The needed duration before the update will be judged over time by Town officials, but we note that some utilities have utilized a 15-year cycle for major updates of utility master plans. This cycle sometimes includes a "mini-update" at 5-year intervals. If Salem wished to follow this philosophy, then the Town could prepare formal updates of the key maps and tables in the Water System Master Plan as part of the 5-year "mini-update", for review and discussion with other Town officials and the public.

To facilitate this coordination process for the current budget cycle, CDM has reviewed the current CIP which covers the period from 2008 through 2017. We met with Town officials in May 2008 after the water system issues presented in Sections 5 and 6 had been developed. During that meeting, a number of project coordination opportunities were identified. From that discussion and subsequent reviews, CDM created Table 11-1.

This table lists all projects in the current CIP (September 2007) that already incorporate, or which could incorporate, water system work. Projects in the existing water system which were identified in Section 5 and which are located along the routes of the CIP's roadway projects are listed in this table. In addition, some CIP roadway projects are in areas that could be considered for future water system expansion as discussed in Section 6. These projects are also noted on Table 11-1.

Year	Roadway Project from 2008 CIP — Project Name	Notes on Potentially-Interrelated Water Projects
2008		
	* Shore Drive Area Phase I	• Potential water system expansion area in N. Salem.
	* 2010 Road Section Design	• Incorporate minor water upgrades in Cluff Crossing Rd. and S. Policy St. • Haverhill St is in potential N. Salem water expansion area.
2009		
	* Bridge & Road Reconstruction -- Design Plan, North Main St.	• Incorporate minor water upgrades on N. Main St.
	* West of I-93 Design Plan	• Connect Manor Parkway high service zone to N. Policy Street via Brookdale Road, to facilitate eventual incorporation of high-elevation area on N. Policy into the high service zone. • Potential water system expansion area in southwestern Salem.
	* Canobie Phase II -- Sewer/Water Construction	• (Project includes water main extensions to currently-unserved areas.)
2010		
	* Bridge & Road Reconstruction -- North Main Street	• See note under the related 2009 design item above.
2011		
	* West of I-93	• See note under the related 2009 design item above.
2012		
	* Corinthian, Teague, Parker	• Potential water system expansion area in N. Salem.
	* Bridge Reconstruction, Bluff Street	• Potential water system expansion area in N. Salem.
	* Shore Drive Area Phase II	• Potential water system expansion area in N. Salem.
	* Lower Lawrence Road and Pond Street, Design	• New water main needed in Pond Street to satisfy ISO fire flow deficiency. • Incorporate minor water upgrades in lower Lawrence Road.
	* Route 28 Corridor Reconstruction Design Plan	• Coordinate with the various proposed water upgrades in Route 28 and its side street connections.
2013		
	* Shore Drive Area Phase III	• Potential water system expansion area in N. Salem.
2014		
	* Lower Lawrence Road and Pond Street	• See note under the related 2012 design item above.
	* Route 28 Improvements Phase I	• See note under the related 2012 design item above.
2015		
	* Route 28 Improvements Phase II	• See note under the related 2012 design item above.
2016		
	* Route 28 Improvements Phase III	• See note under the related 2012 design item above.
2017		
	* Route 28 Improvements Phase IV	• See note under the related 2012 design item above.

Table 11-1

Coordination with Planned Roadway Projects

Preparing a coordination table like this on an annual basis in the spring will help assure that water system improvements are pursued on the most cost-effective basis possible.

11.3 Prioritizing the Improvements to the Existing Distribution System

Table 5-5 presented the DPW's prioritized list of improvements to the existing distribution system. This list was prepared prior to initiation of this Water System Master Plan project. As noted in Section 5, we have reprioritized the projects on Table 5-5 as part of this project.

In developing the reprioritization, we considered the following factors:

- All recommended projects in this Section are being grouped into 5-year Phases, as follows:

  Phase 1 – 2008 through 2012
  Phase 2 – 2013 through 2017
  Phase 3 – 2018 through 2022
  Phase 4 – 2023 through 2027

- As was shown on Table 11-1, a number of projects on the DPW list correspond to roadway projects that are already included in the Town's CIP. These projects already have an assigned date in the CIP, and that date was held for the purpose of this Water System Master Plan. Such projects were slotted into the appropriate Phase based on the CIP's project date.

- Project no. 4-3 on Table 5-5 (Franklin Street—Remove and replace ~ 1000 feet of existing 6-inch with new 8-inch pipe) had been listed by DPW as fourth in the original four-tier priority. From recent meetings with DPW, we understand that the existing main in Franklin Street is now causing frequent water quality complaints from residents. Therefore, this project was assigned a higher priority, and slotted into Phase 1.

- Most of the projects on Table 5-5 are relatively small-scale water main improvements. Given the magnitude and nature of these projects, CDM decided to assign all items on this list into either Phase 1 or Phase 2, thereby completely addressing the list of issues on Table 5-5 within a ten-year period.

- An attempt was made to group the projects by geographic location and estimated project cost so as to create viable, cost-effective potential construction contracts.

The resulting reprioritization of Table 5-5 is shown on Table 11-2.

11.4 Water System Capital Improvement Program

Figure 11-1 presents a one-page summary of the overall water system capital improvement program. All facility-related recommendations are listed on this summary figure, and the report section in which they are discussed is identified on the figure. The program elements are grouped into five major categories, as shown on the left-hand side of Figure 11-1.

The first element is water conservation and demand management.
Such measures are now part of the standard operating procedures and policies of most, if not all, water systems. Their importance will only increase in the future, as concerns regarding environmental and economic effects of water system operation continue to grow. Therefore, most of these efforts are shown as annual in nature and would be carried out by in-house resources. The water meter/AMR program is, however, a significant capital program. Due to the importance of reducing unaccounted-for water, minimizing water losses, and equitably allocating costs to users, we have placed this as a high-priority 2009-2010 program. As noted in Section 3, a planning budget range for the program is $1.9-2.3 million.

The second element includes the supply sources.
As noted in Section 8, Salem is continuing its permitting efforts regarding the raw water transfer, and there is a possibility of completion of that effort in 2009. Depending on the outcome, the Town could then consider other potential supply sources. Reviews of legal water rights, protection measures, and safe yield could proceed at any time as desired. Many of these efforts involve in-house resources; while external consulting and legal assistance are also needed for some.

Section 4.5 presented a series of recommendations from our brief WTP process review. Many of these are regulatory-driven and have public health and compliance implications. Several are already in the process of being addressed. We do, however, recommend a comprehensive review of the WTP to include these issues and also the overall capacity issues. As noted in Sections 4 and 5, the "firm capacity" of the WTP and water pumping systems is 4 mgd, while recent maximum day demands are above this amount. As demands increase in the future, this disparity will increase. These evaluations are listed as high-priority (2008-2010) items.

The third element includes the storage tanks.
The poor condition of the Howard Street standpipe warrants placing its rehabilitation as a high-priority (2009) project. The recommended budget was $600,000 (or $640,000 if the Town defers the project to 2010). As discussed in Section 5, tank inspections should be carried out at least every five years, and the timing and nature of subsequent rehabilitation projects at all three tanks will depend upon the results of those annual inspections. We assigned those future rehabilitation projects to various Phases as shown on Figure 11-1.

	Year	Project Number	Street	Location	Required action	Budget
Phase I	2008	3-7	Cluff Crossing Rd	S Broadway to Lancelot Ct	Connect exist services over to 16" main (1-3/4", 1-2", 2-6" add 3 hydrants)	$31,000
	2009	1-1	North Main St	Main St to Bluff St	Connect 40 services to 16" main, abandon 6"	$141,000
	2009	1-2	Main St	School St to N Main St	Connect 15 services to 16" main, abandon 6"	$53,000
	2009	4-3	Franklin St	Howard St to Millville St	Remove and replace est. 1100' of existing 6" with new 8"	$176,000
	2010	1-3	North Policy St	Pump Station Rd to St. Mary's	Replace with est. 300' of 16" main	$75,000
	2010	1-4	North Policy St	WTP to Pumping Station Rd	New 16" redundant WTP discharge	$575,000
	2010	3-2	North Policy St	St. Mary's to Veronica Ave.	Install 4,400' of 16" main	$1,100,000
	2011	1-6	St. Mary's Ln	N. Policy to Old Rockingham Rd	Connect 12 services to new mains. Connect new 12" directly to new 16"	$42,000
	2011	3-3	Old Rockingham Rd	12" thru back yards	Install 5 services to main on Old Rock Rd, can couple with Catherine, Joseph, Helen problem	$18,000
	2011	3-4	Old Rockingham Rd	At Joseph, at Catherine, at Helen	Connect Dead Ends (Phone duct conflict)	$42,000
	2011	4-2	Old Rockingham Rd	St. Mary's to Range Rd	Replace with est. 3000' of 12" main	$585,000
	2012	2-4	Spicket Hill Tank	to Nirvana Dr	Install 1,800' of 12" main from tank to Bridge St.	$351,000
					Phase I Subtotal	***$3,189,000***
Phase II	2013	3-1	Main St	N Policy to Sullivan Ave	Connect 8 services to 12" main, abandon 6"	$28,000
	2013	3-9	Point A Rd	South Policy St to Fairmont Rd	Connect 2 services to 16" main and remove 6" from service	$7,000
	2013	4-13	Fairmont Rd	South Policy to end	Remove and replace existing 6" with est 1400' of new 8"	$224,000
	2014	1-5	Hampshire Rd	RR Xing to 300' into Methuen	Connect customers to Methuen Water Dept, abandon 6"	$80,000
	2014	2-3	Pond St	Lawrence Rd to Sandhill	Replace existing 6" with 1,600' of new 12"	$312,000
	2014	2-5	South Broadway	469 S B'way to 300 Lawrence Rd	connect 5- 3/4", 1- 1 1/2", 1- 2" and 1- 8" services over to existing 12" mains	$63,000
	2014	4-4	Pond St	Sand Hill to Copper Beech	Remove and replace existing 4" with est. 1800' of new 8"	$288,000
	2014	4-5	Lawrence Rd	Senter to S Broadway	Connect 21 3/4" services and 1 4" service to 12" main, abandon existing 6"	$78,000
	2014	4-6	South Broadway	Lawrence Rd to Mass. Line	Remove and replace existing 6" with est. 700' of new 8" (6, 3/4" services,1, 8" service)	$112,000
	2015	3-5	Howard St	Charles St to Taylor St	Replace existing lines with est. 675' of 12" main	$132,000
	2015	3-6	Taylor St	Lee Joy Lane to Howard St	Install est. 400' of 12" main	$78,000
	2015	4-8	Veterans Parkway	Senior center to Freedom Dr	Install est 1750' of 12" main to connect dead ends	$341,000
	2015	4-9	Geremonty Dr	Court House to Veterans Pkwy	Install est 1000' of 12" main to connect dead ends	$195,000
	2015	4-10	Geremonty Dr	Main St to Meisner Dr	Install est 500' of 8" main to connect dead ends	$80,000
	2016	2-1	Spencer Ave	at Joyce Heard Ave	Install <100' of 6" to connect dead ends	$16,000
	2016	2-2	Haigh Ave	at Streeter	Install <100' of 6" to connect dead ends	$16,000
	2016	2-6	Willow St	All	Remove and replace existing 6" with est 350' of 8"	$56,000
	2016	4-11	Azarian Rd	to Future Rd connection	Require connection as part of subdivision approval of lot 135-8944	Privately Funded
	2016	4-12	Stone Post Rd	Jana Connection	Install est 500' of 8" to connect to Jana, remove cross-country feed from service	$80,000
	2016	3-8	MacLaughlin Ave	North Main St to Oak Ave	Remove and replace existing 6" with est 750 of 8"	$120,000
	2017	4-1	Brady Ave	Cortland to #71 Brady Ave	Replace with est. 3000' of 12" main	$585,000
	2017	4-7	Lake St	Millville to Easy	Remove and replace existing 6" with est 2200' of new 12" main	$429,000
					Phase II Subtotal	***$3,320,000***

Table 11-2
Reprioritized List of Water System Improvements

	Report Section Reference	Phase 1					Phase 2	Phase 3	Phase 4
		2008	2009	2010	2011	2012	2013-2017	2018-2022	2023-2027
WATER CONSERVATION/DEMAND MANAGEMENT									
• Water Audit	3.5	■	■	■	■	■	(Annually)	(Annually)	(Annually)
• Leak Detection and Repair	3.5	■	(Round 1)	■	(Round 2)	■	(Continues indefinitely at frequency determined in Round 2)	■	■
• Meter Replacement/AMR Program	3.5		■	■					(Consider next upgrade)
• Other Efforts (see Table 3-4)	3.5	■	■	■	■	■	(Annually)	(Annually)	(Annually)
SUPPLY SOURCES									
• Applications to NHDES/EPA for Water Transfer	8.3	■	■						
• Safe Yield Evaluations	8.4			■					
• Surface Water Protection Plans	2.1		■						
• Legal Review of Water Rights	8.5	■							
• Evaluate Protection Measures at Former Groundwater Supplies	2.1		■						
• Consider Other Sources after Transfer Permitting (if needed)	8.2-8.6			■					
• WTP Process & Capacity Evaluation	4.5	■	■	■					
• Canobie Raw-water and Finished-water Pump Capacity	2.3, 5.4		■	■					
STORAGE TANKS									
• Howard Street Standpipe Rehabilitation	5.7		■						(Consider next upgrade)
• Lawrence Road Standpipe Rehabilitation	5.7						(Consider need based on future inspections)	■	
• Spicket Hill Tank Rehabilitation	5.7							(Consider need based on future inspections)	■
DISTRIBUTION SYSTEM -- EXISTING									
• Valve Maintenance	7.3	■	■	■	■	■	(Annually)	(Annually)	(Annually)
• Hydrant Maintenance	7.4	■	■	■	■	■	(Annually)	(Annually)	(Annually)
• Manor Parkway Booster Station Upgrade	5.4		■						
• North Main Street Reconstruction Design	11.2		■						
• North Main Street Reconstruction Construction	11.2			■					
• West of I-93 Design	11.2		■						
• West of I-93 Construction	11.2				■				
• Lower Lawrence Road and Pond Street Design	11.2					■			
• Route 28 Corridor Reconstruction Design	11.2					■			
• Other Phase 1 Improvements (see Table 11-2)	5.6, 11.3			■	■	■			
• Lower Lawrence Road and Pond Street Construction	11.2						(2014 only)		
• Route 28 Corridor Reconstruction (four phases)	11.2						(2014-2017 only)		
• Other Phase 2 Improvements (see Table 11-2)	5.6, 11.3						■		
DISTRIBUTION SYSTEM -- EXPANSION									
• Canobie Area Sewer/Water Construction	11.2		■						
• Other Phase 1 Expansion	6.4, 11.2					■			
• Phase 2 Expansion	6.4						■		
• Phase 3 Expansion	6.4							■	
• Phase 4 Expansion	6.4								■

Notes:

1. See Figures 6-2 and 6-3 for maps showing improvements.
2. See Section 11.4 of text for discussion of the overall program.
3. Various recommendations from information systems, organizational, and financial reviews (Sections 7.9, 9 and 10) are not shown here.

CDM

Figure 11-1
Summary of Capital Improvements Program Planning

The fourth element includes work on the existing distribution system. Valve and hydrant maintenance programs are listed first, and should be performed on an annual basis. As noted in Section 7, once the Town has begun to implement systematic maintenance programs for valves and hydrants, it will be possible to estimate the program costs for replacements of hydrants and valves. If significant, such replacement programs can be considered as capital projects in future years. The additional ISO hydrants identified in Section 5.5.3 should be included in such projects.

The Manor Parkway Booster Station Upgrade project did not receive funding in 2008, but should be considered again in 2009 as the project is needed to rectify an existing fire protection deficiency. The budget in the Town's current CIP is $150,000.

Many of the remaining projects in listed the fourth element are associated with projects already identified in the Town's current CIP, as noted above in Section 11.2. Their current budgetary allowances appear in the CIP. In many cases, however, the recommended water system work was not included in the current CIP budget. The additional costs for water system work for the Table 11-1 projects have been included here within either Table 11-2 or within the "system expansion" cost estimate discussed in Section 6.6, depending on the nature of the associated water system improvement.

The remaining distribution system improvements from Section 11.3 above are grouped into a Phase 1 and a Phase 2 program. The specific projects and budgets are listed on Table 11-2.

The fifth and final element on Figure 11-1 is expansion of the distribution system. The only expansion project currently being pursued is the Canobie Area Sewer/Water Expansion, which is a 2009 project in the Town's current CIP. The degree, nature, and timing of further system expansion into North Salem or southwest Salem as described in Section 6 is subject to future policy decisions by the Town. Since the direction and schedule of such efforts over the next 20 years cannot be detailed at this time, Figure 11-1 simply displays the possibility that such efforts could occur in any or all of the four phases.

As suggested earlier in this Section, Figure 11-1 and the tables and maps from which it is derived should be reviewed annually in the spring as part of the Town's annual budgeting and project development process.

Section 10
Financial Management Evaluation

10.1 Introduction & Background

The Town of Salem has engaged CDM to develop a Water System Master Plan with primary emphasis on the water distribution system. The work, however, also includes a brief assessment of the financial capabilities of the Town's water and sewer utilities. CDM has conducted this assessment in accordance with best practices and industry standards as outlined by the AWWA and WEF. The purpose of this section is to outline the water and sewer utilities' current financial status and determine areas where streamlining processes, procedures and organizational structure can help increase efficiency and functionality of the utilities.

This section is divided into seven subsections, not including the Introduction and the Conclusions. Those sections are:

- Financial Planning,
- Financial Budgeting,
- Financial Accounting,
- Financial Reporting,
- Debt Management,
- Reserve Management, and
- Ratemaking.

While this section addresses each of these issues separately, it is important to note that they are all interrelated.

10.2 Summary of Conclusions

The Town of Salem faces a number of financial challenges, including obtaining the necessary political support for moving forward with capital improvements and the resulting and necessary rate increases. This Water System Master Plan will help provide discussion, tables and maps for Town officials and the public to better understand the needs of the utility.

The focus of this evaluation has not been so much on the utility's cash position, but on those policies and procedures necessary from a business perspective to sustain the utility and ensure it is well managed. The types of issues evaluated in this report section are derived from a new AWWA manual, *Business Practices for Operation and Management*. While specific financial goals vary across utilities, there are financial management best practices, as laid out in the following sections, which, if implemented in Salem, will improve financial performance. The performance measures recommended in this report are based on the types of standards and measures that the financial rating agencies (e.g., Moody's, Fitch, and Standard and Poor) use when evaluating the financial status of utilities seeking a bond rating when issuing debt. While a variety of subjects and practices are addressed in the following sections, CDM emphasizes the two end goals of any financial plan it develops:

- Insuring rate adequacy and understanding rate impacts, and
- Maintaining a stable and sustainable cash balance position.

In addition to the issues addressed in the following sections, CDM recommends that the Town also address in its multi-year strategic financial plan performance measures, based on the measures that the rating agencies use to assess utilities:

- 95% of all bills should be based on actual reads,
- Current year collections for all bills be 98% or greater,
- Actual expenditures be within 98% of budgeted expenditures, and
- The Town should establish a operating reserve to cover contingencies (emergency repairs, sales fall-offs) equal to 15% of budgeted expenditures.

The Town needs to ensure that it bills all customers in accordance with their actual use of water. Towards that end, CDM recommends the Town implement a meter replacement program to upgrade the Town's existing meters. As meters age they become more unreliable and will under-report consumption. It is very likely that customers who are using exactly the same volume of water in a billing period are paying significantly different amounts depending on the accuracy of the specific customer's meter (something that a customer has no control over). Replacing the meters will likely increase the amount of revenues the Town actually receives without changing rates. Other communities have experienced sales increases of 15–20 percent. At the same time, the Town should consider implementing an automatic meter reading (AMR) system that will reduce the costs of servicing accounts and facilitate more timely and accurate billing. Section 3 discusses these meter/AMR issues further.

10.3 Financial Planning

Financial planning is a key element in developing and maintaining a stable and sustainable utility. The most effective form of financial planning is a multi-year forecasting plan that incorporates both short-term and long-term objectives. The plan should focus on the capital needs of the system and the implications for the utility's revenue requirements and rates. CDM's current project with the Town is to develop a long term master plan that provides the underlying engineering foundation required for a strategic financial plan. The Town's Finance Department has a multi-year rate model and this model should incorporate the master plan and subsequently be updated regularly as the Town implements the master plan and addresses other system needs. It should be pointed out that the current master plan is primarily assessing the needs of the distribution system. To have an effective financial plan and for all stakeholders to understand the requirements of the water utility, it is important that the Town develop an analysis of the needs at the water treatment plant and the supply system so all needs are fully understood. This tool can provide empirical documentation and inform policy makers of the impact of various capital projects on the rates.

10.4 Financial Budgeting

In line with best practices, the Town does have a formal and detailed budget process. The goal of the process is to ensure that the utility has adequate funds secured for its annual operation, repair and replacement needs, as well as expansion and other capital improvements. A critical element of the budgeting process is to provide departmental managers current expenditure information so that they can effectively manage their department's expenditures.

The Town does have a well-established budgetary process. However, there are several issues that limit its effectiveness. Firstly, the actual development and approval of the budget requires a significant passage of time—the process starts in May and is not completed until the following February or March—this is a result of the Town's form of government. It would be better if the budget was approved before the start of the fiscal year in January.

Secondly, Town Meeting may approve expenditures and capital improvements (typically in the form of service extensions) that were not included in the utility budget that was submitted to Town Meeting. This requires the utility to reshuffle its capital and operating plan to accommodate the new projects. This has caused the utility to deplete its reserves.

10.5 Financial Accounting

The Town's water and sewer utilities are currently organized as special revenue funds. A special revenue fund functions by separating water or sewer revenues as they are collected by the Town and places them into water and sewer special revenue funds that can only be used for water and sewer purposes. A special revenue fund is an adequate form of accounting for the Town's current needs. However, it is CDM's belief that the Town already employs many of the principles of an enterprise fund, and while it is not a crucial or immediate need, financial reporting would benefit from eventually enterprising the Town's water and sewer utilities.

Creating an enterprise fund will more clearly separate out revenue streams in a similar manner as a special revenue fund; however, for accounting purposes, an enterprise system would more accurately reflect the proprietary nature of utilities. Specifically, an enterprise fund defines a utility as a separate entity within the Town's general fund and more effectively represents and allocates the utility's expenditures. An enterprise fund will also enable the utility to retain funds to smooth future rate spikes, fund capital projects, and ensure that sufficient reserves exist to accommodate unanticipated circumstances.

Representing and organizing financial data in the form of an enterprise fund provides managers and decision makers more complete information for their decision making process. A key aim of an enterprise fund is to operate a utility similarly to a private business. This becomes particularly useful in a system where a sizeable portion of the Town is not on sewer or water. Enterprising a system would help ensure that costs are allocated accordingly to those parties incurring costs on the system and those community members who are not part of the water and/or sewer system would not improperly subsidize the system.

10.6 Financial Reporting

Our understanding is that until recently managers did receive timely expenditure reports, but that when the Town upgraded its overall financial management software the expenditure reports provided to departments were lost. The Finance Department is well aware of the issue and is working with the Information Technology group to restore that functionality. The Finance Department is able to provide Departmental Managers the information using a manual process (rather than the managers obtaining the information directly online). The Town should continue to make restoring this capacity a high priority.

Developing financial reporting procedures that are in an electronic format would streamline the process and eliminate many of the inefficiencies created by large amounts of paperwork. This would make financial and budgetary data less time consuming to complete, easier to access, and quicker to update. Providing more complete information to managers allows them to effectively utilize the data, as well as, creating more accountability. This in turn enhances the ability of the utility staff to develop more accurate budgeting and reduces the likelihood of cost overruns. Without timely reporting, it may be unreasonable to hold utility managers accountable for failing to meet their budgets. The Town should expect that the utility's actual expenditures are within two percent of budget (with the exception of true emergencies and changed circumstances).

10.7 Debt Management

Given the long term nature of the infrastructure required for water and sewer services, inter-generational equity suggests that debt financing should be used for system improvements and major rehabilitations. (For smaller system expansions, it is probably appropriate to have those new customers pay directly for those improvements.) Best Management practices also suggest that for rate stability and overall utility flexibility, excessive issuance of debt is not appropriate.

The Town has used debt historically for improvements. The Town's utilities are currently carrying annual debt payments of approximately $698,000 and $178,000 for water and sewer, respectively. As they are presently operating, the water and sewer utilities have budgets of approximately $2.3 and $1.2 million, respectively. Based on typical industry benchmarks, the utilities are not overburdened with debt. A concern does exist with the need for debt going forward. If the Town does not utilize debt, it will be stymied in making necessary capital improvements. However, due to the structural and political organization of the Town and its utilities, issuing debt has the potential to be a difficult and cumbersome process and the Town has not issued debt in some time.

The recent practice of the utility has been to cash-fund small to medium range capital projects, with most of the funding provided through demand and benefit assessments (DBA). This effectively ensures that the beneficiaries of the expansion pay for the growth. It is also good practice to fund a portion of capital improvements from cash revenues, however, that should not be the sole method of funding capital projects. This is especially relevant when the utility faces major upgrades to facilities and the enhancement of treatment processes.

Issuing debt also allows for rate-smoothing. Often the level of free cash necessary to fund capital improvements from year to year varies significantly. This variance can lead to larger than necessary deficits (or surpluses). This in turn can lead to significant rate increases. Issuing debt appropriately eliminates cash-flow issues and smoothes spending from period to period.

The Town should use debt for major capital improvements to upgrade/replace existing infrastructure and any necessary process changes. This master plan and subsequent evaluations can provide the basis for improving public understanding of the need for such improvements and facilitate public approval of bonding.

10.8 Reserves Management

Water and sewer utilities are subject to unforeseeable events that have adverse effects on their cash flow and cash balance position. Since the Town's utilities are intended to be free-standing enterprises, it is necessary and appropriate that the Town fund a contingency or operating reserve within the utility. Currently the Town maintains a free cash balance of approximately ten percent of budgeted expenses. It is CDM's belief that a sequestered fund, in place specifically and solely for emergency uses equivalent to 15 to 20 percent of annual expenses, would be preferable. This belief is in line with industry standards and best practices. When assessing utilities, rating agencies look for free cash of 15 to 20 percent as an indicator of a utility's financial health.

Salem currently maintains a capital improvement fund where the DBA revenues are deposited and secured. The Town also has its special revenue fund that all current revenues flow through but that fund is not really a reserve fund, but to the extent that cash is available, it is used to meet contingencies. The Town also taps the DBA funded capital improvement fund to meet contingencies and emergencies. It is CDM's understanding that the capital improvement fund, formed from DBA revenue, serves as a vehicle for having growth pay for the costs of the system (either directly for the infrastructure required to serve them or indirectly for other system improvements that they benefit from). The capital improvement reserve is both adequately funded and appropriately allocated, and appears to be functioning effectively provided its use is restricted to capital improvements and it is not tapped to meet emergency expenditures or offset shortfalls in revenues.

We strongly recommend that the Town create and fund a true operating reserve with monies accumulated and available to meet a variety of contingencies. The lack of a fully funded operating reserve can leave the utility vulnerable in the event of unexpected occurrences, such as a sales decline (such as from a rainy summer), failure of critical equipment or other emergencies. In the event of such an occurrence the Town would be forced to cut back on operations, use revenue allocated to the capital reserve fund, or use the general fund to subsidize the deficit; all of which create quality of service and/or equity concerns. We recommend that the fund be sized at 15 percent of total operating expenses and be funded through rate revenues over a three to five year period. The Town should adopt a policy that requires if it draws on the fund, it restore the fund over a two to three year period.

To help ensure the solvency of the utilities, CDM recommends that each utility fund and maintain an operational reserve at 15 percent of annual operating costs in addition to its capital reserve fund. Most utilities fund operating reserves over a three to five year period primarily from rate revenues but also through one time payments not required for other purposes (insurance settlements, etc.). If the Town then draws on the utility fund account, the practice would be to restore it over one or two fiscal years.

10.9 Ratemaking

The two key issues in ratemaking are equity and adequacy. In terms of adequacy, it is necessary for the utility to maintain a pattern of rate increases that insure expenditures are met by revenues. As mentioned previously in the financial accounting section, enterprising the water and sewer utilities would help. Ensuring that the financial model is updated and the results regularly reviewed with elected officials, Town management staff and utility staff would help develop an understanding of the utility's current financial situation and how it will change over time. By implementing moderate annual increases to meet cost increases and inflationary pressures, the Town will avoid future rate shocks and widespread alarm at rate increases. In recent history and to this point, the utility has done an adequate job increasing rates to meet cost increases, although rate increases over the last ten years have not fully matched inflation as gauged by the Bureau of Labor Statistics Consumer Price Index. The Town needs to make sure that the utility budgets reflect the real needs of the utility and that budgets not be set based on what will be approved. While there is a need to balance those two pressures, the ultimate objective is to ensure that the utility can provide safe reliable water to meet the Town's needs.

Without more complete analysis, the level of equity of the current rate structure can not be fully determined, however, based on a limited analysis, CDM believes the Town's current rate structure, combined with DBAs and miscellaneous fees, is in accordance with industry standards and best practices as outlined in *AWWA M-1* "Principles of Water Rates, Fees, and Charges" (5th Edition) and the *WEF Manual of Practice* No. 27 (2004). However, CDM does have several suggestions for the Town's consideration.

The first is that the Town considers implementing a rate structure, or fee, to recover fire protection costs, from both public and private customers. Due to the limited scope of this study, CDM is not providing a more detailed analysis or giving recommendations in regards to specific methodologies that may be appropriate for the Town to recover fire protection costs.

The second is that the Town considers implementing an inclining block rate structure that would better encourage conservation, as well as, assign the highest costs to the users that create the greatest burden on the system. If a meter/AMR program were implemented, as discussed earlier, a seasonal rate structure could be considered also.

Lastly, within the Town there are several mobile home parks in which each home is metered but off of a private piping system. The water that flows from Salem's piping into the private system is not currently metered and therefore unaccounted for water loss can occur before the meter to each home. The result is that the Town is unable to effectively monitor and maintain the integrity of the system. This potential unaccounted for water loss creates a potential revenue loss for the utility. Given these circumstances, it would be appropriate for mobile home parks to be master metered.

Section 9
Utilities Division Organization Evaluation

9.1 Introduction

This section describes the results of CDM's evaluation of the Salem Utilities Division organization, including structure, management systems and overall work environment. The intent is to look at the "people" side of the Salem water system as one component of the overall Water Master Plan and to identify organizational issues that should be addressed as part of the long term planning for the future. This evaluation complements our assessment of the technical and physical aspects of the water system; however, this was not intended to be as comprehensive in scope or as detailed an investigation as our technical assessment.

The organizational evaluation is based on direct input and observations from Utilities Division employees and CDM's experience with many similar sized water and sewer utilities in New Hampshire and New England. CDM distributed a questionnaire to all employees that asked for their rating of the Division on a number of organizational issues. CDM received responses from 100 percent of the employees. CDM also visited work sites and conducted personal interviews with each employee as well as the Utility Manager.

9.2 Questionnaire Results

A confidential questionnaire was distributed to each Utilities Division employee along with an envelope stamped and pre-addressed back to CDM. 100 percent of the questionnaires were completed and returned. The one-page form asks the employee to give a ranking of 1 to 5 on how they perceive that the Salem Utilities Division performs on 20 aspects of the organization. The 100 percent completion rate is indicative of high level of interest in providing input on the organization. This was confirmed by the openness of individuals during the interview process. A copy of the questionnaire and a summary of responses are included in Appendix F of this report.

Key Findings

The comments below are based on a review of the questionnaire responses that had the highest and lowest numerical averages. These reflect common concerns and a general consensus among employees that the topic addressed in the specific question is noteworthy. The results were used in preparing for the employee interviews as indicating areas to be followed up during the one-on-one discussions.

- Overall, the questionnaire results indicate that the Division's employees have a sense of personal responsibility for and a high level of individual commitment to the Division's mission.

- This personal commitment is also reflected in the high rating given to the level of cohesiveness during emergency situations. Specific examples of teamwork were cited during the interview sessions that validated this questionnaire response.

- Employees also indicated a high level of satisfaction with their own contributions and productivity.

- While employees expressed satisfaction with their compensation and benefits package, they did not feel that there was an effective program for rewarding or recognizing their efforts. When followed up in interviews, the ability of private industry to provide bonuses and reward individual performance was cited by many as a disadvantage of their public employment.

- The lack of training opportunities was given the lowest overall rating and was confirmed as a strong interest and area for improvement during the interviews.

- "Staff communication and teambuilding" also received a low rating by most employees. The interviews highlighted several issues related to this. The work location of the Distribution Section at the DPW Garage and the mix of work schedules of staff who work out of the Administration Building have made it difficult to have regular all-staff meetings or even regular meetings of the three Foremen. Each of the three sections of the Division is effective in their own area and, over time, the three sections have become more independent. This is a common occurrence in utility operations but it is important to be aware of this trend and work to make sure all functional areas know what is happening throughout the Division and continue to work as a team.

9.3 Findings and Observations from Interviews and Site Visits

General Structure and Staffing

The Utilities Division is a branch of the Salem DPW. The Utilities Manager is one of two Managers reporting directly to the DPW Director, the other being the Operations Manager, who oversees Streets, Parks, Fleet and Solid Waste. The Utilities Division is responsible for water treatment and distribution and sewer collection, including pump stations. Current staffing in the Division is shown in Figure 9-1. It includes a Utilities Manager and a staff of 12, organized into three sections: Distribution (4), Systems (3) and Meters (4) plus a Chemist who runs the laboratory. There is an Administrative Secretary reporting to the DPW Director that shares duties between the two divisions, but no separate administrative position in the Utilities Division structure.

All positions are currently filled. The staffing level is very lean for the size of the Town and the scope of the Utilities Division activities. It is especially lean given the level of responsibility for snow removal that Utility staff have. This is discussed in more detail later in this Section.

Utilities Manager

M. Wiser

Distribution Foreman G. Burton	**Systems Foreman** P. Floriddia	**Meter Foreman** R. Sarcione	**Chemist** M Poor
Const./Maint. Repair III E. Thompson	**Plant Operator II** J. Spalding	**Backflow Inspector** F. Wallace	
Heavy Equip. Oper. D. Fredrickson	**Plant Operator I** R. Benjamin	**Meter Repair Tech.** S. Witkowski	
Const./Maint. Repair I P. Eisan		**Meter Reader** S. Bryson	

Figure 9-1
Utilities Division Organizational Structure

The Utilities Manager has announced his pending retirement, expected before the end of 2008. This is obviously a critical position for the Utilities Division and it is important for the Town to start to prepare for this transition now.

It is most important to note that Salem is extremely well served by the Utilities Division staff, especially the three individuals in the Foremen positions. They know their areas of responsibility well, have extensive experience (all three have more than 20 years with the Division), have positive attitudes about their work and their staff, work together extremely well and back each other up when needed. However, it will be very difficult to meet the operation and maintenance of Salem's expanding water and sewer system needs in the future without additional staff and/or additional contracted services.

The Chemist position is a recent addition. Prior to this position, the Utility Manager did the required lab work. The Chemist has upgraded the equipment and brought the lab into compliance, and it is now certified by state. One Plant Operator is being trained on lab procedures as a personal interest, not a planned cross-training program.

Staff Development

Only a minimum number of Salem staff have the appropriate licenses for their current jobs, either an Operator or Distribution license. Under New Hampshire regulations, Salem is considered to be a Grade 3 system. The Utility Manager and one of two operators have that level of license or higher. That operator also has a Distribution license. Only one of the three foremen has the minimum Distribution license and none have the minimum Operator license. Most are not working on the next license level or additional licenses at this time. The Town does not provide an incentive for obtaining higher level or additional licenses. Also, the training budget is extremely limited and obtaining approvals for training appears to be difficult. Most water utilities encourage staff to obtain higher levels of license in their function and many encourage staff to have both Operator and Distribution licenses. This adds flexibility to work assignments and builds staff capabilities for future openings.

There is a perception that there are more options for getting additional certifications and increased pay in the "Highway Department", which has certifications for different types of trucks and highway equipment. (Reference was frequently made by Utilities staff to a "highway department". This actually refers to the Streets Section of DPW. There are frequent comparisons made regarding staffing numbers, position grade levels and promotional opportunities between the Utility and Highway Department staff.)

There is no training program and very little money available for training. The 2007 budget had approximately $100 for each employee in the combined sewer and water budgets for training. This is less than 0.3 percent of salaries. The industry benchmark for training is approximately one percent of salaries and an average of 40 hours of training per employee per year, excluding safety training. In addition, there has been little safety training conducted in recent years.

Also, there is no formal cross-training program although most expressed strong interest in learning new skills and working in other areas within the Utilities Division. This interest in cross training is noteworthy. Our experience is that water and sewer staff cross training is very cost effective. It provides needed flexibility in work assignments, increases overall productivity and provides motivation for employees. It also is usually seen as a benefit to both management and union membership, in unionized workforces.

Staff Deployment

The Systems Section shift schedule is 6:30 am — 3:30 pm for the Foreman and Plant Operator I. The Operator II works 10:00 am — 6:30 pm. This shift schedule evidently is based on past practices but very little operations or maintenance work can be done in the plant or in the field between 3:30 and 6:30 with only one person on duty. The schedule should be re-evaluated, given current responsibilities and requirements.

Weekend and off-hours coverage is rotated among the three Foremen. Each must work every third weekend plus evenings. They must be on site for at least three hours on Saturday and three hours on Sunday mornings and on call during all off-hours. The availability of a reliable SCADA system and better communication and control from remote locations would make this on-going responsibility less of an inconvenience.

Any review of staffing and staff deployment has to acknowledge the impact that snow plowing has on the water and sewer operations in the winter. In Salem, all employees excluding the Utility Manager and the Chemist but including the Foremen are assigned fixed plowing routes for the Town. While it is common in many New Hampshire towns for water and sewer staff to assist with plowing in emergency situations or to be on call, in Salem it is a part of their job responsibilities.

Distribution Section

The Distribution Section works out of the DPW garage which is about six miles from the Utility Division administration building (10–15 min by truck, or longer depending on traffic in the Rt. 28 commercial area). Their shift schedule is 6:30 am to 3:30 pm.

There is no computerized work management or even work order system; most work records and transactions are done on paper. Also there are multiple manual data transfers from one computer database to another and difficulty in extracting the necessary information. This is one example of the lack of proven technology available to Utilities Division managers and supervisors to get their work done more efficiently.

It appears that a significant amount of time is spent in the inspections of fire hydrants, both those owned by the Town and private hydrants. Salem has fairly strict requirements for private hydrants. There are over 200 private hydrants and the tests are time consuming. They could be handled by an outside contractor and paid for directly by the private owners.

Systems Section
The Systems Section staff is responsible for operations and maintenance of the Water Treatment Plant as well as the dams, pump stations, storage tanks for the water system and the sewer system lift stations. They also handle sewer blockages. The majority of sewer maintenance and repair is contracted out, including cleaning of wet wells, Jetvac cleaning, etc.

As with the Distribution system, the section would benefit from improved SCADA system and laptop computers, which are especially useful given the large geographic area they are responsible for with a small staff. However, the Foremen noted that there have been occasional problems with the Utilities Division phone line during times when the Foremen are on call. This issue should also be address along with improved SCADA capabilities for this section.

Meter Section
The Water Meter Section handles meter installations, repairs and replacements. One full time position is dedicated for meter reading. One-third of the Town's meters are read every month, and customers receive quarterly statements. The Town has a recent validation project with the goal of testing residential meters once every three years and commercial meters every year. The purpose of this validation program is to determine the extent of differences between residential meters and the registers attached to the outside of homes to reduce complaints. This project is very resource intensive and maintaining this project is difficult given the limited resources.

One full time position is dedicated to the cross connection program and backflow inspections. This requires a specialized certification. The Backflow Inspector has developed his own spreadsheet for data management but this is another example of where available computerized systems would be a benefit by eliminating multiple handling of data and facilitating analysis and report generation. Computerized work scheduling would be extremely helpful for this section.

Also, automatic meter reading has been proposed in the past but has not been approved to date and is not included in the 2009 capital budget. The move to automatic meter reading has become common practice among water utilities and should be encouraged in Salem.

It was reported that the price structure for water services was not been updated since the 1980s, including new water hookups, fees for backflow tests and others. Often updating pricing structure involves a rate change or similar approval process and may be difficult for Salem to undertake at this time. The staff perception is that there is not a high level of interest or support for this and other aspects of water services at the Town level.

Use of Technology

Each of the operating sections and the laboratory would benefit significantly from expanded use of computerized technology for data handling and information management. The water and sewer industry has made huge strides in recent years to employ new technology in all aspects of utility and all business processes. This has become well proven technology and very cost effective. When compared to other utilities in New Hampshire and elsewhere in New England, the Salem Utilities Division is not competitive in use of technology to support efficient operations and maintenance. Examples of this were cited elsewhere in this section.

DPW/Utility Relationship

This is a major issue for Utilities staff and for water and sewer programs. This relationship overshadows every aspect of the Utilities Division programs and operations. One significant contributing factor relates to the location of the Distribution crew in the DPW garage. In the current arrangement, Distribution is located in the DPW space, away from the rest of Utilities and separated from the plant. This issue is further addressed in the conclusions and recommendations presented in this report section.

9.4 Recommendations

1. Increase Town Involvement in Water Programs

Salem would benefit from new and broader perspectives to the planning and oversight of Water and Sewer programs. The level of expenditures, the importance of water and sewer services to the town's residents, and the risk to the Town for not complying with capacity and regulatory requirements, all justify an elevation of water and sewer planning and operations in the Town's priorities. The importance and complexity of water programs and issues apparently have become diminished when considered within the multiple priorities related to public works programs. Water programs become even less of a priority when DPW needs are considered with the other Town Departments' needs by the Board of Selectmen and at Town Meeting.

2. Reinforce the Importance of the Master Plan

The development of the Water Master Plan is an effective vehicle and a timely opportunity to raise the understanding of the Town officials and the general public. As noted in a May 5, 2008 *Eagle Tribune* editorial, "Salem needs a long-term water plan". More specifically, the editorial noted several critical areas of need that will require a much higher level of awareness, knowledge and involvement of the Town in water issues. While the editorial did not discuss the CDM Water Master Plan and emphasized some issues beyond the scope of this Plan, it is noteworthy that the future water needs of Salem received this attention. In any case, publicity about the Master Plan and open dialog within the Town will bring needed attention to water issues and future needs.

3. Establish an Advisory Committee

The increased level of Town and Town Meeting attention to water programs that the editorial noted and that is, in fact, much needed could be addressed by establishing a separate Water and Sewer authority in the town or making the Utilities Division as a separate Town department. These are major changes in structure, roles, responsibilities and town governance and would be difficult and time consuming to implement.

We believe that increased attention and involvement could be immediately and effectively addressed by creating a Master Plan Advisory Committee or similar group. CDM recommends the committee have wide representation from within Town government and the public, including representatives of planning, economic development, public works and engineering as well as environmental, neighborhood and commercial interests. Many towns in New Hampshire have used similar advisory committees, some tied to a specific program and its duration, others as permanent town committees.

4. Maintain Current Staffing and Structure

CDM does not recommend any changes to staffing in or structure of the Utilities Division. As noted before, the three current Foremen are very effective in running their areas of operation. CDM believes that additional staff will be needed for the Utilities Division to meet the future water and sewer system needs of the Town, including additional operations, maintenance and administrative resources, but the manager should be the one who decides on staffing levels and structure changes.

5. Conduct a Comprehensive Organization Review

Salem should consider participating in a more thorough assessment of its operations to include a detailed assessment of staffing levels, organization structure and compensation. This level of assessment was beyond the scope of the limited organizational review included in this Master Plan.

Salem should consider the American Water Works Association Qualserve program which includes a very comprehensive self-assessment and an opportunity for a peer review of the organization. Qualserve also has a benchmarking program which would offer Salem the opportunity to compare performance with other utilities on specific performance measures.

The Salem Utilities Division has been assigned responsibilities and has established a structure that fits the situation and historical distribution of work in Salem, but that is not typical of most small-to-medium water and sewer utilities that are separate departments of towns or separate authorities. Other areas of operations need to be looked at, such as the mix of in-house and contracted water and sewer repair work, the current work schedule and coverage during off-hours and specific major equipment needs of Utilities staff.

CDM is not advocating that the Utilities Division be made a separate entity at this time but it would be a useful comparison to see how separate water utilities are structured and what their responsibilities are as part of a more comprehensive assessment of the Salem organization.

6. Improve Use of Proven Technology

The technology to support Salem's water and sewer operations and utility management requires investigation and needs to be addressed, particularly in the areas of SCADA and work management systems. There are very reasonably priced, extensively proven work management systems available. Use of laptops and access to computers by all employees should also be addressed.

7. Improve Training and Recognition Opportunities

The limited budget for training and the lack of planned training activities is a negative for a variety of reasons: new requirements for water quality and sewer system performance need to be understood by utility staff, on-going training is needed to maintain required licenses, and training is an opportunity to reward and motivate employees. Active training programs are common in well-run private utilities. Many towns in New Hampshire and elsewhere provide salary increase or other financial incentive for achieving licenses and certifications. The training should also include a program for cross-training staff within each of the three Utility Division sections and across the sections, including laboratory skills. A training needs assessment was beyond the scope of this study but should be included in any further organizational assessment. Specific training programs and skills needs and desired outcomes should be identified.

Section 8
Supply Source Issues

8.1 Introduction

As noted earlier in this report, CDM's scope of services did not include an assessment of supply source alternatives. Nevertheless, we believe it would be helpful to briefly review the current status and key issues regarding supply sources. Doing so will allow this Master Plan to reflect the Town's current situation and direction regarding several key issues.

8.2 Groundwater Resources

The prior use of Salem's two former groundwater supply sites was described in Section 2. Other potential groundwater supply sites in Salem were previously reviewed in SEA's 1996 "Comprehensive Source Development and Conservation Plan for Water Supply", and more recently in SEA's 2003 "Long-Term Water Supply Needs Analysis".

In their 2003 report, SEA evaluated 22 potential groundwater supply source sites, including both sand-and-gravel well sites and bedrock well sites. All sites were ranked with respect to their hydrogeologic characteristics, needed infrastructure, water quality, environmental/social impact, and regulatory issues. Four sites emerged as those with the highest potential:

1. Turner Well site
2. Town Forest bedrock well site
3. Foster Corners bedrock well site
4. Foster Corners sand-and-gravel well site

SEA estimated capital costs and O&M (operations and maintenance) costs for these four sites, and developed recommendations for the "next steps" should Salem wish to evaluate these sites further. These Phase II recommendations included geophysical assessments of the Town Forest and Foster Corners sites, test well drilling in the Town Forest bedrock aquifer, and other measures. As part of the foregoing work, SEA also evaluated the feasibility of using Hittytity Brook water as a potential supply source on a seasonal basis.

Based on the foregoing, it would appear that the odds of locating a groundwater supply source with a high capacity (1.0 mgd or more) in Salem are not good. As SEA stated, "All sites considered in the Groundwater Source Evaluation had potential difficulties associated with supply development." These difficulties included "low estimated yield" (0.3 to 0.7 mgd); "water quality concerns; lack of open space; or distance from the water distribution system."

8.3 Arlington Mill Pond Transfer

As was noted in Section 2, the Town is continuing in its efforts to obtain regulatory approval to transfer Arlington Mill Pond water directly to Canobie Lake.

CDM contacted Paul Currier of NHDES in early June 2008 to determine NHDES' current view of this matter. NHDES and its Water Quality Standards Advisory Committee are in the process of reviewing and modifying the existing rules which currently prohibit Salem from applying for a 401 Water Quality Certification for the transfer of Arlington Mill Pond water to Canobie Lake. Mr. Currier indicated that around the end of 2008 he expects the NHDES rules will be modified such that Salem would then be allowed to apply for this permit. Once the Town applies, NHDES would perform an "Antidegradation Review" and then would either confirm or deny the 401 application.

At the time of our discussion, Mr. Currier indicated that, based on past legal precedent (Loon Mountain), he felt it likely that Salem would be instructed to apply for a National Pollutant Discharge Elimination System (NPDES) permit with the EPA. To his knowledge, EPA Region I has never approved such a request.

However, shortly thereafter on June 9, 2008, EPA issued a ruling that NPDES permits are not required for raw water transfers. This new ruling is likely to be contested in court but, if it stands, it would eliminate the need for Salem to apply to EPA for an NPDES permit for the proposed transfer.

CDM notes that there are several possible actions that would improve the quality of the water being discharged into Canobie Lake and might mitigate many of the water quality concerns. Three are listed below, the first two of which have been mentioned by DPW Director Rick Russell in meetings during this Master Plan project:

1. Use of wells to withdraw water near Arlington Mill Pond, thereby taking advantage of in-ground filtration.

2. Discharge of the Arlington Mill Pond water to infiltration basins near Canobie Lake, to take advantage of in-ground filtration. Mr. Russell mentioned there was a parcel near the WTP that could possibly be considered for that purpose, if soils were suitable.

3. Use of slow sand filtration, and/or UV treatment, and/or other low-maintenance treatment for the Arlington Mill Pond water before discharge to Canobie.

Mr. Currier indicated that this type of consideration would help Salem's cause and could be considered as part of their 401 application, but he also indicated that there are a number of water quality parameters beyond the key invasive species issue that would also serve as the basis for NHDES' determination.

CDM recommends that Salem continue to pursue approvals for a transfer from Arlington Mill Pond to Canobie Lake, given the June 2008 EPA ruling and given that it appears possible to get a formal answer (one way or the other) from NHDES in 2009. We do not believe it would be appropriate to simply stop this effort at this time, given the significant efforts the Town has made to get this far. However, we do recommend consideration of one or more of the three above listed concepts, which could perhaps be included as alternatives in the application to improve the likelihood of success.

8.4 Safe Yield Evaluations

SEA's 1996 report documents the available yield information for Canobie Lake and Arlington Mill Pond, and the hydrologic evaluations utilized to determine the yields. The evaluations included standard statistical and graphical techniques.

In view of the passage of time since those analyses, the Town may wish to consider updating the safe yield evaluation. Today's hydrologic computer models permit much more powerful and flexible assessments than were possible with the older techniques. Several such models now on the market offer advanced graphics capabilities to display the results and illustrate their implications.

We note the following points for the Town's consideration:

1. A computer model of the water supply systems would incorporate the actual stage-storage relationships in the surface water bodies, the actual hydraulic transfer capacities of the pumping station and transfer pipeline (which did not yet exist at the time of the 1996 work), and actual operating rules for the transfer.

2. Use of a model would facilitate sensitivity analyses on a wide variety of environmental factors that may be of interest to the Town of Salem and/or other stakeholders. Variations in allowable drawdowns, required releases, times of transfers, hydrologic conditions, and other factors can be readily incorporated into the analysis. For example, the prior analysis of Canobie Lake yield utilized the current intake depth of 210 feet and assumed that ten feet of drawdown was available; the model would permit ready assessment of the benefit of a deeper intake and/or the effects of different allowable drawdowns.

3. The simulations could, if desired, utilize a more accurate daily timestep to determine supply adequacy, rather than using average monthly values.

4. The 1996 study utilized hydrologic data through 1995. Since that time, several drought events have occurred. In some other cases in New England, these events have been significant in yield analyses. An updated analysis would include consideration of the hydrologic data that has been collected since the prior study.

5. A computer model would allow the evaluation of all surface water bodies as the interconnected hydrologic system which they in actuality are. This provides better information for planning and operations than separate analyses of individual water bodies.

8.5 Legal Rights to Other Waters

Salem officials have indicated that Salem may have water rights to Big Island Pond and possibly other water bodies, but that a legal review of such issues would be needed to clarify the existence and extent of such rights.

CDM concurs that a legal review of such water rights would be appropriate at this time, to clarify any issues that may affect the Town's decisions in the next few years regarding supplemental supply sources.

8.6 Methuen Interconnections

The existing Methuen interconnections were described in Section 2.

As was noted there, the newest of the three interconnections is located between the two municipal tanks on Spicket Hill. CDM utilized the Methuen and Salem hydraulic models to determine the hydraulic transfer capacity of this interconnection. The results indicate the hydraulic transfer rate from Methuen's high-service zone tank to Salem's tank exceeds 9 mgd. Other information about the capacities of the interconnections appears in Section 2.

Despite that high interconnection capacity, there are other issues regarding the Methuen system and Massachusetts regulatory stances that constrain the actual amount that Salem could obtain from Methuen. They are as follows:

1. Water is delivered to Methuen's high service zone by a booster pumping station. This station has two 1,000-gpm pumps. The "firm capacity", therefore, is 1,000 gpm (1.44 mgd). This is comparable to Methuen's projected maximum day demand for its own high service area. Thus, Methuen's ability to transfer water to Salem is limited by Methuen's high-service zone customer demands. As was noted in Section 2, however, a third pump could be added to the booster station, which could significantly increase the station's ability to deliver water to Salem.

2. In a letter to Methuen dated June 3, 2005, the Massachusetts Department of Environmental Protection (MADEP) stated that DEP approval was needed before Methuen could activate the new interconnection on Spicket Hill for the purpose of conveying water to Salem. This statement is consistent with Chapter 106 of the Acts of 1985, a special act of the Massachusetts Legislature titled "An Act Authorizing … Methuen to Take, Hold and Convey Additional Water from the Merrimack River". Among its other provisions, this act states that MADEP and also the Massachusetts Water Resources Commission "shall

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annually approve or disapprove any acquisition of water supply between (Methuen) and the state of New Hampshire or any community thereof." This same act also explicitly gives Methuen the ability to make water sale contracts with bordering communities including those in New Hampshire.

3. Methuen's water supply source is a water treatment plant (WTP) on the Merrimack River. Historically, the capacity of the WTP has been 10 mgd. Methuen's recent maximum day demands have exceeded 9 mgd. Thus, while there has been plenty of excess capacity during most demand conditions, there has been limited excess capacity on maximum demand days. Methuen is, however, currently constructing upgrades to its WTP which will be completed later this year. Methuen will then have additional capacity available on maximum day conditions.

4. Methuen's operations are also constrained by its permit issued by DEP under the Massachusetts Water Management Act (WMA). This permit governs Methuen's average day (not maximum day) withdrawal from the Merrimack River. Methuen is currently allowed to withdraw 6.0 mgd on that basis, and its current average day demands are about 5.5 mgd. Depending on Methuen's future needs and the amount that might be sold to Salem, the river withdrawal could approach the permit limit. The permit expires in 2014 and will need to be renewed then, but the authorization for the 6.0 mgd limit actually extends only through November 2009 and the permitted volume is subject to reconsideration at that time.

5. Methuen already has an inter-municipal agreement to sell water to Dracut, up to 0.5 mgd. Dracut is currently utilizing only about 0.1 mgd.

6. In 2002, the Town of Seabrook, New Hampshire, experienced a water supply shortage and considered purchasing water on an emergency basis from the Town of Salisbury, Massachusetts. MADEP stipulated that before a water transfer was allowed from Massachusetts, Seabrook had to demonstrate it was taking certain measures to promote water conservation. It is conceivable that MADEP would take a similar position should Salem seek Methuen water. Further discussion with MADEP would be needed to determine the current nature of any such requirements.

Salem and Methuen once drafted an inter-municipal agreement for sale of water during emergencies. This 1985 agreement is included in Appendix D. Among its provisions were the following:

- Salem's use of the connection was limited to no more than six months out of the year.

- Over the course of one month, the average sale was limited to 0.5 mgd.

- Methuen had the ability to reduce the flow to Salem as needed, should the water be needed to supply Methuen's customers.

- The term of the agreement was one year, subject to annual extension upon the agreement of Methuen and Salem.

The agreement is not formally in effect at this time, but it may nevertheless provide a useful starting point should the two communities wish to consider a new agreement for emergency or non-emergency water sale and purchase. On September 13, 2005, the two communities executed a Memorandum of Understanding (MOU) in connection with the construction of the interconnection on Spicket Hill. This MOU, included in Appendix E, commits both municipalities to "negotiate and adopt amendments/revisions to their 1985 agreement" for the emergency sale of water. The two specific such provisions in the MOU are the following:

- "Increase the quantity of water available from Methuen to Salem on an emergency basis to 2.2 million gallons per day (as soon as that quantity is available)", and

- "Clarify that the cost to Salem of water supplied under this agreement will be equal to Methuen's then present water charges to its city customers".

The current water rates for Methuen's customers are $4,011 per million gallons for large volume residential customers and $4,345 per million gallons for commercial customers. Methuen is considering a rate increase in 2009, which may be on the order of 10%. There is no wholesale rate at this time, though Methuen is reportedly willing to consider establishing such a rate should Salem commit to a minimum purchase.

In a 2004 project for another New England client, CDM reviewed several issues related to interstate water system connections. As part of that effort, CDM personnel spoke with an environmental attorney at the Boston-based law firm of Nutter, McClennen & Fish, LLP (NM&F). NM&F indicates that while several systems have constructed and have used interstate water connections, most have not addressed the issue fully in the legal arena. NM&F informed CDM that interconnections between municipalities in adjacent states can be challenged and contested by concerned parties unless an agreement between the two systems is ratified by the United States Congress. If Salem were to pursue purchase from Methuen, especially on a non-emergency basis, Salem may wish to seek an opinion from its professional legal counsel on this issue.

8.7 Concluding Remarks

Given the June 2008 EPA ruling on raw water transfers and given that it appears possible to get a formal answer (one way or the other) from NHDES in 2009 regarding approval of the proposed water transfer from Arlington Mill Pond to Canobie Lake, CDM recommends that Salem see this permit process through to completion. We also recommend the Town consider the various means of treating Arlington Mill Pond water noted above, to improve the likelihood of success of the permit application. If these efforts are ultimately unsuccessful, Salem should pursue one of the other options noted herein to secure a reliable supply source system for present and future needs.

Section 7
Operation and Maintenance Practices

7.1 General

A comprehensive operation and maintenance program is an essential aspect of any municipal water system. These programs are most effective in extending the life of existing water system facility assets and optimizing investment in the municipal infrastructure. In addition to the asset management benefits, proper maintenance of the distribution facilities reduces long-term maintenance costs and reduces the potential of a catastrophic failure of segments of the system during critical operating periods. Maintaining the existing water system also optimizes available hydraulic capacity, thus minimizing the need to increase capacity by investing in additional piping. Finally, proper maintenance can also improve water quality by reducing the number of inadvertently closed valves in the system and ensuring the proper operation of tanks.

This section provides a brief review of the Town of Salem's current water system operation and maintenance efforts and provides recommendations to enhance these programs, where practical. Though the programs discussed below will likely require additional investment in time and materials, many of these efforts are able to be completed concurrently. This consolidation of maintenance programs will minimize the time required and enable the Town to proceed systematically through the system, collecting comprehensive distribution system data. In addition, the GIS system currently being developed for the Town's water system should be used to plan and document results from each of these programs. When maintained properly, this GIS system can be an invaluable asset to the operations of the Salem Water Department.

It should be noted however that the recommendations included herein are intended to provide a framework for future O&M related goals rather than recommendations which require immediate implementation. As discussed in Section 9, CDM recognizes that the staffing level within the Utilities Division is considered to be lean and that the existing staff currently handles a significant amount of responsibilities. It should also be noted that CDM recognizes that many of the recommendations included herein related to Geographic Information Systems (GIS) and asset management will require the involvement of the Town of Salem's Information Technology Department. Since historically the IT department has maintained a conservative approach related to implementation of these systems, it will be critical that implementation of these systems be a collaborative effort between the two departments which will likely involve a significant educational component.

7.2 Water Main Flushing Program

The Town of Salem currently performs an annual flushing program, systematically operating hydrants to flush accumulated sediment from the entire distribution system piping. Additionally, the Town of Salem currently performs distribution system flushing on an as-needed basis in areas where historical water quality problems have been experienced.

At the current time, however, unidirectional flushing is not practiced. Unidirectional flushing involves isolating each pipe by a series of valve closings and openings such that the flow proceeds from a clean water source down the isolated pipe to the flushing hydrant. This procedure results in a one-way movement of deposits within the pipelines which facilitates cleaning. Flushing should be continued for a sufficient amount of time to clean the system of poor quality water and sediment.

The Town could consider preparing a formalized unidirectional flushing program that has written procedures and a map showing flushing directions. Field operations such as this also help the Town to continually assess the status of its hydrants and valves in the system. This assessment can then be coordinated with the hydrant and valve improvement programs as discussed below.

It should also be noted that NHDES regulation Env-Ws 361.04 requires that annual distribution system flushing be performed and that flushing velocities of 2.5 feet per second be obtained during flushing. During unidirectional flushing programs, a goal of 4 feet per second is often set to improve removal of sediment from the pipes.

7.3 Valve Exercising and Spacing

NHDES regulations (Env-Ws 361.05) require, and good waterworks practice suggests, that all distribution system valves be operated annually. This procedure will allow water department personnel to note malfunctioning valves and initiate maintenance work or possible replacement. As the Town does not currently have a valve exercising and inspection program in place, it is recommended that this be instituted as an annual maintenance program. This will ensure that no valves are inadvertently left closed indefinitely after construction, for a water main break, or for other activities.

Some guidelines to consider when developing the valve maintenance program are:

- All distribution system gate valves shall be exercised at least annually (subject to the availability of field staff);
- Any valves that do not completely close or open should be replaced;
- Valves that leak around the stems should be repacked;
- Valves should be exercised in both directions (fully closed and fully opened) and the number of turns and direction of operation recorded;
- Valves operating in a direction opposite to that which is standard for the system need to be identified, recorded and considered for replacement; and

- The Town should consider conducting the annual valve exercising program to coincide with the hydrant maintenance program.

Once these valve operations have been completed, a followup maintenance program should be initiated to correct any problems. Typical maintenance work might include raising gate valve boxes to the finished grade, removing rocks and dirt from gate boxes, and replacing damaged boxes or covers.

Notwithstanding the NHDES regulation, CDM recognizes that most municipalities do not have sufficient resources to complete annual exercising of all valves. In such cases, we recommend that the community implement a more modest program. One possibility may be to exercise all large valves (12-inch and up) annually, and other valves every three years. Another possibility might be simply to divide the system into three sectors and work on one sector per year.

Following the first year of this type of systematic valve exercising program, a community can make a realistic estimate of how many valves need to be replaced. The funds to perform systematic valve replacement can then be included in the operations budget or, if the program is of larger scale, as a capital project.

As an additional effort, the Town could also consider reviewing valve spacing throughout the system. General waterworks practice suggests that valves be located, as necessary, at all intersections and branch connection mains. As noted in Section 5, NHDES requires that "Valves should be located at not more than 500 foot intervals in commercial districts … and at not more than one block or 800 foot intervals in other districts. Where systems serve widely scattered customers and where future development is not expected, the valve spacing should not exceed one mile."

7.4 Hydrant Replacement and Spacing

Hydrant exercising and maintenance is currently performed by the Town during the annual flushing program. As stated earlier in this report, individual fire flow requirements are considered to be met if a 20 psi residual pressure is available, under design fire flow conditions, at a specific location from contributing hydrants. However, adequate capacity of water mains, although essential, is not sufficient in itself; the hydrants themselves must be in good condition and capable of delivering this fire flow.

The Town should continue and expand its current hydrant maintenance program. The goal of this program should be to operate every hydrant at least once a year. Some elements of this program may be conducted with cooperation from the fire department. Typical procedures for hydrant inspection and maintenance follow:

- Inspect for leakage and make corrections where necessary;
- Open hydrant fully, checking for ease of operation;

- Flush hydrant barrel to waste (take care to direct flow);
- Remove all nozzle caps and inspect for thread damage from impact or cross threading. Wire brush the nozzle and cap threads. Clean and lubricate outlet nozzle threads, preferably with a dry graphite base lubricant, and check ease of operation. Check that the nozzle cap gaskets are in good condition;
- Replace caps, tighten with a spanner wrench, then back off on the threads slightly so that the caps will not be excessively tight but will leave sufficient frictional resistance to prevent removal by hand;
- Check for any exterior obstruction that could interfere with hydrant operation during an operation;
- Check dry-barrel hydrants for proper drainage;
- Clean exterior of hydrant and repaint in accordance with Town standards, if necessary;
- Be sure that the valve on the hydrant branch line is in the fully opened position;
- If hydrant is inoperable, tag it with a clearly visible marking to prevent loss of time by firefighting crews if an emergency should arise before the hydrant is repaired. Immediately report the condition of this fire hydrant to the fire department;
- Prepare a record of inspection and maintenance operations and any repair work; and
- Replace aging hydrants, as time and finances permit, in an effort to eliminate the presence of older style units.

If the hydrant is old, clogged with sediment, or corroded, it should be removed and replaced with a new hydrant. Because there is no current record of which hydrants are in such condition, the total number requiring replacement is not known. After a portion of the water system has been systematically evaluated in this way, it should be possible for the Town to establish an annual budget to repair and replace all defective hydrants as needed over the course of a selected period (perhaps 2–5 years).

As was noted in Section 5, ISO has identified some locations with large fire flow requirements at which additional hydrants should to be installed to be able to deliver the needed fire flow to the firefighting apparatus. The Town could evaluate hydrant spacing adequacy in other areas throughout the Town as well. As was stated in the Section 5 regulatory review, "Fire hydrants should be provided at each street intersection and at intermediate points between intersections as recommended by the State Insurance Services Office. Generally, fire hydrant spacing ranges from 350 to 600 feet depending on the area being served."

7.5 Unlined Cast Iron Pipe Rehabilitation

Though only a small portion of Salem's distribution system consists of unlined cast iron mains, the Town should continue to address the remaining unlined pipes. In general, the carrying capacity of unlined mains will continue to be reduced as metallic salts continue to deposit on the interior walls of the pipe. Structural integrity of very old pipes (over 100 years) becomes increasingly questionable over time. 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 or surges are frequent. Leakage through joints and service connections can be more prevalent in older pipelines due to settlement over the years, especially in heavily traveled roadways.

Over the long term, Salem should eventually clean and cement line or replace all remaining unlined cast iron mains in the distribution system with new, cement lined ductile iron pipe. The distribution system improvements in Section 5 include several such projects. Although the Town is not certain that the locations of all unlined cast iron mains have been identified, the Town should continue to pursue this issue over time until such mains have been eliminated.

7.6 Pipe Looping

Eliminating dead-end mains typically improves available fire flows and water quality. Pipe looping projects can sometimes be combined with other pipe replacement or cleaning and cement lining projects. The distribution system improvements program in Section 5 includes several key looping projects. Others could be considered for the various dead-end mains in the system, particularly when new subdivisions and commercial developments are being considered near such mains.

7.7 Parallel Main Removal

In Salem, as in many other communities, parallel mains were often left in service with hydrants and house services still connected, when newer mains were constructed in the same street. The older mains often consist of unlined cast iron mains that provide little additional capacity. As a result, while the new, larger diameter main conveys the majority of the flow, the relatively stagnant water in the old, unlined main is supplied to customers, sometimes leading to water quality concerns. In addition, the tuberculated unlined main can cause unnecessary hydraulic constrictions for fire flows from the attached hydrants. As discussed in Section 5, these older parallel mains are being targeted for abandonment, to eliminate these concerns. If the Town locates other such mains beyond those listed in Section 5, CDM recommends that their abandonment also be addressed in future programs.

7.8 Tank Inspection Program

There is a need to routinely inspect the storage tanks, including internal inspection. The latter can be accomplished by diver or a remotely operated vehicle equipped with a video camera. Internal inspection can reveal information on the level of sediments and the condition of walls and floors. Concrete tanks should be inspected externally for cracks and signs of leakage. In addition, the condition of steel tanks should also be assessed regularly so that coating systems and repairs can be accomplished in a timely manner. As discussed in Section 5, NHDES regulations (Env-Ws 361.08) require that tank inspections be performed at a maximum interval of every five years. The next scheduled inspection should be performed in 2012.

7.9 Geographic Information Systems and Asset Management

The Town of Salem has invested, and continues to invest, in the development of its Geographic Information System (GIS) and Asset Management system in an effort to improve efficiency throughout its organization. These systems are currently being implemented in a limited number of town departments under the direction of the Town's Information Technology (IT) department. Due to a variety of factors, including the conservative approach of the current IT department to the implementation of these systems, the Town departments, including the Utilities Division, do not currently utilize these systems to the greatest extent possible.

At the present time, the Town of Salem Utilities Division is in the process of performing a quality review of the water system GIS data layer that was developed by the Town's IT department. It is the intent of the IT department to rectify the discrepancies in the current data layer for eventual inclusion in the town-wide geodatabase of utilities data. There are currently no official plans to make this data available for active use and maintenance by the Utilities Division.

The Town's IT department currently maintains storm water assets within the VUEWorks asset management system. This system has robust maintenance management capabilities that are integrated with the GIS, including call logging, work order management, and work and workforce scheduling. Wherever possible, the system should be used to associate work performed to assets in the GIS so that there is a record of work performed. Also, when work orders are closed, the system should be used to capture the labor, material, and equipment charges to provide visibility into what assets are costing to maintain. This information, in addition to asset criticality, condition assessments, redundancy, age, manufacturer, and other data that VUEWorks supports, should be collected so that it can support maintenance, replacement, and capital planning decisions.

CDM recommends that the Utilities Division begin to more fully embrace the systems which are currently in place, including the town-wide GIS system and the VUEWorks asset management system. As discussed in Section 9 of this report, the technology to support water and sewer operations and utility management is critical to the overall operations of the Division. The Division's investment in this technology should be capitalized by fully incorporating the software and hardware into its business processes and, where appropriate, modifying its business processes to more efficiently manage assets and asset data. Though the scope of this project was not intended to include a detailed review of these opportunities, the following provides general comments as to needs in this area.

Key elements of a systematic and comprehensive asset management program include:

- A defined asset management philosophy and effective asset management plan to schedule, monitor, and plan the efficient use of the Division's resources (dollars, staff and capital equipment);
- Implementation of the asset management plan using VUEWorks, GIS, and ultimately with additional technology tools such as SCADA, the hydraulic model, and financial information systems to guide long-term capital improvement planning and to manage the timely rehabilitation and replacement of system assets;
- Availability of and access to centralized, accurate information for use by departments, managers, and other decision-makers for the effective management of treatment, distribution system operations, and customer service; and
- Electronic presentation of engineering drawings and system design information (historic documents scanned in and new drawings prepared in CADD) that are linked to assets in the asset management system.

Though a more detailed review of the opportunities to improve in this area is warranted and beyond the scope of this report, general recommendations as to how information systems and technology should be used within the Utilities Division are as follows:

- Complete the quality review checks of the draft water system GIS data set.
- Define the objectives of both the GIS and asset management systems with respect to the operations of the Utilities Division. Document how the systems will be used, what data will be maintained, and who is responsible for updating and maintaining systems. These business processes provide the structure that is required to ensure the completeness and accuracy of the GIS and asset data. The asset data is the foundation for capital improvement planning and for day to day preventive and corrective maintenance planning.
- Make GIS easily accessible by developing a web-based interface, using ArcIMS. Make it simple to use and accessible by all Town personnel and possibly by the public as well.
- Educate staff at all levels on what the systems do, why they do it, what the objectives are, and what their role in the process is. Train staff on all levels on how to use and update the systems. Provide applications that allow data to be easily accessible.

- Move toward replacing the hard-copy plans and paper-based work orders with electronically generated data. Make GIS generated maps a Town standard. Populate these maps with pertinent attribute information and include asset IDs on these maps.

- Once existing technologies are optimized, look to other technologies to help increase efficiency. These may include truck-based laptops to access GIS and VUEWorks data, enhancing wireless data access, GPS units in the field, and custom applications or integrations that expand the functionality of the GIS and VUEWorks.

Appendix A
Arlington Pond Protective Association Agreement for Water Management, 1996

AGREEMENT FOR WATER MANAGEMENT

AGREEMENT made this 14th day of MARCH, 1996 by and between the Town of Salem, New Hampshire, a political subdivision of the State of New Hampshire, with a principal place of business at 33 Geremonty Drive (hereinafter "the Town") and Arlington Pond Protective Association, a New Hampshire corporation, with a principal place of business at SALEM, NH.

WITNESSETH

WHEREAS, in 1982 the Town acquired certain dam and water rights located within the Town, including the dam and water rights at Arlington Reservoir; and

WHEREAS, the Town seeks, from time to time, to use a portion of the water flowing through Arlington Reservoir as additional supply to the Town's water supply; and

WHEREAS, the Arlington Pond Protective Association has requested that as a condition of such use that the Town operate the dam, discharge gates and transfer mechanisms, and use the water flowing through Arlington Pond in a manner that recognizes the recreational and aesthetic needs of residents abutting

Arlington Reservoir; and

WHEREAS, the Town is agreeable to operate the dam, water pipes and transfer mechanisms in Arlington Reservoir in order to use water flowing through Arlington Reservoir from the south/dam end of the lake in a manner that

(a) addresses the Arlington Pond Protective Association's concerns;

(b) recognizes the rights of others, if any, to water flowing through Arlington Reservoir; and

(c) meets the Town's need for additional water supply.

NOW, THEREFORE, in consideration of the foregoing and for other good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the Town and the Arlington Pond Protective Association agree:

1. Use of Arlington Reservoir Water: Withdrawal of water from Arlington Reservoir for use in the Town's water supply will be restricted as follows:

A. Period from April 30 - October 10 of each year:

The Town of Salem will not withdraw, take, or transfer water from Arlington Reservoir, for use in the Town's water supply system between the period of April 30th through October 10th of each year unless the surface level of Arlington Reservoir exceeds 161.712 FT MSL. Further, the Town of Salem will use its best efforts to operate the control structure, discharge gates and transfer mechanisms and associated piping at the

Arlington Reservoir to obtain a surface water elevation of 161.712 FT MSL in the Arlington Reservoir on or before April 30 of each year.

B. Period from October 11 of each year to April 29 of the following year:

The Town of Salem will not withdraw, take, or transfer water from Arlington Reservoir, for use in the Town's water supply system between the period of October 11th of each year through April 29th of the following year unless the surface level of Arlington Reservoir exceeds 154.5 MSL.

C. Elevations Established

For the purposes of this agreement, the top of the spillway at the Wheeler Dam is 160 MSL.

2. Recreational Use. The Town of Salem shall take no action to change the current recreational use of Arlington Reservoir.

3. Conditions Precedent. The benefits and obligations of this Agreement are expressly conditioned upon and subject to the following conditions precedent:

(1) That the 1996 Salem Annual Town Meeting votes to approve the terms and conditions of this Agreement;

(2) That the piping, valves, pumping station and other mechanisms to transfer water from Arlington Reservoir to the Town's water supply are completed to the satisfaction of the Town and that the Town of Salem receives all permits, final approvals and authorizations necessary for it to transfer water from Arlington Reservoir to the Town's water supply and treatment

facilities and/or Canobie Lake from all permitting authorities, courts and state or federal agencies with jurisdiction over the use of water in Arlington Reservoir or the Town's public water supply.

In the event either condition is not satisfied, then this Agreement will terminate without recourse to either party.

4. Term. The term of this Agreement shall commence on the date first above written, and shall terminate 50 years from said date unless extended by agreement of the parties provided, however, that if on or before March 15, 2045 the parties have not reached an agreement to extend and or modify this agreement as needed, they will commence negotiations, in good faith, to extend this agreement and modify it as needed and provided further that if the parties have not reached an agreement on or before March 30, 2046, then this agreement will be extended for 1 year and the parties will submit the issue of the agreement's continuation to binding arbitration.

5. Force Major.

A. Notwithstanding anything herein to the contrary, in the event of substantial destruction to or damage to Wheeler Dam or appurtenances thereto, maintained by the Town in connection with the control of water, including but not limited to pipelines, valves, pumping stations and control mechanisms associated with Arlington Reservoir, due to acts of God, fire or other events beyond the reasonable control of the Town, the Town shall have no obligation to re-build said structures. If the

Town, in its sole discretion, elects to re-build said structures at any time during the term hereof, from and after the date said structures are repaired and reconstructed and the Town resumes the transfer of water from Arlington Reservoir to the Town's water supply, the provisions of paragraph 1 of this agreement shall, at that time, apply to the management, transfer and use of water from Arlington Reservoir in the Town's water supply system.

B. In the event any final orders or other governmental action by any state or federal court/or agency having jurisdiction over the management use and/or discharge of water in Arlington Reservoir or the management of the Town's public water supply affect the Town's management, use and/or discharge of water as provided in this Agreement, the Town's obligations hereunder shall be suspended during the pendency of such order, provided, however, that unless the Town is able to meet provisions in paragraph 1 of this Agreement, water will not be transferred for use in the Town's water supply system.

<u>6.</u> <u>Application</u>. This Agreement shall bind the parties only for so long as the Town of Salem continues to make use of water from Arlington Reservoir in its water supply system.

<u>7.</u> <u>Mutual Cooperation</u>. Each of the parties hereto agrees to reasonably cooperate with the other party hereto in furtherance of the purposes of this Agreement.

<u>8.</u> <u>Remedies</u>. The parties' sole remedy in the event of breach will be to enforce their rights at equity, and each party hereby waives any rights to bring an action at law.

9. Notices. All notices shall be sent to the parties' address as set forth above.

10. Governing Law. This Agreement is made in and shall be interpreted in accordance with New Hampshire law.

11. Integration. All representations, statements and agreements heretofore made are merged in this Agreement which is the full expression of the parties' obligations and rights and no party entering into this Agreement has relied upon any statement or representation not set forth herein.

12. Assignability. The parties' rights and obligations shall not be sold, assigned, optioned, pledged or transferred, in whole or in part without the express written consent of the governing body of Salem.

In witness whereof, the Town of Salem and the Arlington Pond Protection Association have executed this Agreement as of the date and year first above written.

TOWN OF SALEM

By: [signature] 3/14

[Insert Name]
Duly Authorized

[signatures]

ARLINGTON POND PROTECTIVE ASSOCIATION

By: [signature] Pres.

[Insert Name]
Duly Authorized

Appendix B
2002 ISO Results

INSURANCE SERVICES OFFICE, INC.

HYDRANT FLOW DATA SUMMARY

City Salem

County Rockingham State NH Witnessed by Insurance Services Office, Inc. Date June 4, 2002

TEST NO.	TYPE DIST.*	TEST LOCATION	SERVICE	FLOW - GPM $Q=(29.83(C(d^2)p^{0.5}))$ INDIVIDUAL HYDRANTS			FLOW - GPM TOTAL	PRESSURE PSI STATIC	PRESSURE PSI RESID.	FLOW - AT 20 PSI $Q_R=Q_F(h_R^{0.54}/h_F^{0.54})$ NEEDED **	FLOW - AT 20 PSI AVAIL.	REMARKS***
1a	Comm	Main St. @ Broadway	Main	2780			2780	92	86	5000	10600	(A)-(2400 gpm)
1b	Comm	Main St. @ Broadway	Main	2780			2780	92	86	2500	10600	
2a	Comm	Old Rockingham Rd. @ Joseph Rd.	Main	1060			1060	74	72	5000	6300	(A)-(3000 gpm)
2b	Comm	Old Rockingham Rd. @ Joseph Rd.	Main	1060			1060	74	72	3500	6300	(A)-(2550 gpm)
3a	Comm	N. Policy St. @ Webster St.	Main	1690			1690	50	48	4500	7300	
3b	Comm	N. Policy St. @ Webster St.	Main	1690			1690	50	48	3000	7300	
4a	Comm	Pelham Rd.@ Stiles Rd.	Main	1300			1300	79	70	5500	3600	(A)-(4500 gpm)
4b	Comm	Pelham Rd.@ Stiles Rd.	Main	1300			1300	79	70	3500	3600	
5a	Comm	Industrial Way @ Commercial Dr.	Main	1300			1300	70	50	4500	2100	
5b	Comm	Industrial Way @ Commercial Dr.	Main	1300			1300	70	50	2250	2100	
6	Comm	Lowell Rd. @ Delaware Dr.	Main	1400			1400	88	86	2000	9400	
7a	Comm	S. Broadway @ Cluffs Crossing	Main	2780			2780	95	91	5500	Adeq	(A)-(4500 gpm)
7b	Comm	S. Broadway @ Cluffs Crossing	Main	2780			2780	95	91	3500	Adeq	
8a	Comm	Pleasant St. @ Rockingham Park Mall	Main	1400			1400	87	84	6000	7500	(A)-(5950 gpm)
8b	Comm	Pleasant St. @ Rockingham Park Mall	Main	1400			1400	87	84	3500	7500	
9a	Comm	S. Broadway @ Cumo Dr.	Main	1440			1440	92	86	6000	5500	(A)-(3400 gpm)

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

*Comm = Commercial; Res = Residential.

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

***(A)-Limited by available hydrants to gpm shown.

INSURANCE SERVICES OFFICE, INC.

HYDRANT FLOW DATA SUMMARY

City Salem

County Rockingham State NH Witnessed by Insurance Services Office, Inc. Date June 4, 2002

TEST NO.	TYPE DIST.*	TEST LOCATION	SERVICE	FLOW - GPM Q=(29.83(C(d²)p^0.5)) INDIVIDUAL HYDRANTS			TOTAL	PRESSURE PSI STATIC	RESID.	FLOW - AT 20 PSI $Q_R=Q_F(h_R^{0.54}/h_F^{0.54})$ NEEDED **	AVAIL.	REMARKS***
9b	Comm	S. Broadway @ Cumo Dr.	Main	1440			1440	92	86	3500	5500	(A)-(2700 gpm)
10	Comm	Cross St. @ Green Acre Dr.	Main	1450			1450	95	84	2000	4100	
11	Comm	Sand Hill Rd. @ Pond St.	Main	920			920	76	54	3500	1500	(A)-(2250 gpm)
12	Comm	School St. @ Stone Pond Rd.	Main	1380			1380	90	84	3000	5200	
13a	Comm	Main St. @ Henderson Circle	Main	1300			1300	80	76	4000	5600	(A)-(2700 gpm)
13b	Comm	Main St. @ Henderson Circle	Main	1300			1300	80	76	2250	5600	
14a	Comm	Geremonty Dr. @ High School	Main	1350			1350	80	73	5000	4300	(A)-(3250 gpm)
14b	Comm	Geremonty Dr. @ High School	Main	1350			1350	80	73	2250	4300	
15a	Comm	S. Policy St. @ Raymond Ave.	Main	1520			1520	85	78	4000	5100	(A)-(3400 gpm)
15b	Comm	S. Policy St. @ Raymond Ave.	Main	1520			1520	85	78	2250	5100	
16	Comm	Main St. @ Hampstead Rd.	Main	1190			1190	66	65	2250	9400	
17	Res	Wells Ave. @ McLaughlin Ave	Main	1190			1190	89	38	750	1400	
18	Res	Dustin Rd. @ Atkison Rd.	Main	1470			1470	81	77	750	6400	
19	Res	Cole St. @ Shepard Ave	Main	1140			1140	90	71	750	2300	
20	Res	Lawrence Rd. @ Linwood Ave.	Main	920			920	100	48	750	1200	
21a	Comm	Northeastern Blvd. @ N. Policy St.	Main	1260			1260	73	70	4000	5900	(A)-(2700 gpm)

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INSURANCE SERVICES OFFICE, INC.

HYDRANT FLOW DATA SUMMARY

City Salem

County Rockingham State NH Witnessed by Insurance Services Office, Inc. Date June 4, 2002

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21b	Res	Northeastern Blvd. @ N. Policy St.	Main	1260			1260	73	70	750	5900	

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

*Comm = Commercial; Res = Residential.

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

Grading Sheet For: Salem, NH
Rockingham County

Public Protection Class: 5 / 9

Surveyed: May, 2002

Feature	Credit Assigned	Maximum Credit
Receiving and Handling Fire Alarms	8.10%	10.00%
Fire Department	23.51%	50.00%
Water Supply	36.87%	40.00%
*Divergence	-9.03%	
Total Credit	59.45%	100.00%

The Public Protection Class is based on the total percentage credit as follows:

Class	%
1	90.00 or more
2	80.00 to 89.99
3	70.00 to 79.99
4	60.00 to 69.99
5	50.00 to 59.99
6	40.00 to 49.99
7	30.00 to 39.99
8	20.00 to 29.99
9	10.00 to 19.99
10	0 to 9.99

*Divergence is a reduction in credit to reflect a difference in the relative credits for Fire Department and Water Supply.

The above classification has been developed for use in property insurance premium calculations.

Appendix C
Inspection Reports

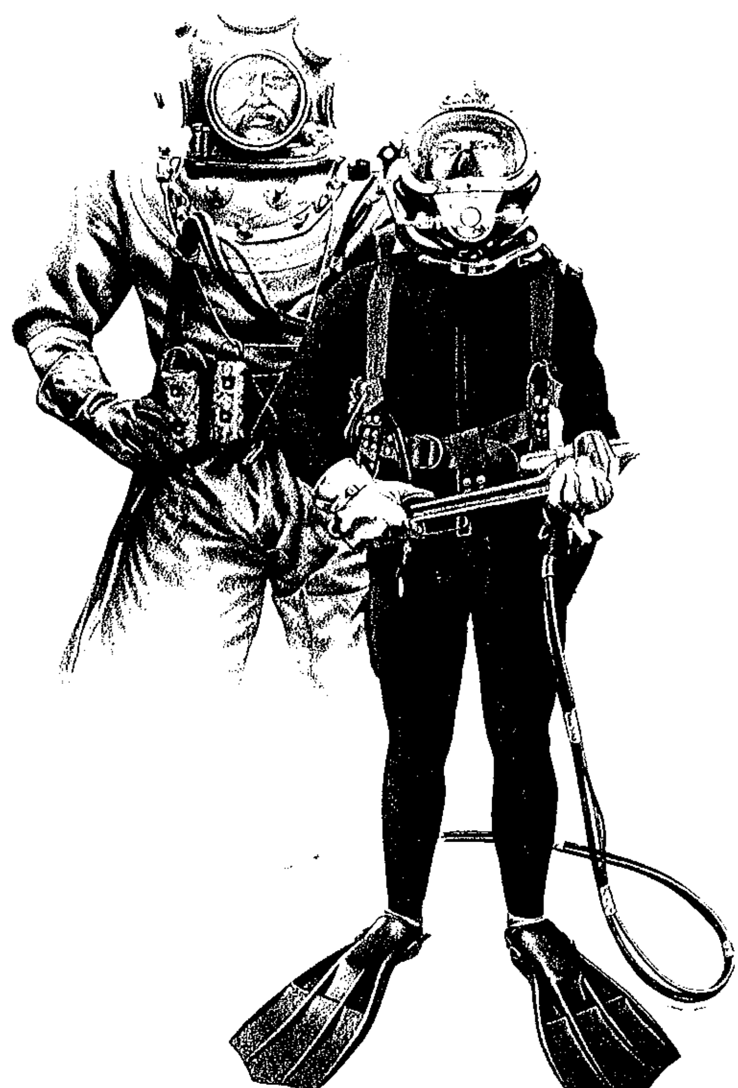
C.1 Lawrence Road Tank Inspection

UNDERWATER SOLUTIONS INC.

INSPECTION AND CLEANING OF THE LAWRENCE ROAD 1.58-MILLION GALLON WELDED STEEL WATER STORAGE TANK

CANOBIE LAKE WATER TREATMENT PLANT SALEM, NEW HAMPSHIRE

SEPTEMBER 11, 2007



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www.underwatersolutionsinc.com

UNDERWATER SOLUTIONS INC.

INSPECTION AND CLEANING OF THE LAWRENCE ROAD 1.58-MILLION GALLON WELDED STEEL WATER STORAGE TANK

CANOBIE LAKE WATER TREATMENT PLANT SALEM, NEW HAMPSHIRE

SEPTEMBER 11, 2007

SCOPE:

On September 11, 2007, Underwater Solutions Inc. conducted an inspection and cleaning of the Lawrence Road 1.58-million gallon welded steel water storage tank to provide information regarding the overall condition and integrity of this structure and removed the sediment accumulation found on the floor of the structure.

EXTERIOR INSPECTION:

The entire exterior of this water storage tank (and components) was inspected to include anchor bolts, walls and coating, manways, ladder and safety cage, overflow, roof, vent and hatches.

Anchor Bolts

Fifteen 1 ½" anchor bolts extend up through welded chairs 9" up the tank wall. All bolts were found with a nut securely in place while all coating remains intact at this time.

Walls and Coating

The exterior wall surfaces were inspected and found very sound.

All surfaces of these walls are uniformly coated at this time while good adhesion value remains.

No failures within these surfaces were witnessed at the time of this inspection.

A moderate mildew accumulation was found throughout the tank circumference within the lowest 24" of the ground.

Manways

Two 24" inside diameter manways penetrate the lowest row of wall panels on opposite sides of the tank. Each manway was found securely installed while good coating adhesion exists on all surfaces.

Ladder/Safety Cage

A ladder and safety cage extend from 18' above the ground up to the rooftop properly supported in place with eighteen welded standoffs.

This structure was found in very sound condition while blotch rusting shows through the coating on approximately 5% of all surfaces due to decline in the coating film thickness.

Overflow

A 10" inside diameter overflow pipe exits the base of a welded steel weir box then extends down to within 17" of the ground and terminates having a functioning flap-cap at its end. This pipe was found properly secured to the tank wall with twenty-one welded standoffs and has good coating adhesion on all surfaces.

Roof

The entire rooftop of this water storage tank was found with very sound conditions. All surfaces of these roof panels are well coated and in very good condition at this time.

Vent

The vent is located in the center of the domed rooftop having a 22" inside diameter and standing 30" tall.

A 36" outside diameter cap was found properly secured at the top of this vent and perimeter screening is intact preventing access.

Hatches

Two 24" inside diameter hatches are located on opposite sides of the roof dome. Each hatch was found in good condition and having good coating adhesion.

Locks installed on these hatches prevent unwanted access.

INTERIOR INSPECTION:

The entire interior of this water storage tank (and components) was inspected to include sediment accumulations, floor, manways, piping, walls and coating, overhead, overflow, and aesthetic water quality.

Sediment Accumulations

A uniform layer of precipitate was found on all floor surfaces ranging from 2" to 3" in depth.

Upon completing this inspection, all floor surfaces were vacuumed.

Floor

After removing all accumulated precipitate these steel floor panel surfaces were inspected and found with very good conditions.

All Coating was found having good adhesion value and no failures were seen.

Manways

Two 26" outside diameter manways were inspected on opposite sides of this tank, located 17" above the floor, penetrating the lowest row of wall panels.

These manways were each found with very good coating adhesion while no indications of leakage were witnessed.

Piping

The inlet/outlet pipe penetrates the tank floor 31" in from the wall having a 14" inside diameter. This pipe extends up approximately 6" and consists of a removable pipe section inserted into the floor.

Flow was entering the tank at the time of this inspection.

Walls and Coating

All interior wall surfaces were inspected beginning at the floor and spiraling the circumference up to the water surface.

Although mild staining extends from 25' below the overflow down to the tank floor, no indication of fatigue or failures were found. All coating remains intact while having good adhesion value with these wall panel surfaces at this time.

Overhead

The entire overhead of this storage tank was inspected from the water surface.
These overhead panels were found with four distinct areas of coating damage measuring 6" by 6" in diameter. This condition is due to welding done on the tank exterior.

All remaining overhead surfaces were found with very good conditions.

Overflow

A 32" long by 12" wide overflow cutout within the top wall panel was found completely unobstructed at the time of this inspection.

Aesthetic Water Quality

The aesthetic water quality within this tank was found to be fair. This condition caused our visibility during this inspection to be somewhat limited due to suspended particulate at all tank elevations.

CONCLUSION:

It is the opinion of Underwater Solutions Inc. that this water storage tank remains in good condition.

All exterior wall panel and roof dome surfaces were found sound while very good coating adhesion provides good protection of these panels and welds.

All components affixed to this structure to include manways, ladder, and safety cage overflow pipe, hatches, and vent are properly installed at this time.

All interior floor and wall panel surfaces were found without any signs of fatigue or failures while good coating adhesion remains.

Four 6" by 6" areas of coating failure causing corrosion on the overhead are believed to be the result of welding on the exterior of the dome.

Upon completing this inspection all floor surfaces of the tank were vacuumed.

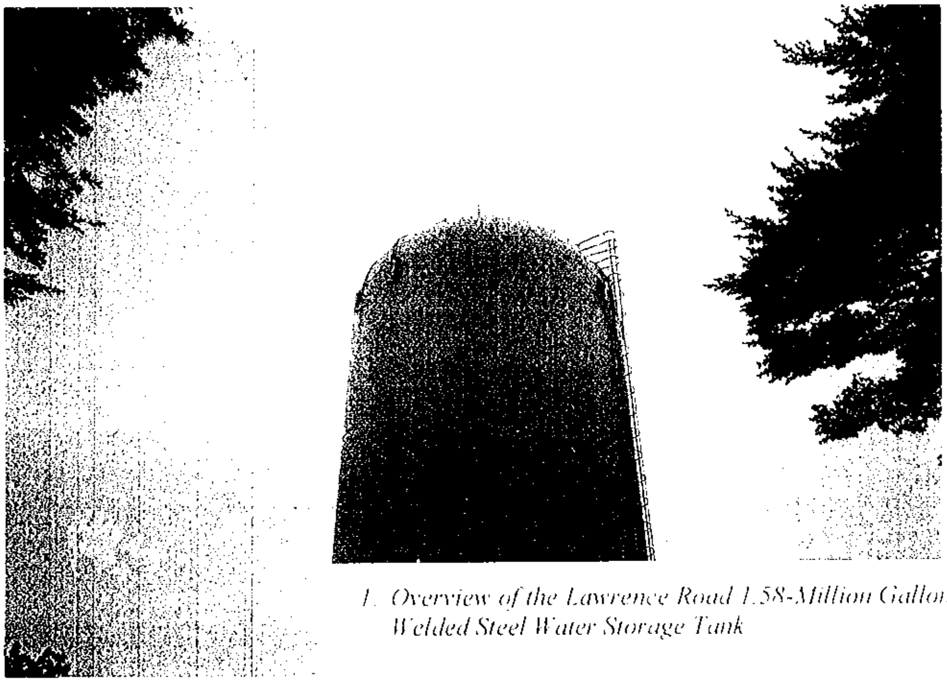
As always, we recommend re-inspection and cleaning of all water storage facilities in accordance with A.W.W.A. Standards and local guidelines.

UNDERWATER SOLUTIONS INC.

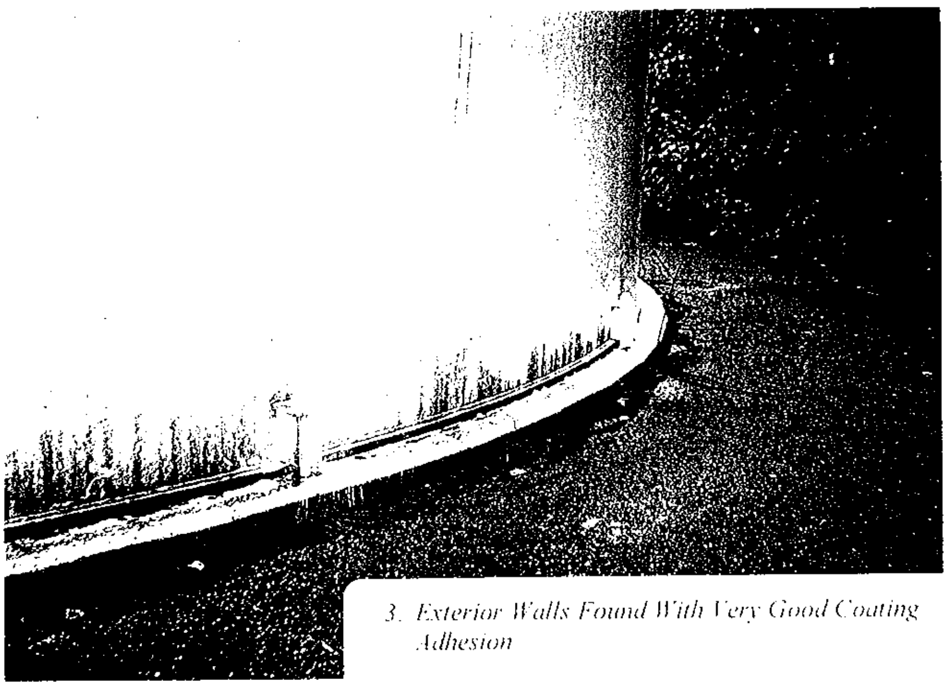
Christopher A. Cole, Project Manager

This report, the conclusions, recommendations and comments prepared by Underwater Solutions Inc. are based upon spot examination from readily accessible parts of the tank. Should latent defects or conditions which vary significantly from those described in the report be discovered at a later date, these should be brought to the attention of a qualified individual at that time. These comments and recommendations should be viewed as information to be used by the Owner in determining the proper course of action and not to replace a complete set of specifications. All repairs should be done in accordance with A.W.W.A Standards.

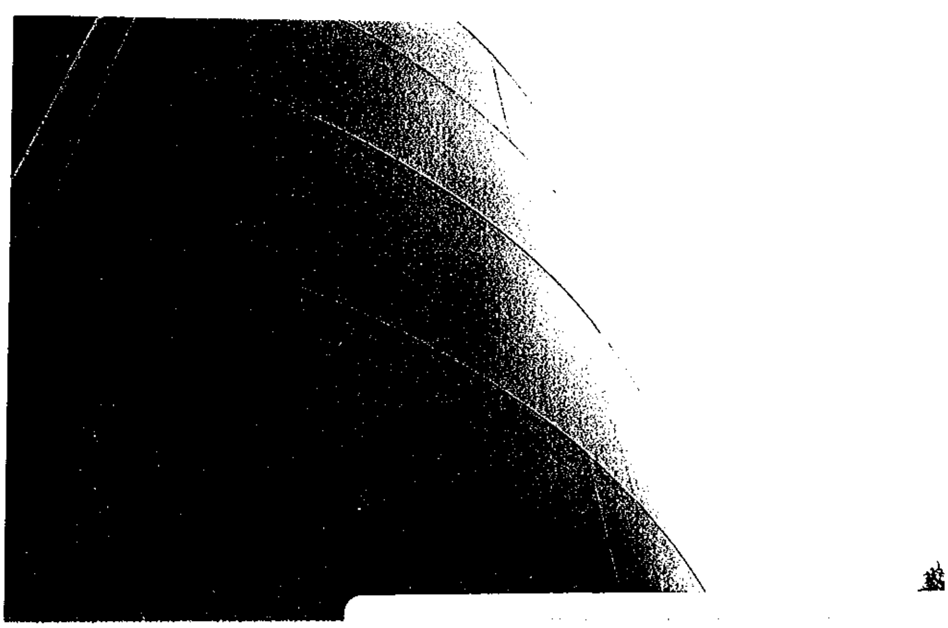
CAC/cmk

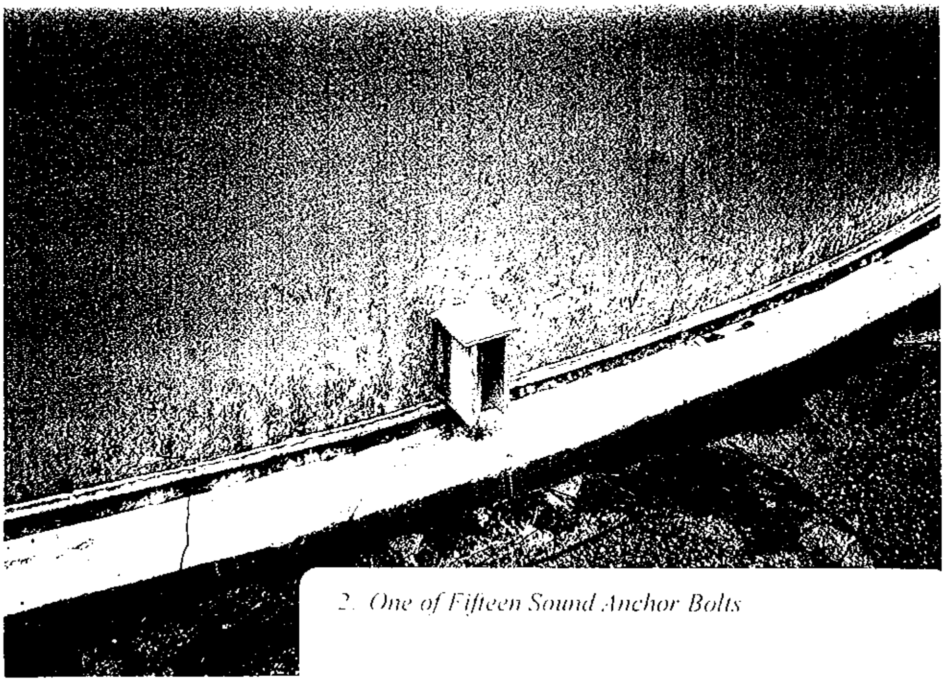


1. Overview of the Lawrence Road 1.58-Million Gallon Welded Steel Water Storage Tank

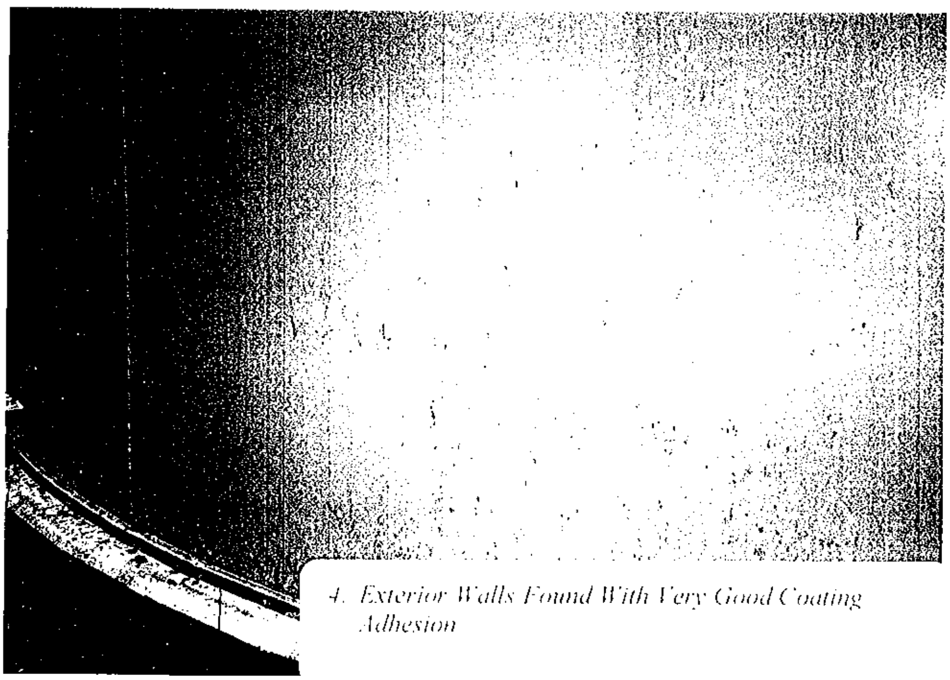


3. Exterior Walls Found With Very Good Coating Adhesion

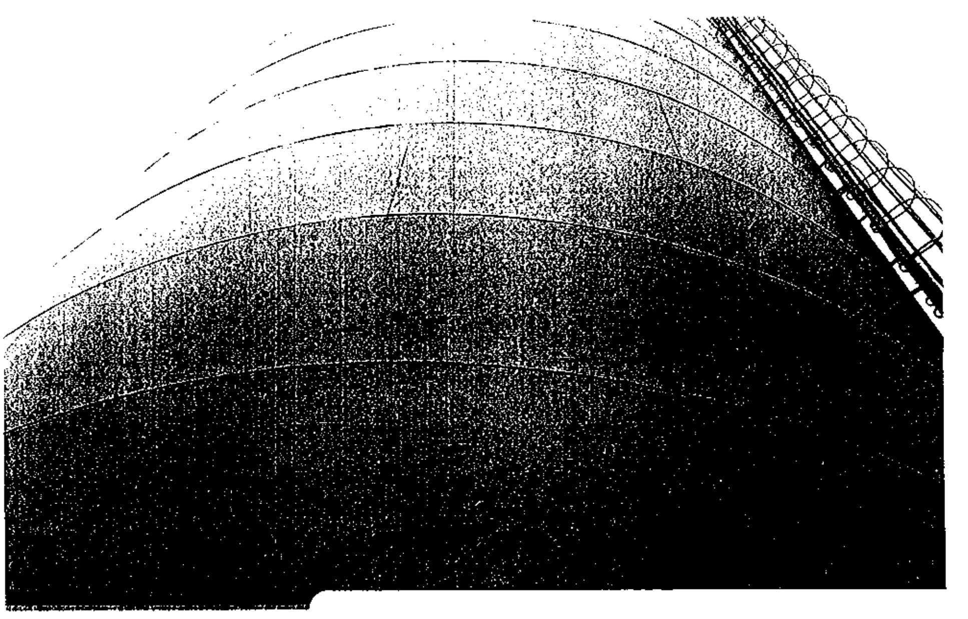




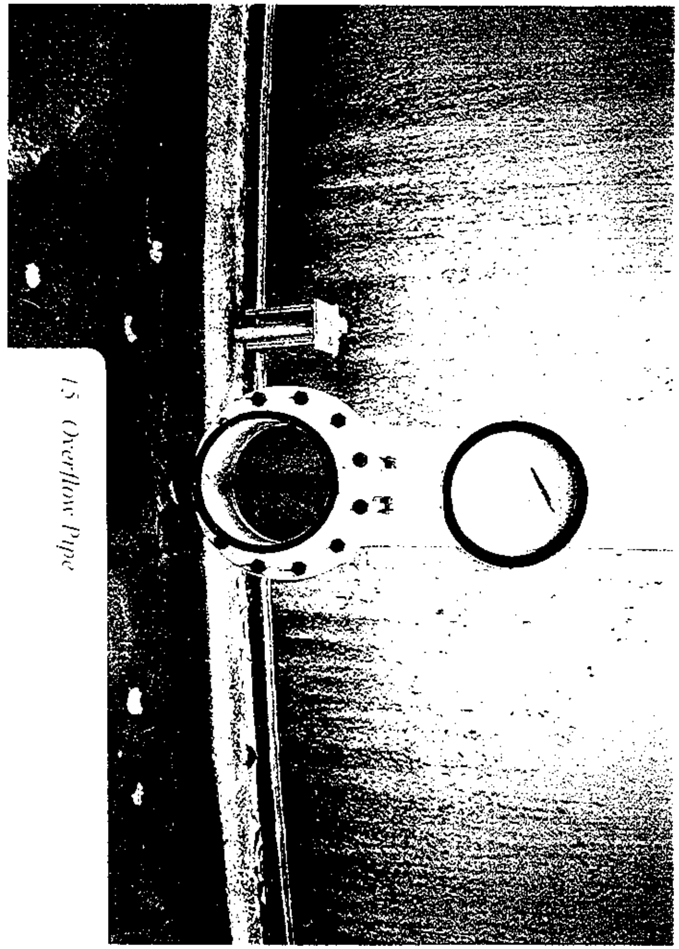
2. One of Fifteen Sound Anchor Bolts



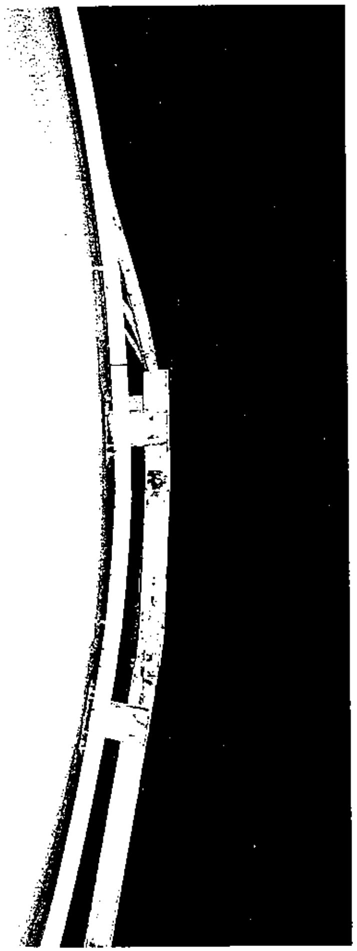
4. Exterior Walls Found With Very Good Coating Adhesion

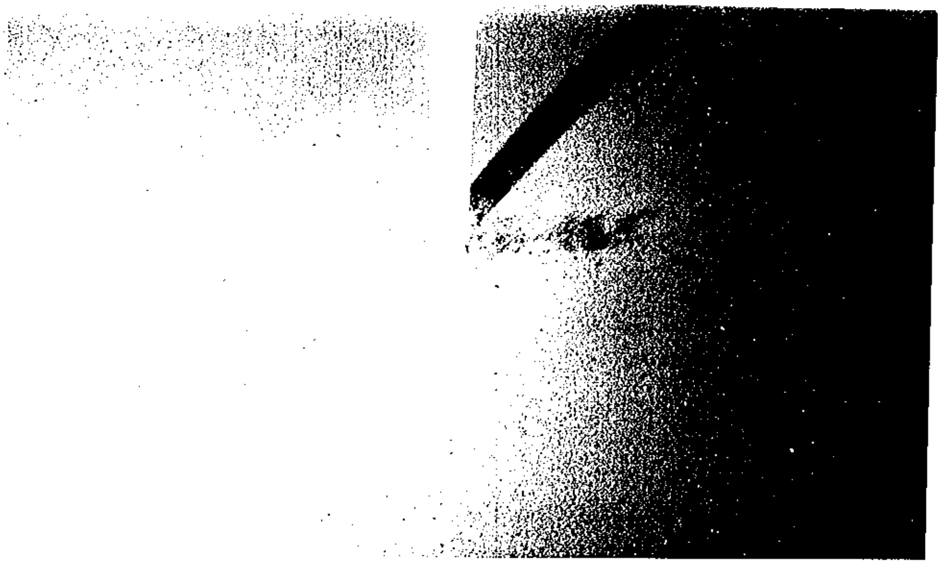


13. Ladder and Safety Cage

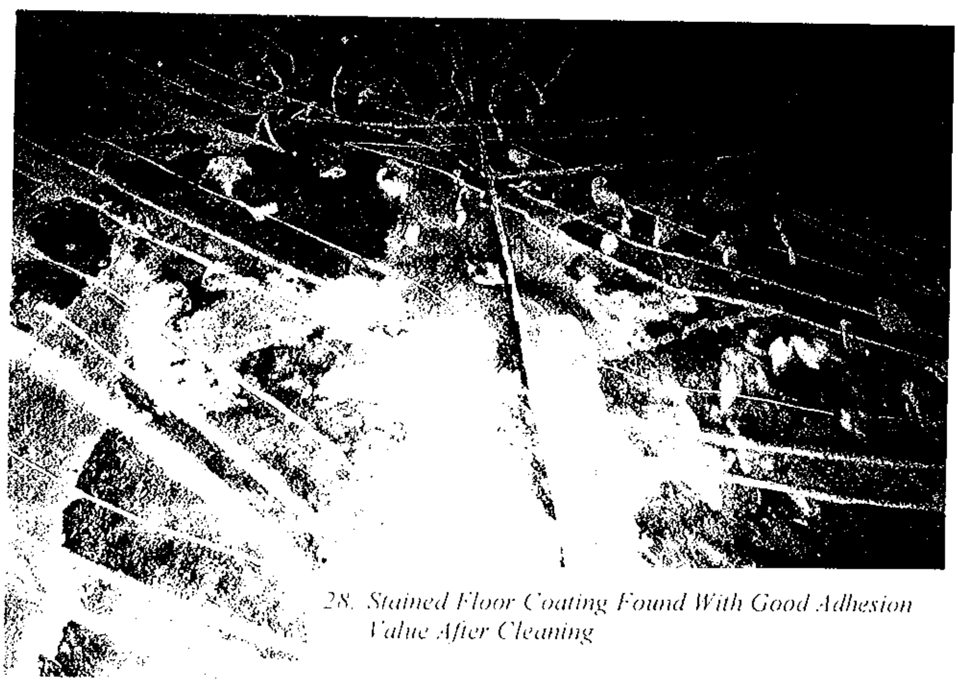


15. Overflow Pipe

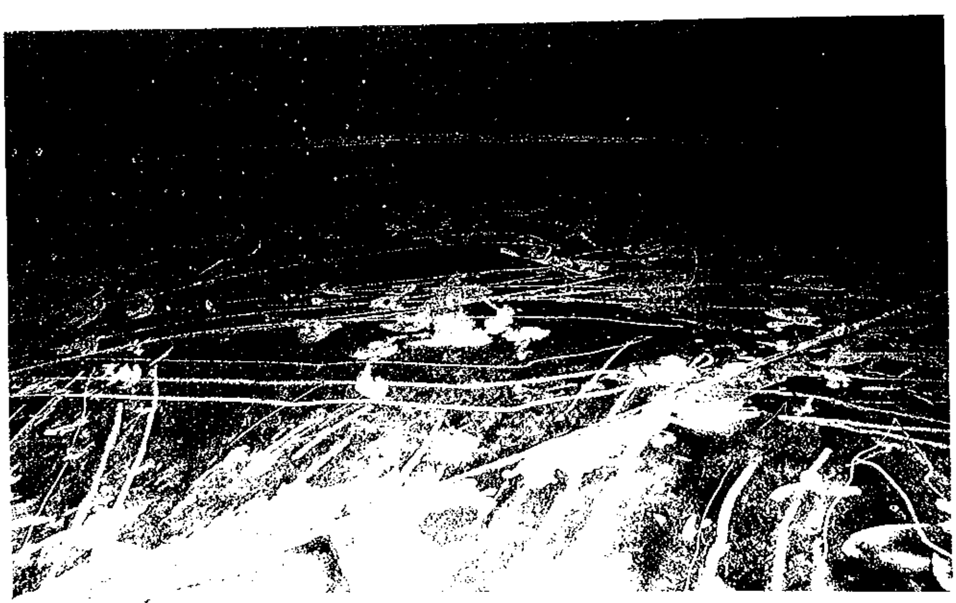




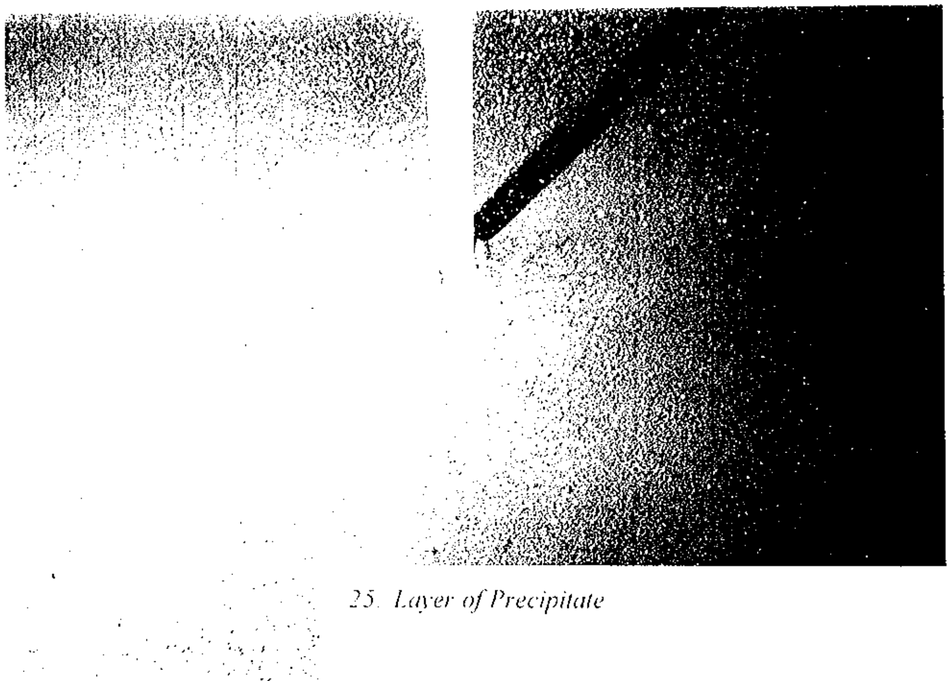
26. Layer of Precipitate



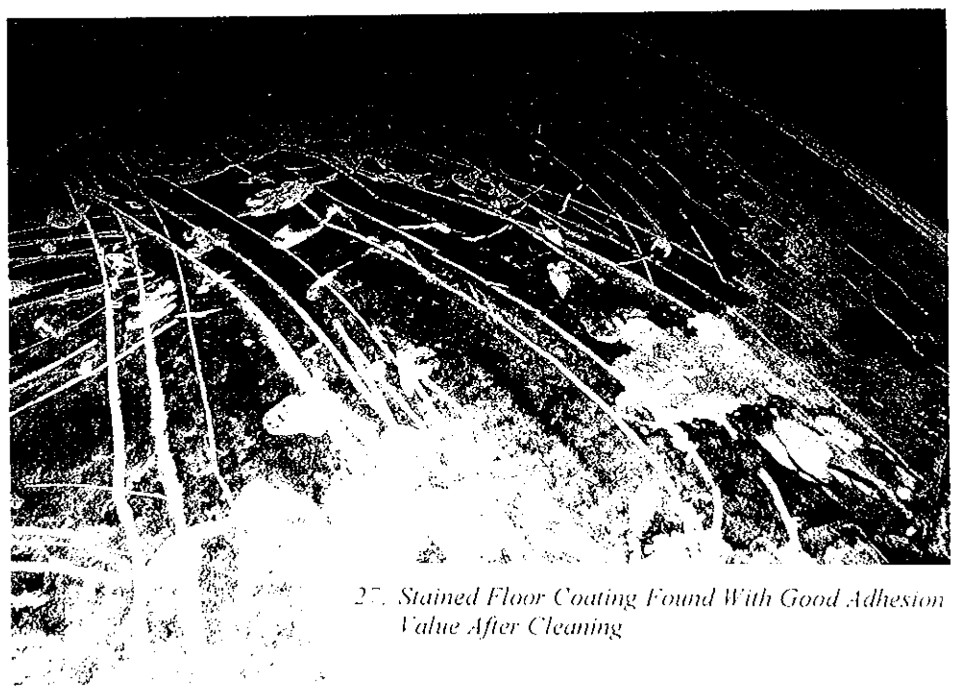
28. Stained Floor Coating Found With Good Adhesion Value After Cleaning



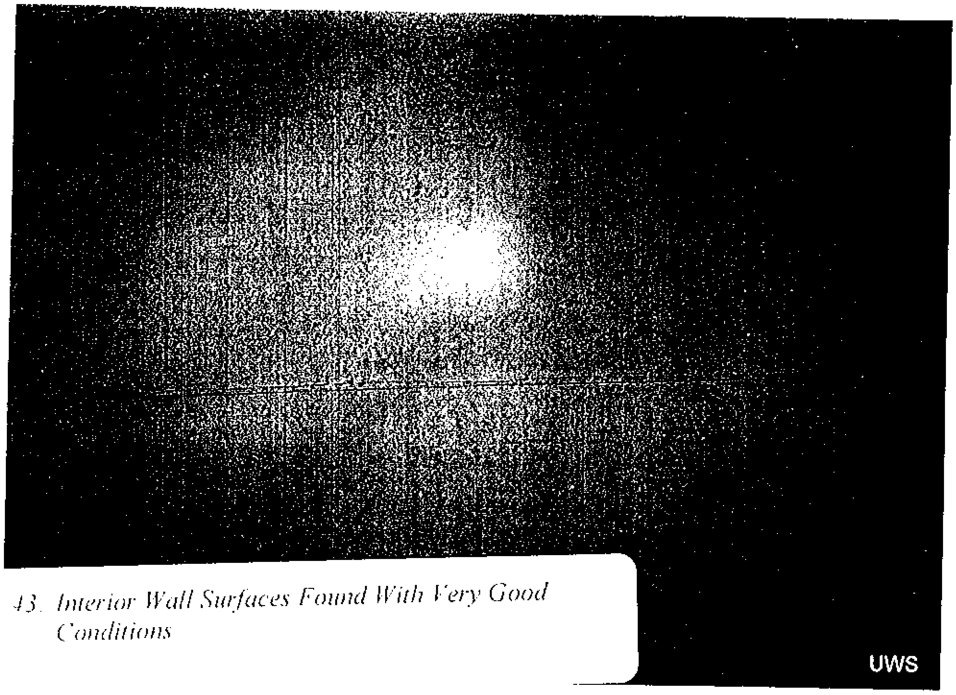
30. Stained Floor Coating Found With Good Adhesion



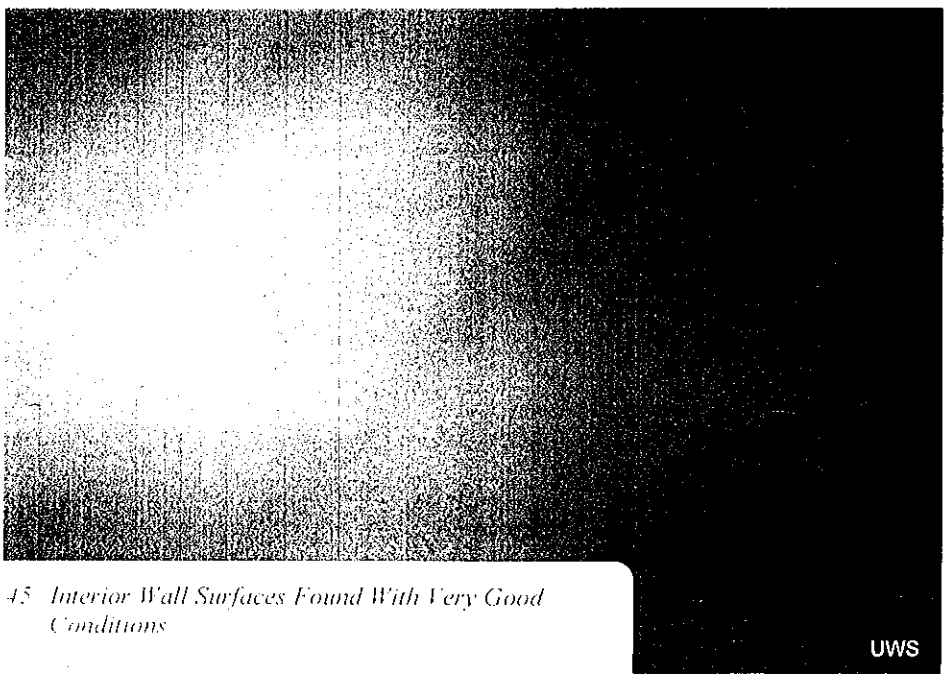
25. Layer of Precipitate



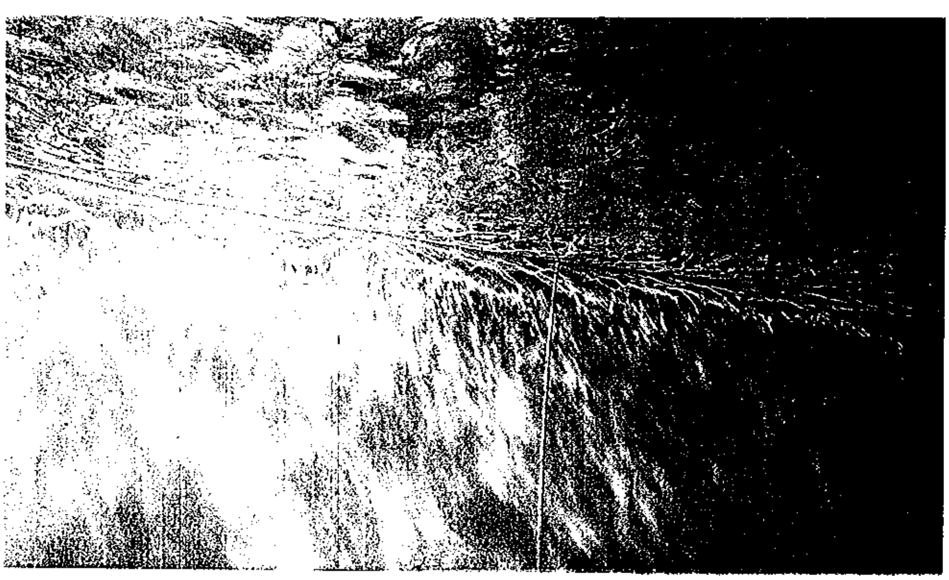
27. Stained Floor Coating Found With Good Adhesion Value After Cleaning

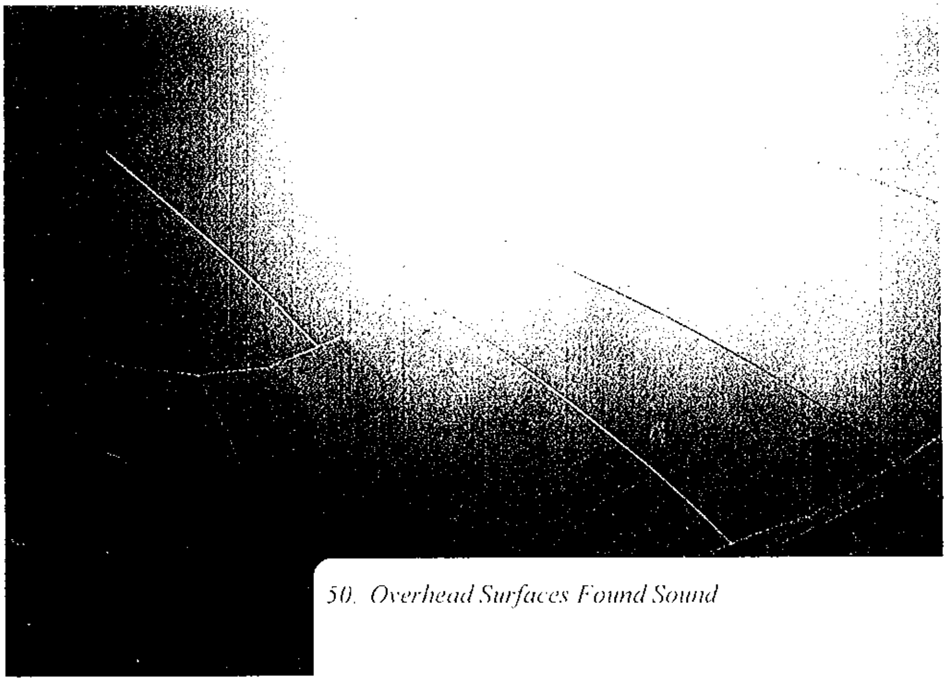


43. Interior Wall Surfaces Found With Very Good Conditions

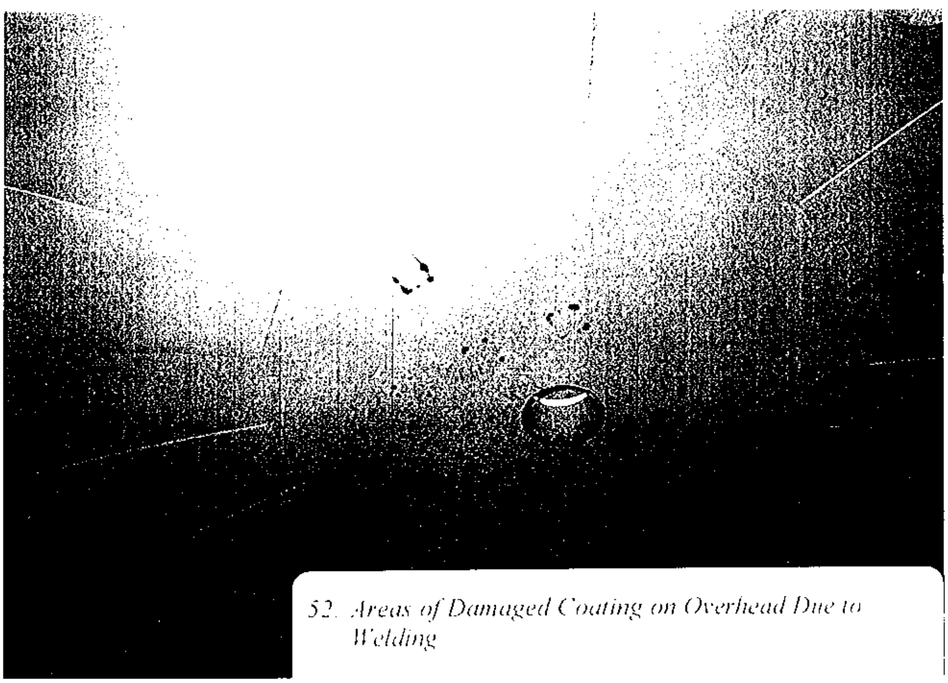


45. Interior Wall Surfaces Found With Very Good Conditions

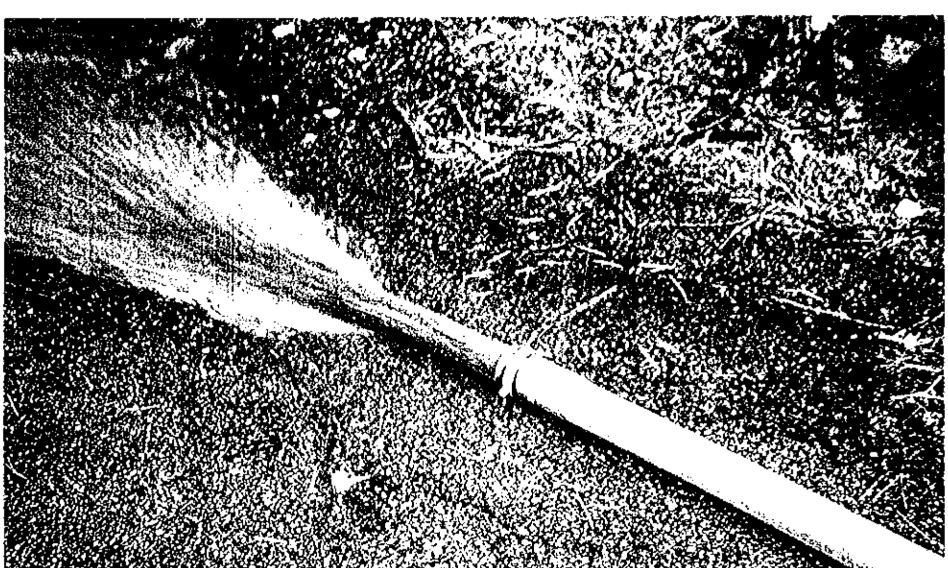




50. Overhead Surfaces Found Sound



52. Areas of Damaged Coating on Overhead Due to Welding



Appendix C
Inspection Reports (cont'd)

C.2 Howard Street Tank Inspection

UNDERWATER SOLUTIONS INC.

INSPECTION AND CLEANING OF THE HOWARD STREET 1.58-MILLION GALLON WELDED STEEL WATER STORAGE TANK

CANOBIE LAKE WATER TREATMENT PLANT
SALEM, NEW HAMPSHIRE

SEPTEMBER 10, 2007

MUNICIPAL DIVING SERVICES • P.O. Box 208 • Mattapoisett, MA 02739 • Tel: (508) 758-6126 • Fax: (508) 758-6128
www.underwatersolutionsinc.com

UNDERWATER SOLUTIONS INC.

INSPECTION AND CLEANING OF THE HOWARD STREET 1.55-MILLION GALLON WELDED STEEL WATER STORAGE TANK

CANOBIE LAKE WATER TREATMENT PLANT SALEM, NEW HAMPSHIRE

SEPTEMBER 10, 2007

SCOPE:

On September 10, 2007, Underwater Solutions Inc. conducted an inspection of the Howard Street 1.55-million gallon welded steel water storage tank to provide information regarding the overall condition and integrity of this structure and removed the sediment accumulation found on the floor of the structure.

EXTERIOR INSPECTION:

The entire exterior of this water storage tank (and components) was inspected to include anchor bolts, walls and coating, manways, ladder and safety cage, overflow, roof, vent and hatches.

Anchor Bolts

Forty 2 1/2" diameter anchor bolts were found extending up from the foundation through welded chairs approximately 17" tall. Although all bolts and nuts are sound and secure, each was found with coating failure and light corrosion.

Walls and Coating

The exterior wall surfaces were inspected and found with sound overall conditions while numerous coating chips expose the steel panel surfaces, and a great deal of damage to the coating has been caused by installing cellular communications equipment.

Hundreds of coating chips within the lowest 50' of these wall panel surfaces cause exposure of the steel having mild to moderate corrosion. Numerous areas of coating failure caused by the cellular equipment installation average 8' long by 1/2" wide exposing the primer, and in a few areas exposing the steel causing corrosion.

Manways

Two 24" inside diameter manways penetrate the lowest row of wall panels approximately 27" above the ground. All coating applied to these manways remains in place having good adhesion while mild corrosion exists on all hardware surfaces.

These manways were found securely installed and are free of leakage at this time.

Ladder/Safety Cage

A ladder and safety cage having a fall prevention device properly installed extends from 18' above the ground to the roof. This ladder remains in very good condition and is properly installed to the tank wall with ten sets of welded standoffs.

Coating failure causes mild corrosion on approximately 50% of the length of this ladder.

Overflow

A 10" inside diameter overflow pipe extends out of welded steel weir box and continues down the tank wall properly supported in place with eleven welded standoffs. This pipe terminates 16" above the ground and is unscreened at its end.

Mild surface corrosion was found on these pipe surfaces due to objects striking the pipe causing coating chips.

Roof

The entire rooftop of this water storage tank was found sound while the film thickness of the coating has declined, causing blotch rusting to show through the coating on approximately 50% of all panel surfaces.

Vent

A 24" inside diameter vent stands 14" tall. This vent has a 48" outside diameter cap properly installed and all perimeter screening is intact. Mild primer exposure on the vent cap was found due to breakdown and failure of the secondary coating.

Hatches

Two 24" inside diameter hatches provide access to the interior of this tank through the roof.

The hatch located above the ladder was found in good condition and has a lock installed. Mild corrosion was found on the interior surface of this hatch due to coating failure.

A second bolted shut 24" inside diameter hatch is located up at the top of the dome beside the vent.

INTERIOR INSPECTION:

The entire interior of this water storage tank (and components) was inspected to include sediment accumulations, floor, manways, piping, walls and coating, cathodic protection system, overhead, overflow, and aesthetic water quality.

Sediment Accumulations

A uniform layer of accumulated precipitate was found on all floor surfaces ranging from 11" to 17" in depth.

Upon completing this inspection, a portion of this floor was vacuumed, yet not all precipitate could be removed in one day.

Floor

Approximately 1/4" of the floor is presently exposed due to a significant layer of accumulated precipitate. Within the exposed floor panels extensive coating failure was found due to adhesion loss of the coating.

Numerous coating blisters have formed on these floor surfaces while many blisters have ruptured exposing the steel.

Although corrosion was found in all areas having steel exposure, no pitting (metal fatigue) was seen.

Manways

Two 24" inside diameter manways were inspected on opposite sides of the tank located 27" above the floor. Each manway was found to be free of leakage while ruptured coating blisters on all trunk surfaces cause surface corrosion of the steel and heavy rust staining.

Piping

A 14 3/4" inside diameter inlet/outlet riser extends up 12 1/8" tall above the floor located 29" in from the tank wall.

This pipe was found properly installed and having flow entering the tank at the time of this inspection.

Walls and Coating

All interior wall surfaces were inspected beginning at the floor and spiraling the circumference up to the water surface.

These interior wall panels and welded surfaces were found with extensive coating failure and poor conditions.

Within the lowest thirteen rows of panels all coating was found with adhesion loss resulting in blistering. Approximately 60% of all surfaces yield ruptured coating blisters at this time, resulting in exposure of the steel, heavy corrosion and metal fatigue. Pit depths range in depth yet average 1/8" at this time.

The top row of ring wall panels was found with numerous 2" by 3" diameter areas of exposed steel due to welding on the tank exterior during the installation of cellular communication equipment. These exposed areas of steel yield surface corrosion, yet no metal fatigue was witnessed at the time of this inspection.

Cathodic Protection System

A cathodic protection system installed within this structure has completely failed. All lines, cables, and floats have broken loose; rendering this system inoperable.

All cement blocks used to anchor this system were found on one side of the tank floor indicating that an ice cap on the water surface may have dragged this system causing damage.

Overhead

All overhead panels were found with very sound conditions at the time of this inspection. Reduced film thickness of the coating applied to these panel surfaces causes mild blotch rusting to show through the coating at the junctions of the panel edges as well as at the junction of the roof and walls.

Overflow

The overflow consists of an unobstructed 32" by 12" cutout within the top wall panel located approximately 8" below the top of this wall panel

Aesthetic Water Quality

The aesthetic water quality within this tank was found to be poor. This condition caused our visibility during this inspection to be limited due to color and suspended particulate at all tank elevations.

CONCLUSION:

It is the opinion of Underwater Solutions Inc. that this water storage tank remains in fair condition while extensive coating failure, adhesion loss, and damage caused by installing cellular equipment exists.

The exterior surfaces of this structure yields numerous coating chips caused by objects striking the walls within the lowest 50' exposing the steel and causing surface corrosion. The coating also has been damaged on the exterior surfaces as a result of installing cellular equipment.

All components to include manways, ladder, hatches, vent, and overflow remain properly installed, while coating fatigue exists on many surfaces.

We recommend installing a screen over the end of the overflow pipe to prevent access to the tank interior.

The interior floor surfaces and throughout all lowest thirteen rows of wall panels, complete coating failure has occurred.

Adhesion loss of all coating resulting in ruptured coating blisters causes extensive, heavy corrosion and pitting of these surfaces.

Welding to the tank exterior within the top row of wall panels causes exposed steel and surface corrosion on the tank interior.

Only a portion (approximately 1/4) of the accumulated precipitate were removed during this project, due to this layer exceeding the 6" of removal proposed and what could be removed in the course of one day.

We strongly recommend that this structure be completely cleaned removing the potential for bacterial nutrient and poor aesthetic water quality.

We recommend that this structure be scheduled for a complete coating rehabilitation within the immediate future in an effort to halt corrosion and prevent further metal fatigue of the steel panel surfaces.

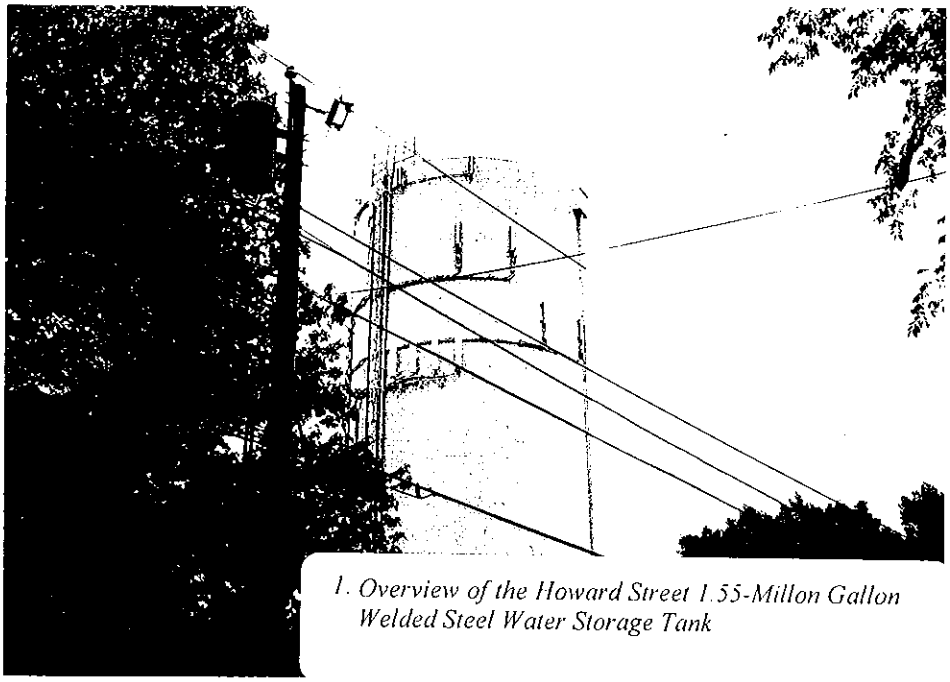
We also recommend that the failed cathodic protection system be replaced with a system less susceptible to ice formation.

As always, we recommend re-inspection and cleaning of all water storage facilities in accordance with A.W.W.A. Standards and local guidelines.

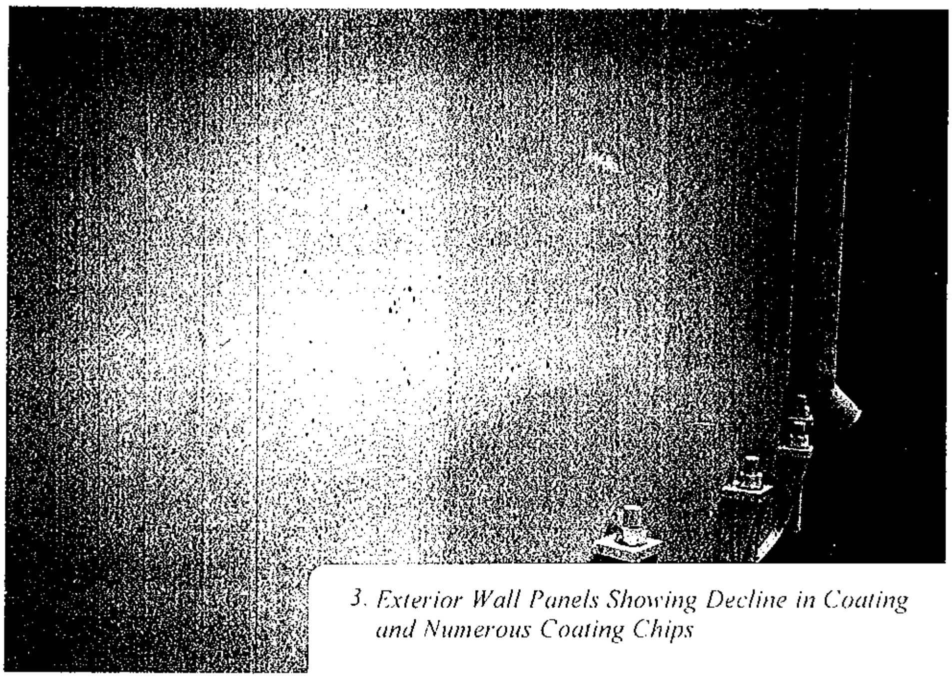
UNDERWATER SOLUTIONS INC.
Christopher A. Cole, Project Manager

This report, the conclusions, recommendations and comments prepared by Underwater Solutions Inc. are based upon spot examination from readily accessible parts of the tank. Should latent defects or conditions which vary significantly from those described in the report be discovered at a later date, these should be brought to the attention of a qualified individual at that time. These comments and recommendations should be viewed as information to be used by the Owner in determining the proper course of action and not to replace a complete set of specifications. All repairs should be done in accordance with A.W.W.A Standards.

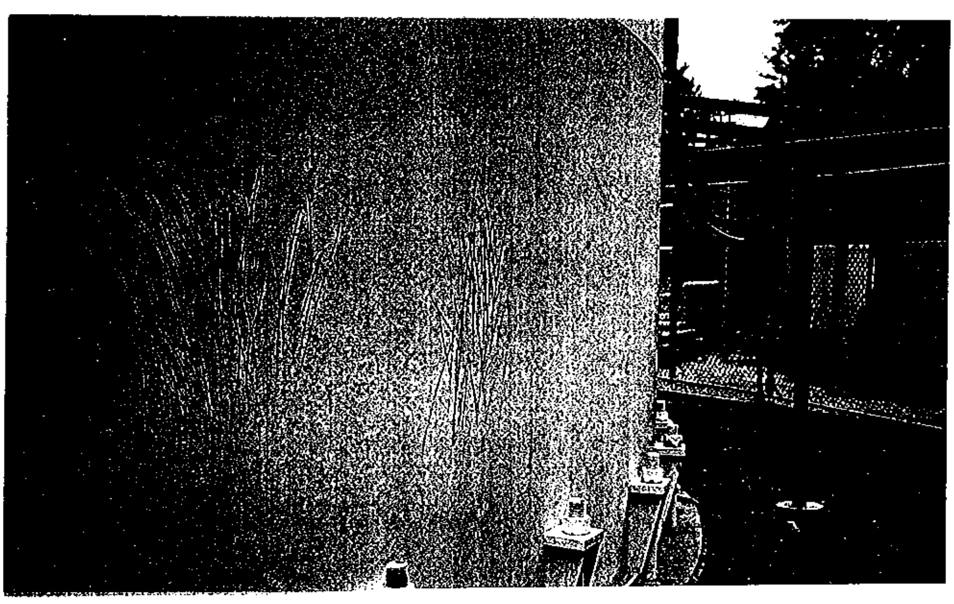
CAC/cmk

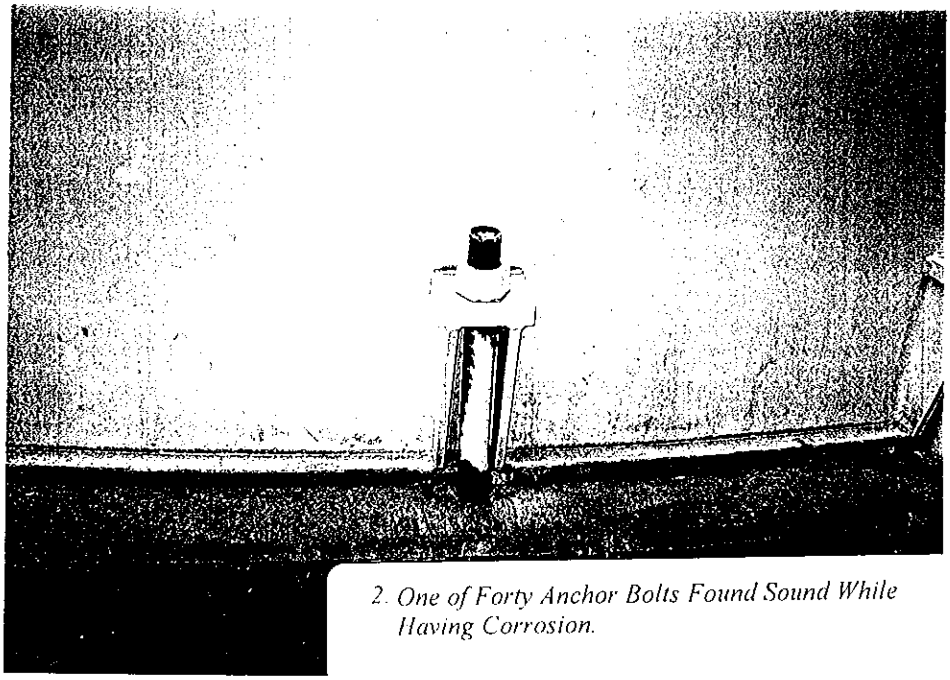


1. Overview of the Howard Street 1.55-Millon Gallon Welded Steel Water Storage Tank

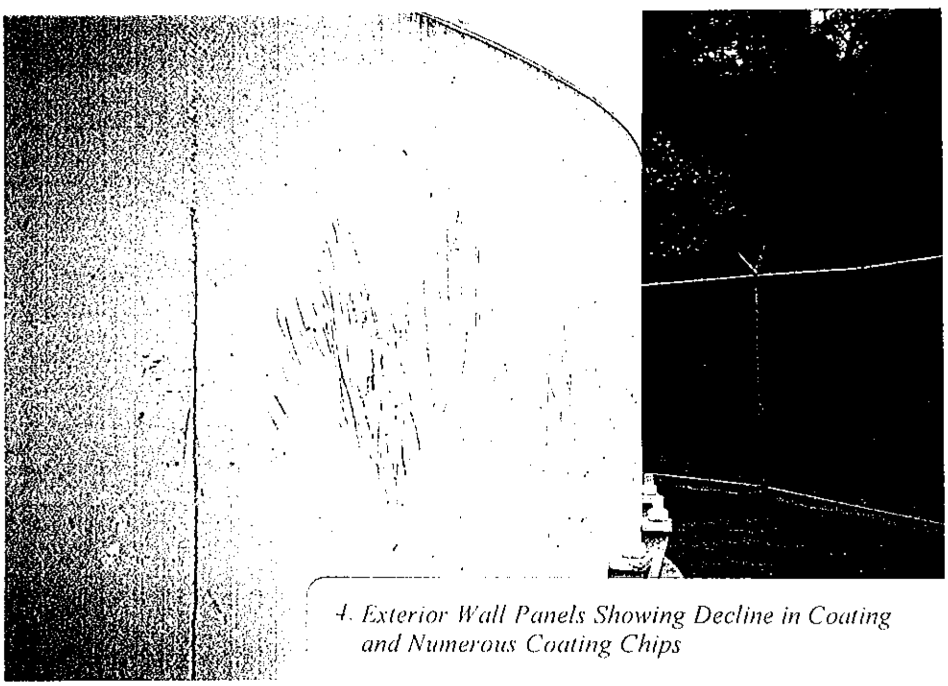


3. Exterior Wall Panels Showing Decline in Coating and Numerous Coating Chips

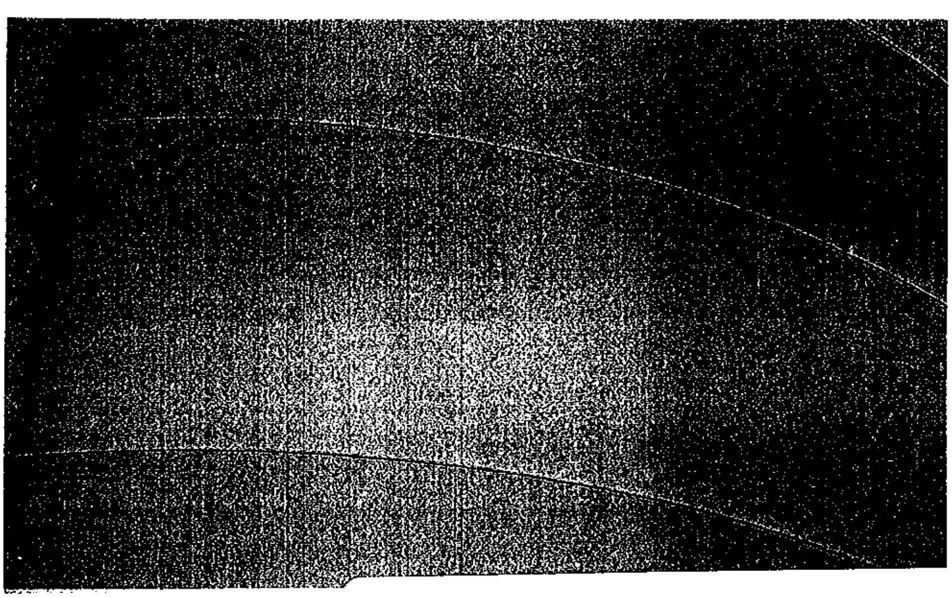


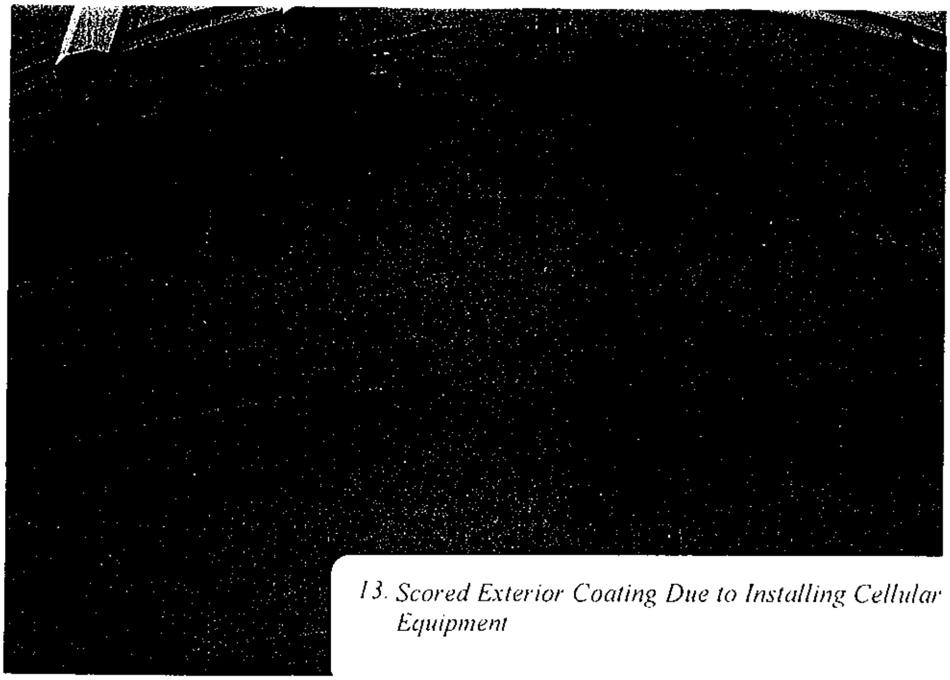


2. *One of Forty Anchor Bolts Found Sound While Having Corrosion.*

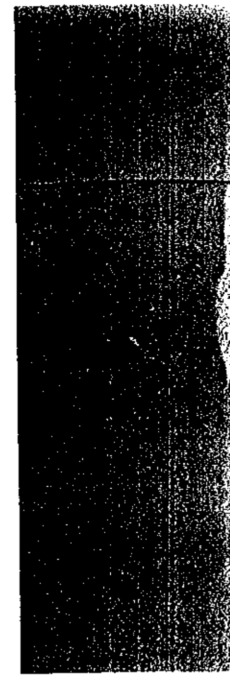


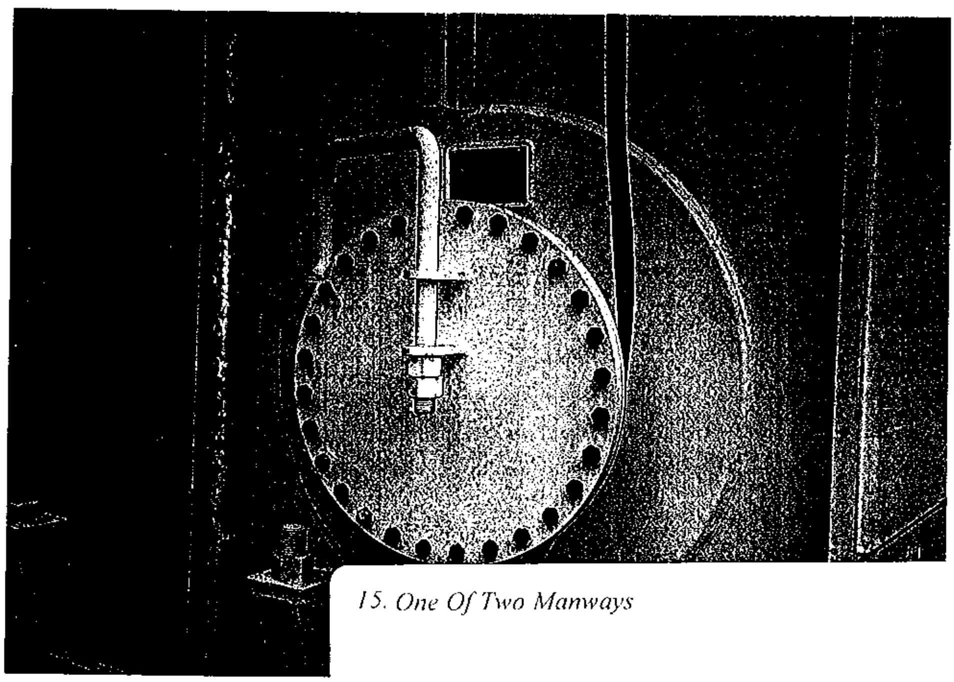
4. *Exterior Wall Panels Showing Decline in Coating and Numerous Coating Chips*



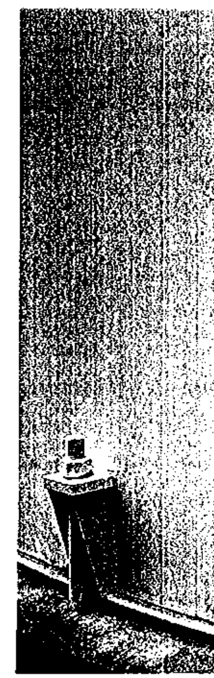


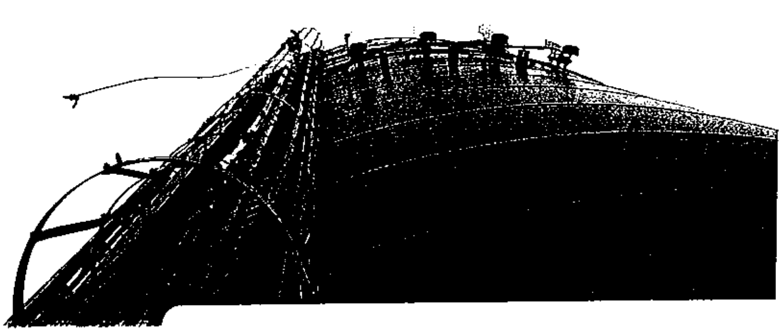
13. Scored Exterior Coating Due to Installing Cellular Equipment

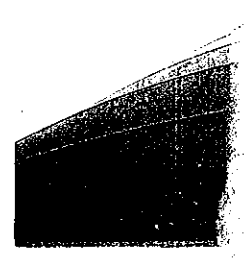


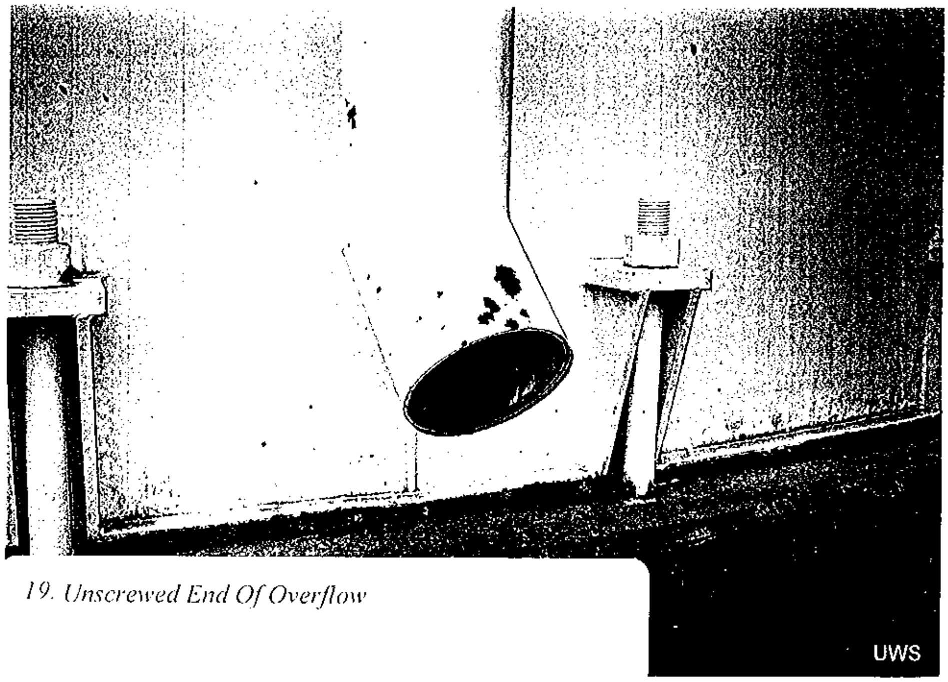


15. One Of Two Manways

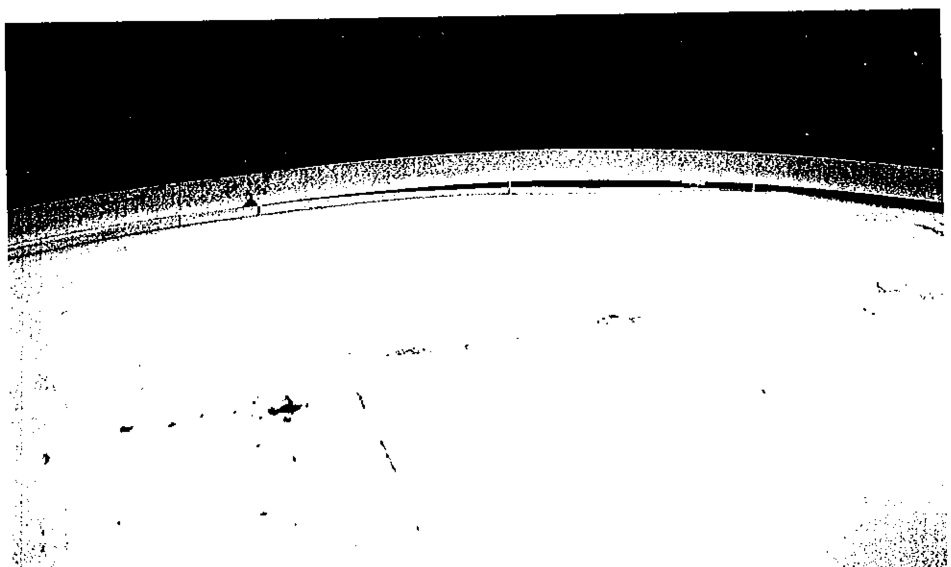




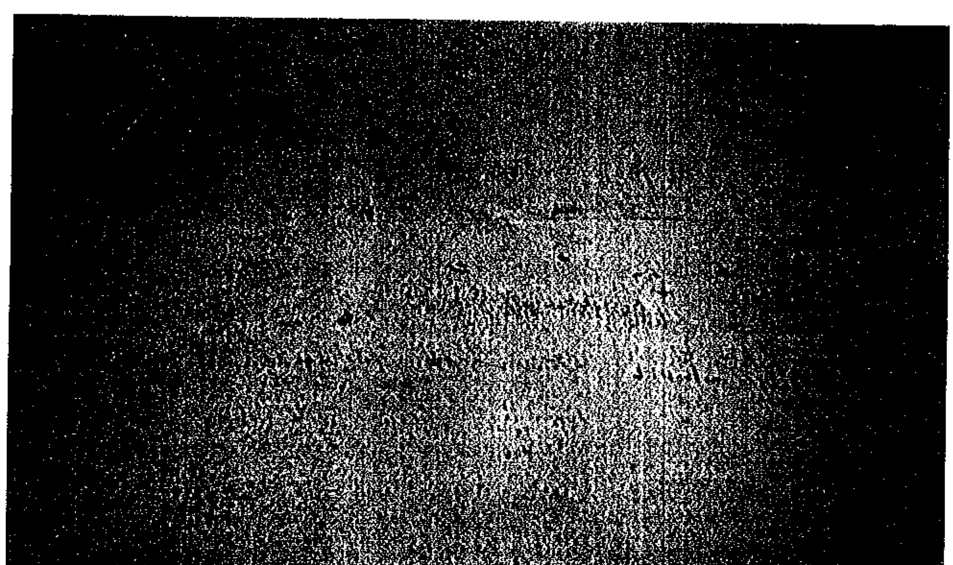


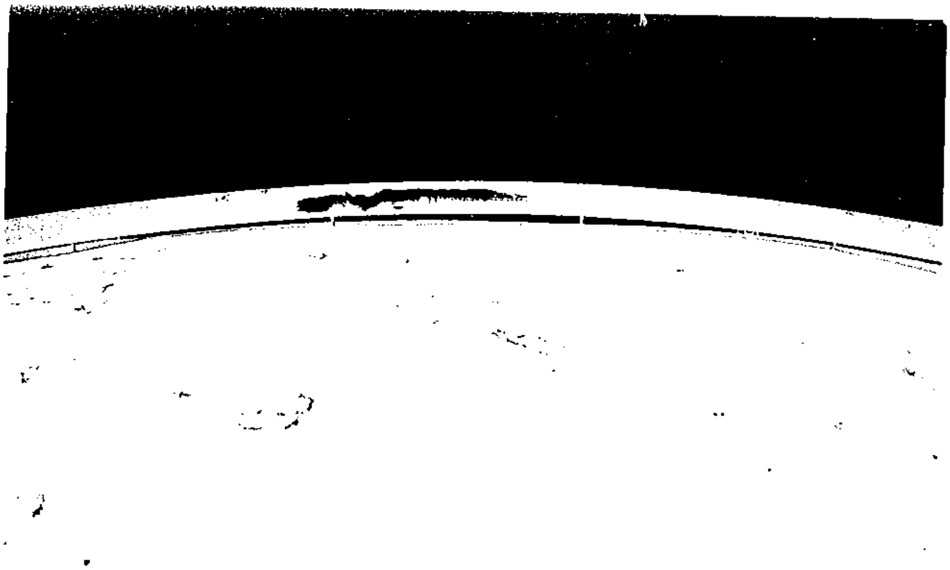


19. Unscrewed End Of Overflow

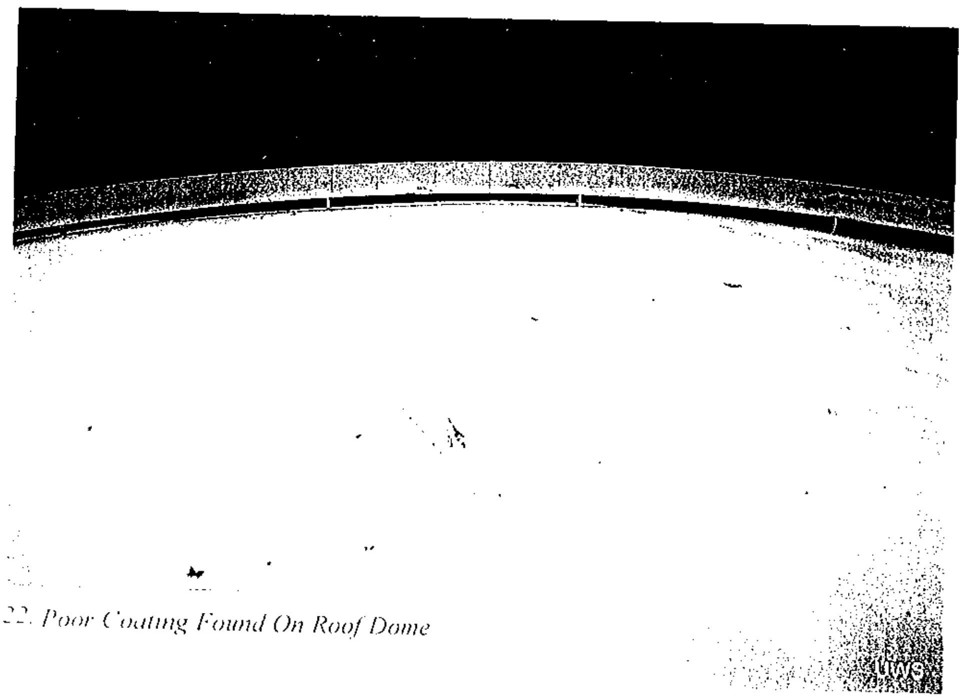


21. Poor Coating Found On Roof Dome

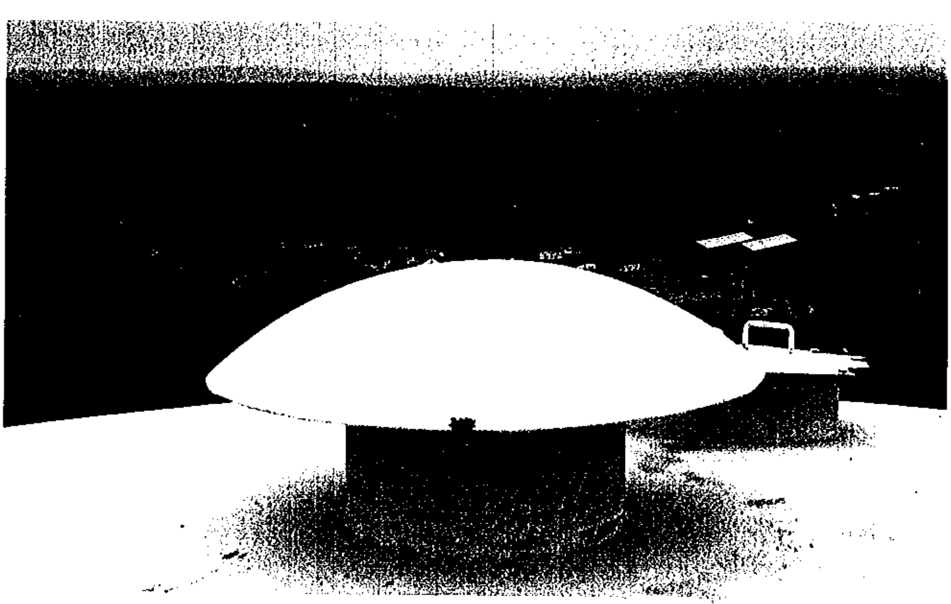


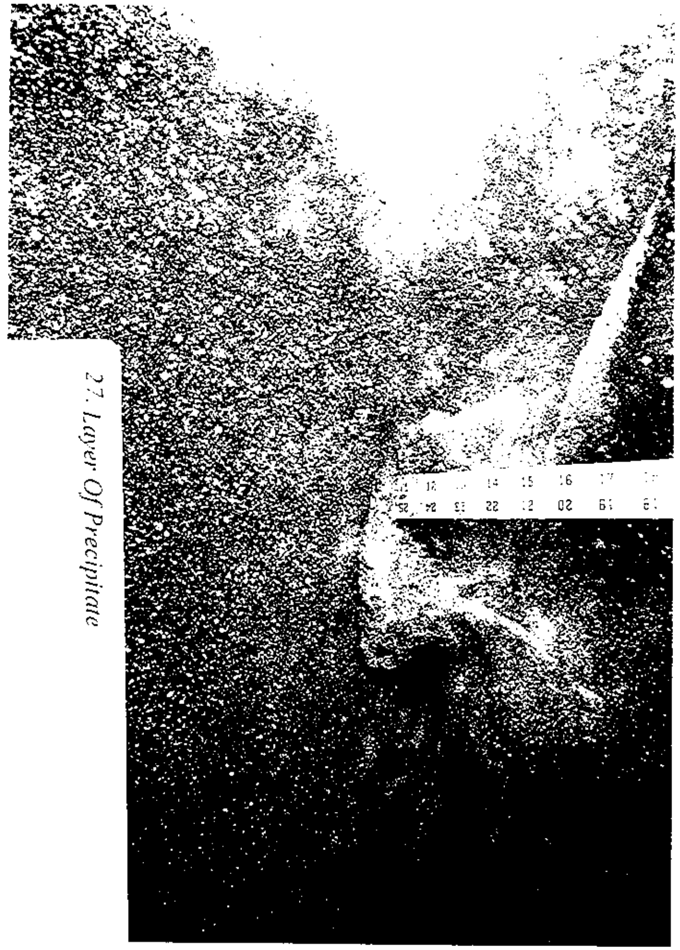


20. *Poor Coating Found On Roof Dome*

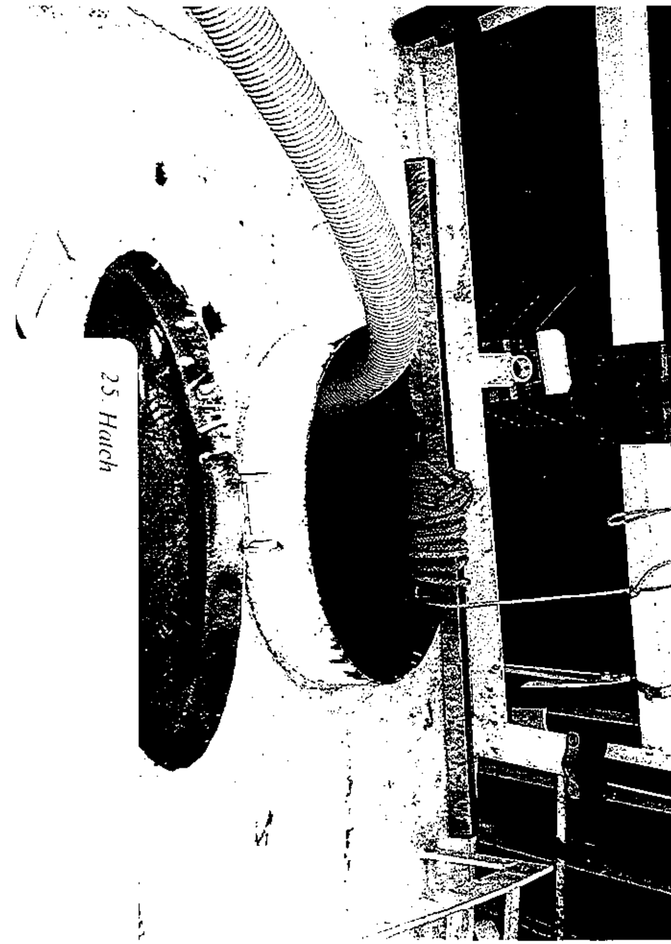


22. *Poor Coating Found On Roof Dome*

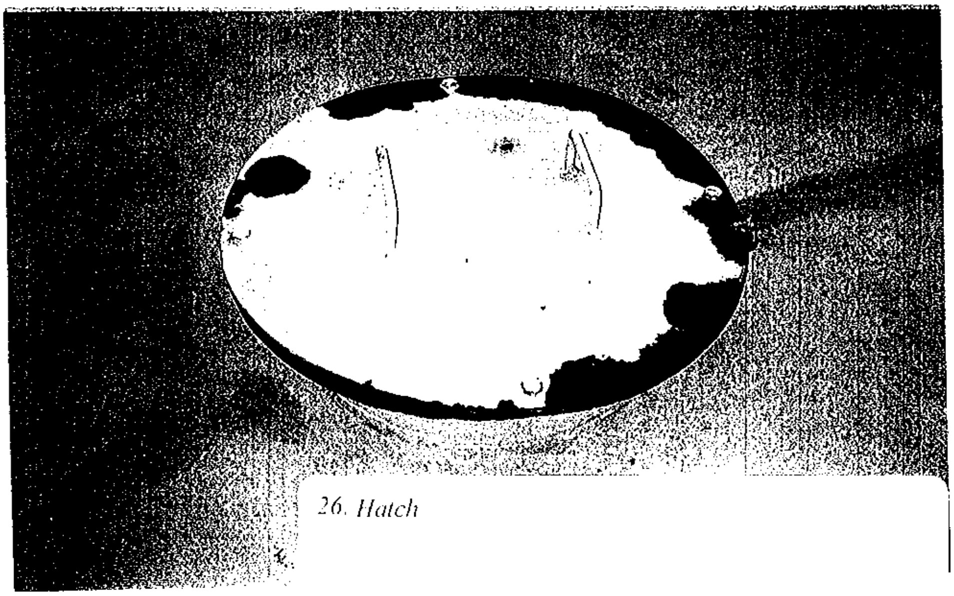




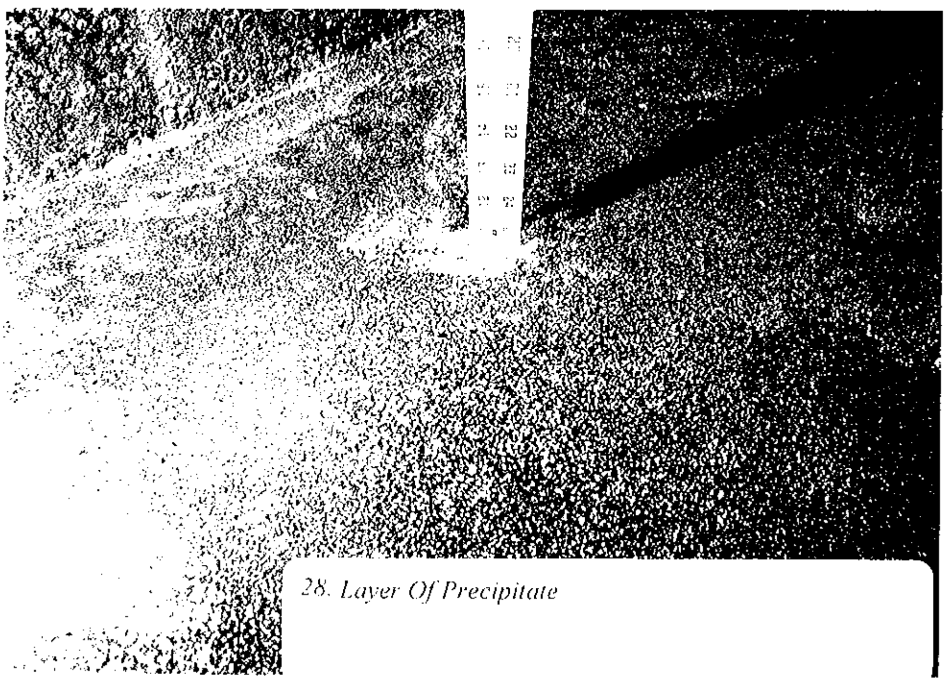
27. Layer Of Precipitate



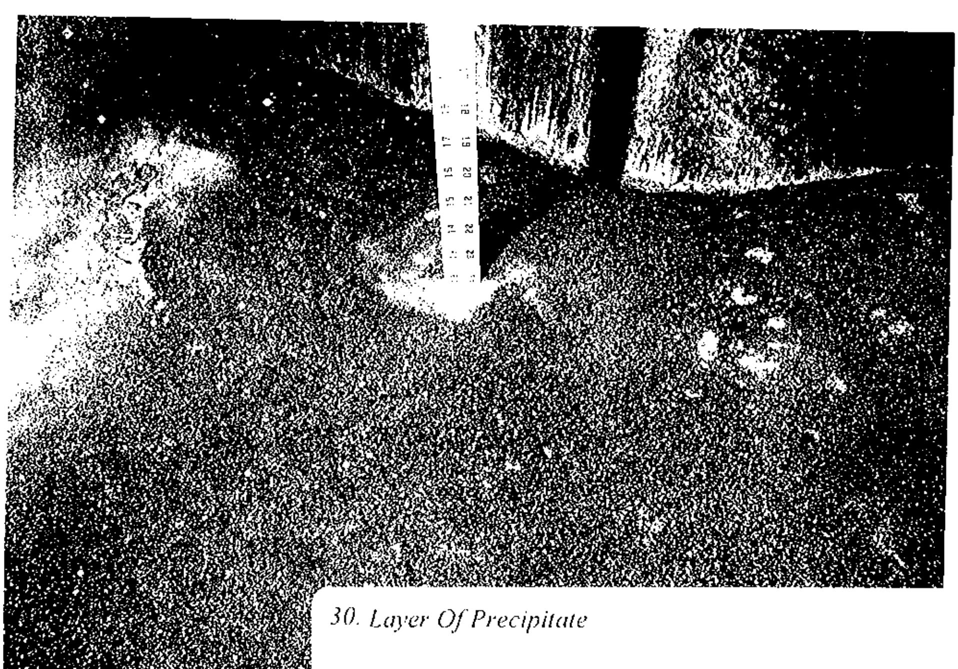
25. Hatch



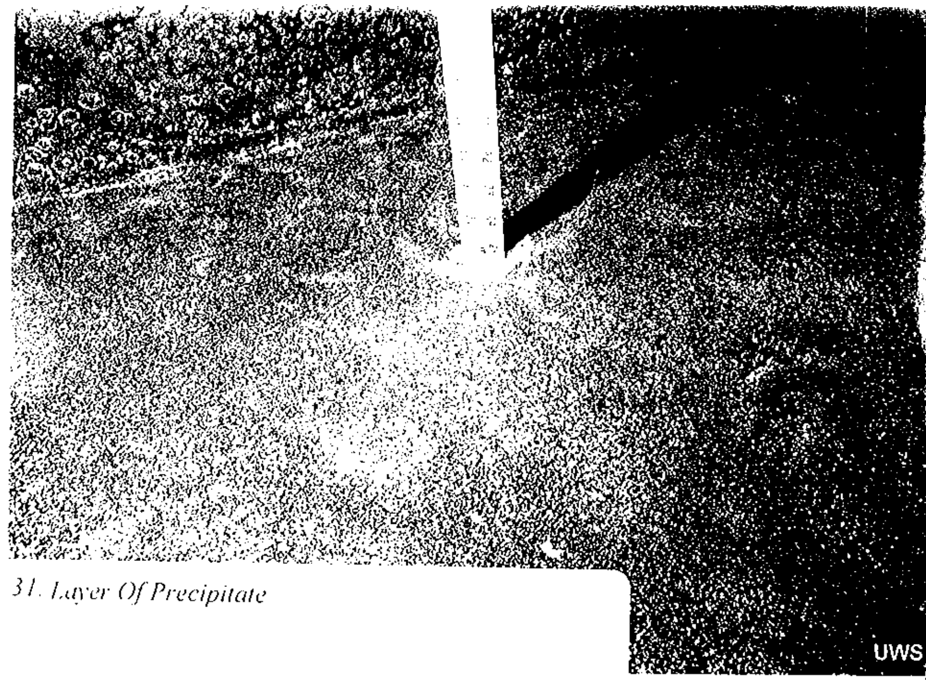
26. Hatch



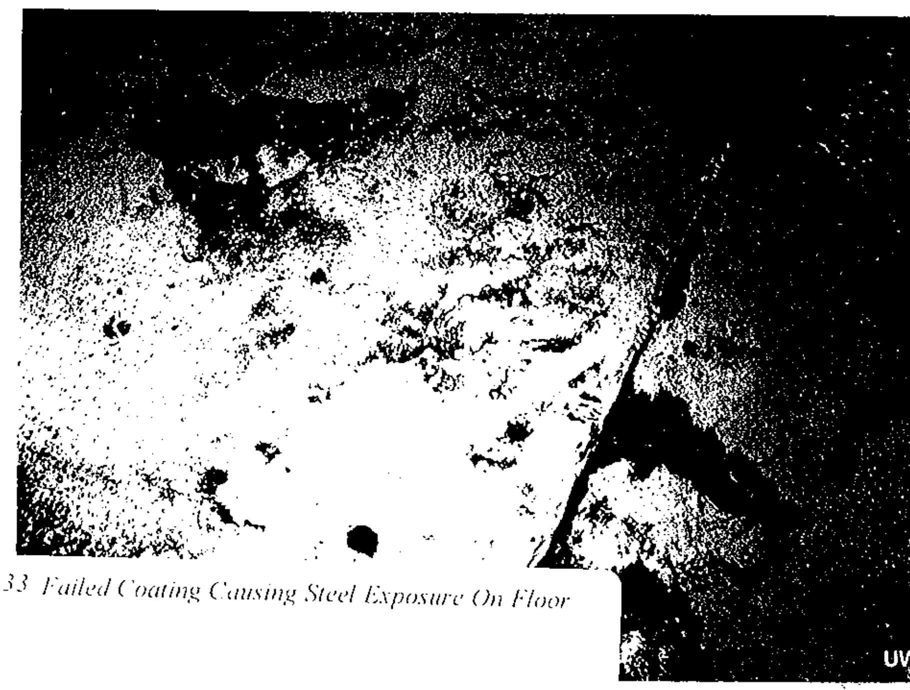
28. Layer Of Precipitate



30. Layer Of Precipitate



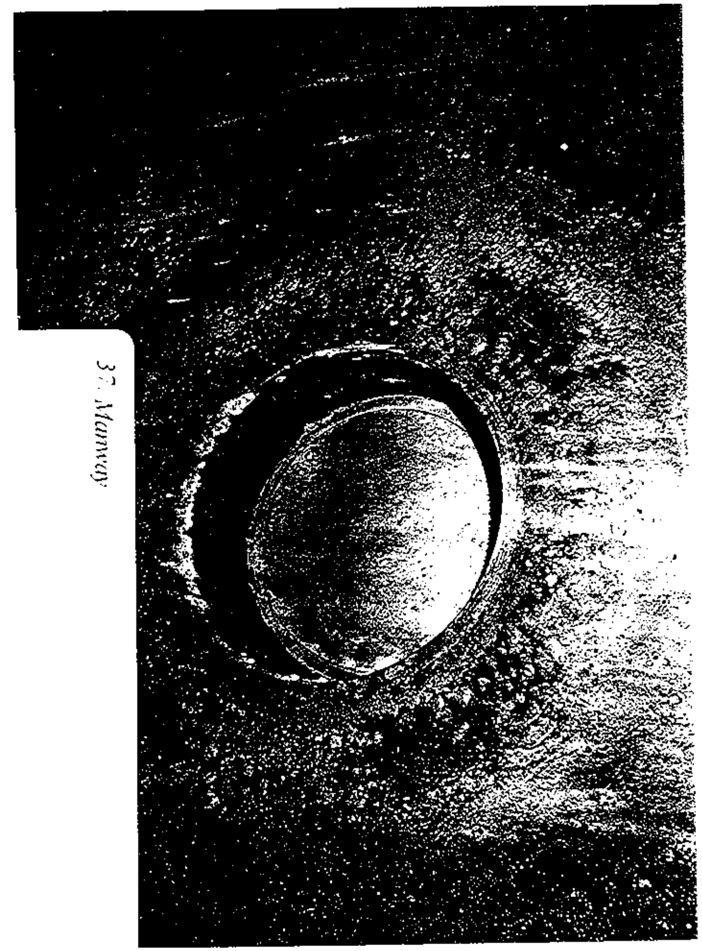
31. Layer Of Precipitate



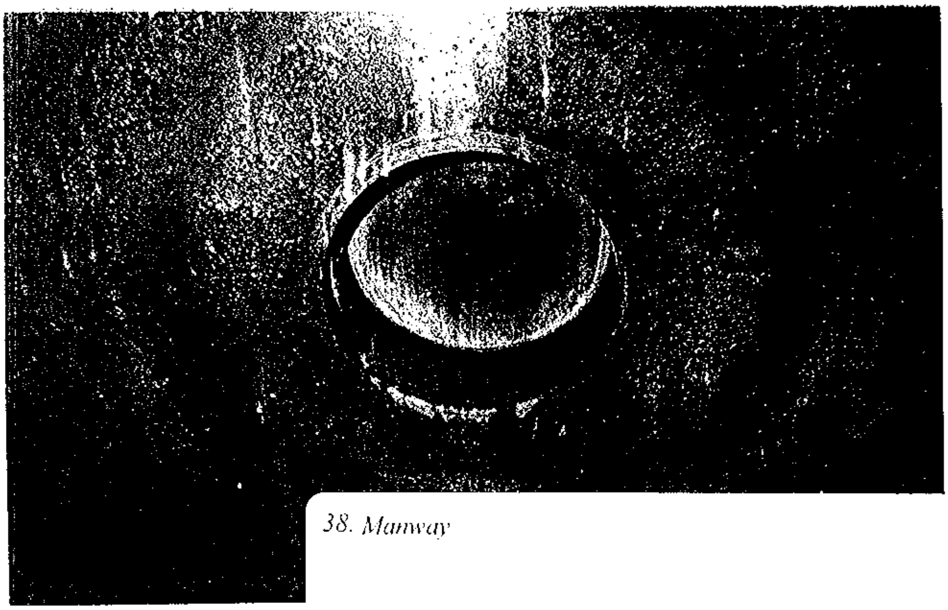
33 Failed Coating Causing Steel Exposure On Floor

35 Failed Coating C

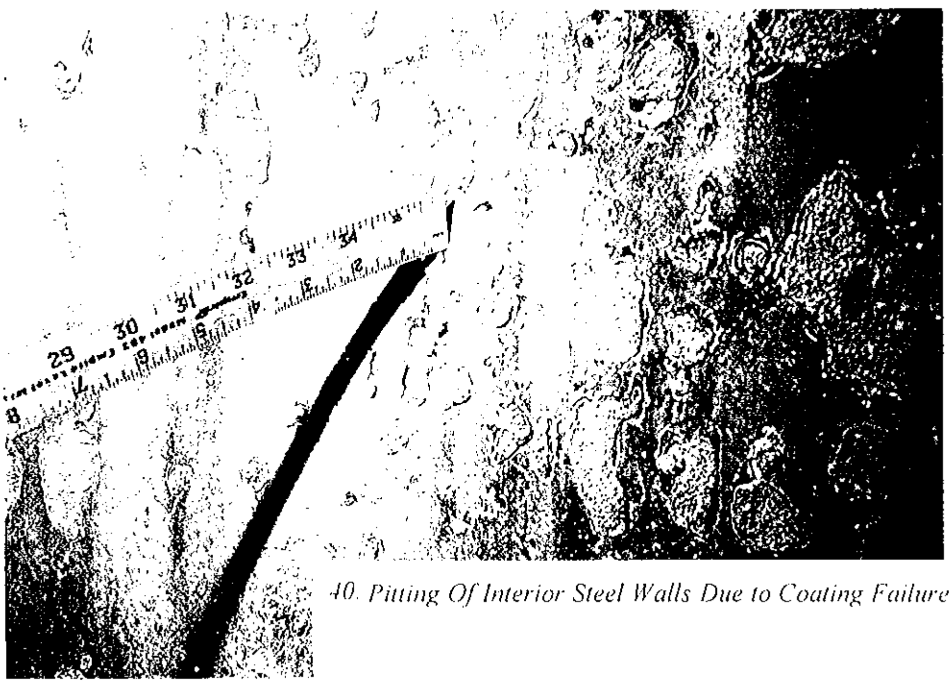
39. Pitting Of Interior Steel Walls Due to Coating Failure



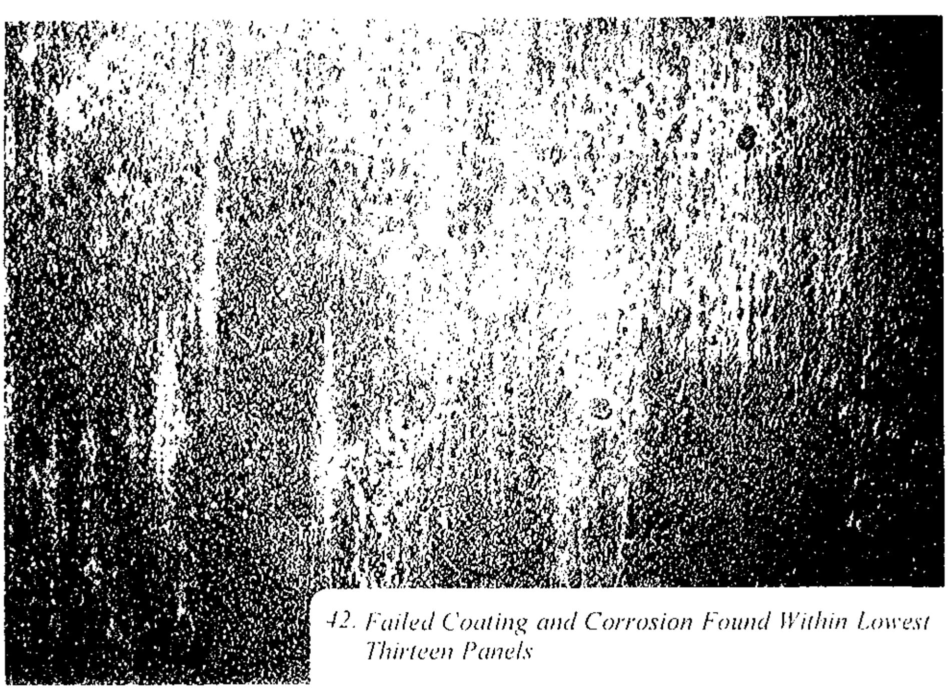
37. Manway



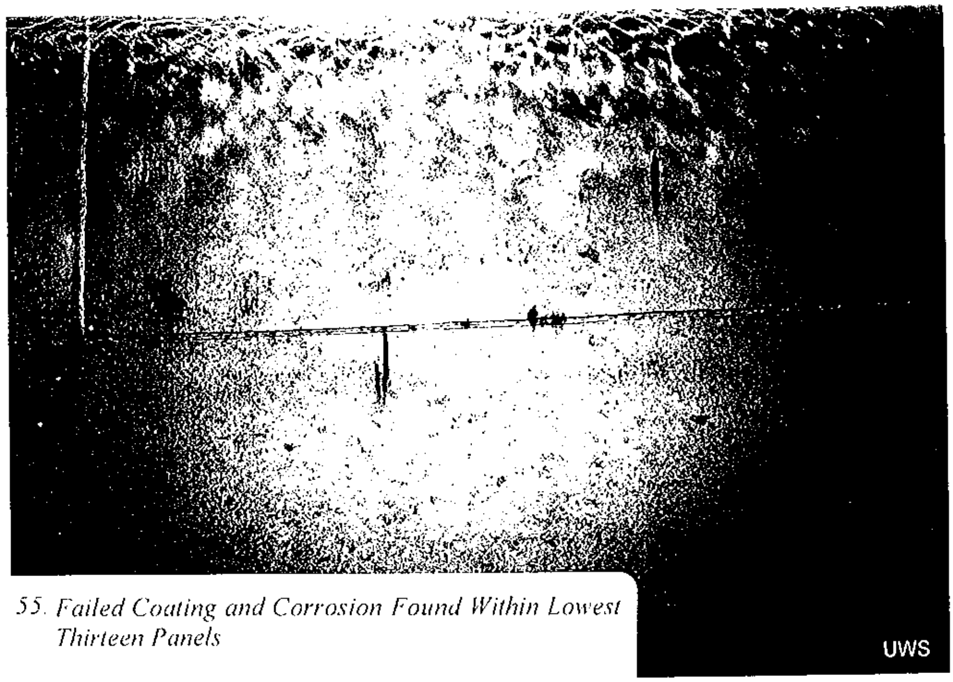
38. Manway



40. Pitting Of Interior Steel Walls Due to Coating Failure

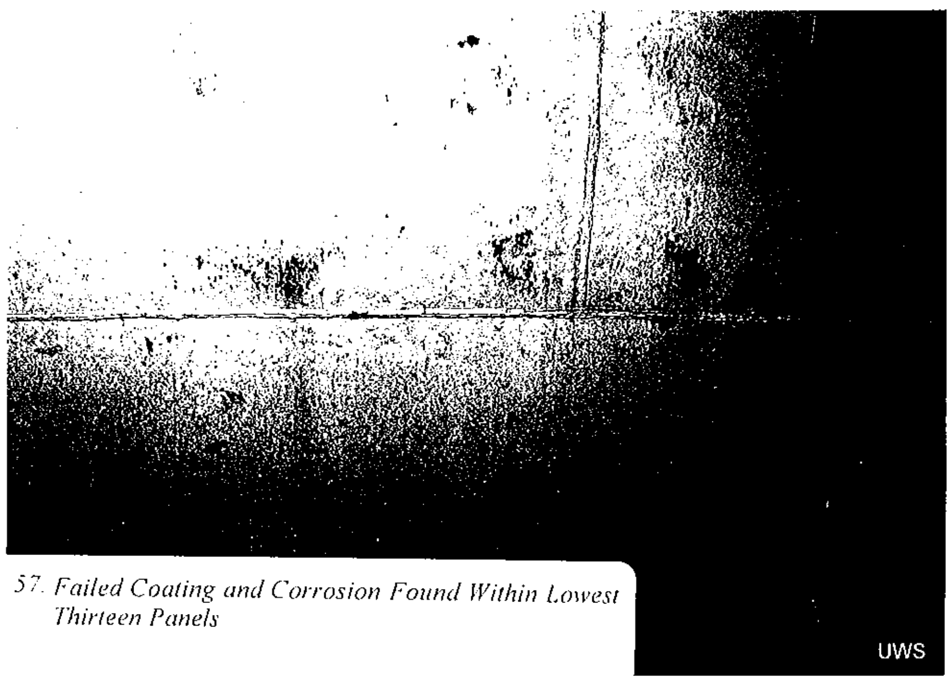


42. Failed Coating and Corrosion Found Within Lowest Thirteen Panels



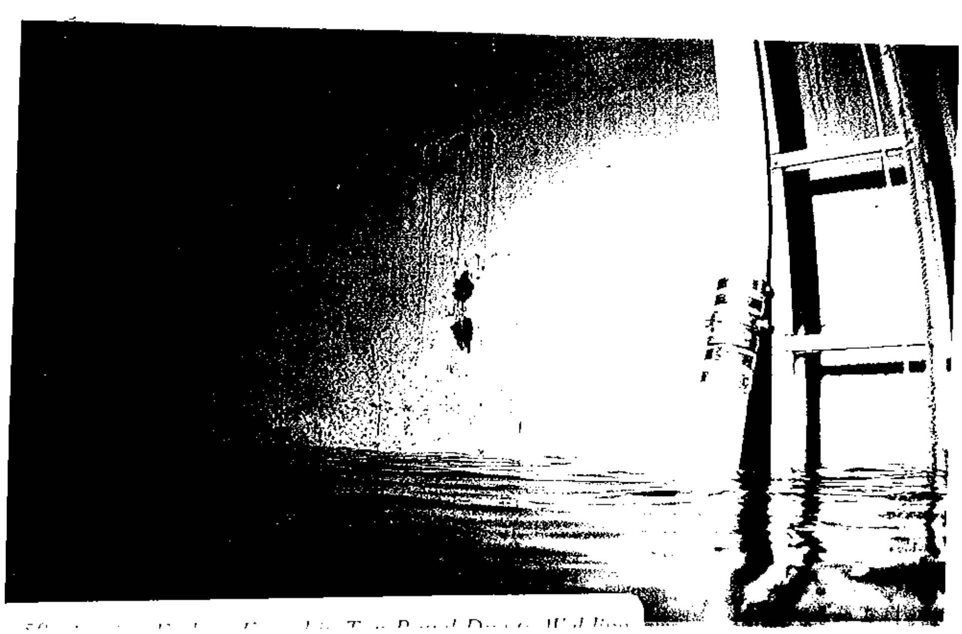
55. *Failed Coating and Corrosion Found Within Lowest Thirteen Panels*

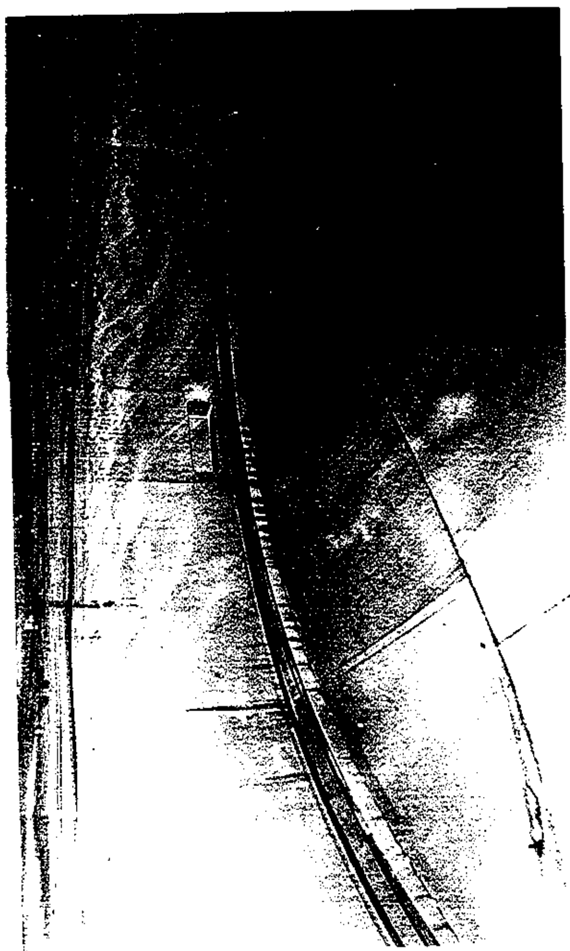
56.

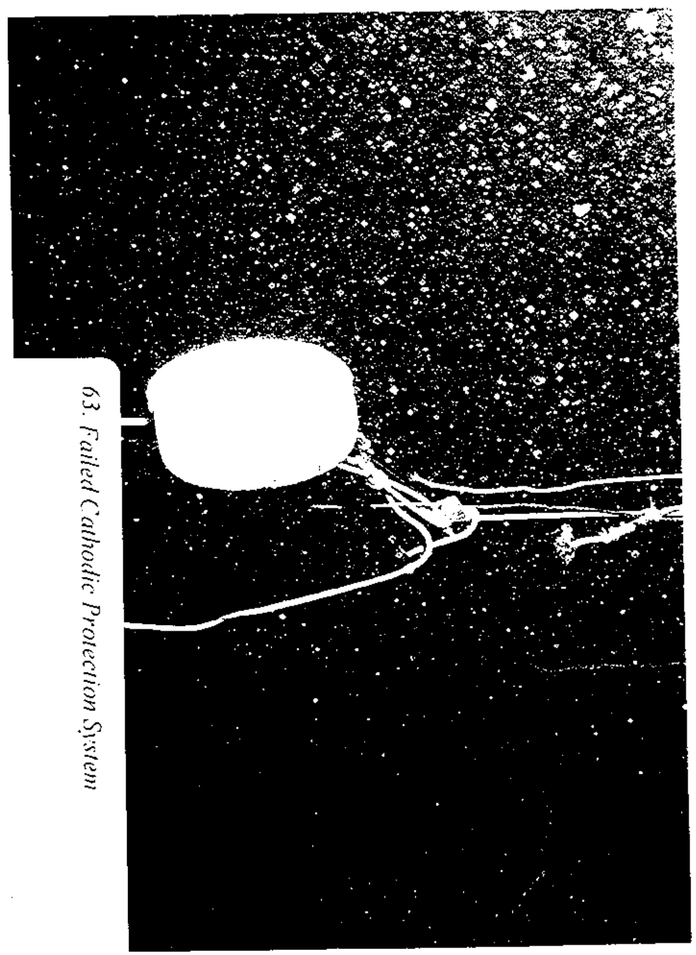


57. *Failed Coating and Corrosion Found Within Lowest Thirteen Panels*

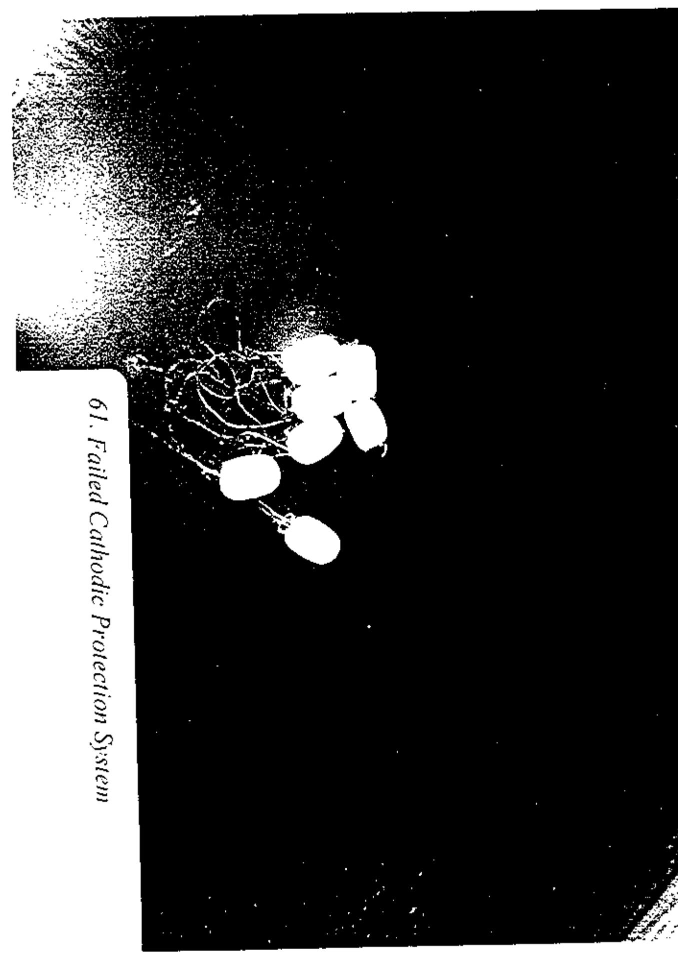
58.







63. Failed Cathodic Protection System



61. Failed Cathodic Protection System

Appendix C
Inspection Reports (cont'd)

C.3 Spicket Hill Tank Inspection

UNDERWATER SOLUTIONS INC.

INSPECTION AND CLEANING OF THE SPICKET HILL 1.43-MILLION GALLON CONCRETE RESERVIOR

CANOBIE LAKE WATER TREATMENT PLANT SALEM, NEW HAMPSHIRE

SEPTEMBER 12, 2007

MUNICIPAL DIVING SERVICES • P.O. Box 208 • Mattapoisett, MA 02739 • Tel: (508) 758-6126 • Fax: (508) 758-6128
www.underwatersolutionsinc.com

UNDERWATER SOLUTIONS INC.

INSPECTION AND CLEANING OF THE SPICKET HILL 1.43-MILLION GALLON CONCRETE RESERVOIR

CANOBIE LAKE WATER TREATMENT PLANT SALEM, NEW HAMPSHIRE

SEPTEMBER 12, 2007

SCOPE:

On September 12, 2007, Underwater Solutions Inc. conducted an inspection and cleaning of the Spicket Hill 1.43-million gallon concrete reservoir to provide information regarding the overall condition and integrity of this structure and removed the sediment accumulation found on the floor of the structure.

EXTERIOR INSPECTION:

The entire exterior of this reservoir (and components) was inspected to include walls and coating, overflow, roof, vent and hatches.

Walls and Coating

The exterior wall surfaces were inspected and found very sound while tight shrinkage cracks exist within the shotcrete cover coating within the lowest 8' of the tank circumference.

These tight cracks are sound and without voiding while no exposure of the underlying pre-stressing wires was seen. No voids spall or other indications of structural fatigue were witnessed.

A coating applied to these wall surfaces remains having good adhesion value.

Overflow

A 12" inside diameter overflow pipe exits the tank wall 34" above the ground and extends 17" away from the tank. This pipe has a flap-cap over its end preventing access.

Roof

The entire rooftop of this reservoir was found very sound.

This entire poured-in-place dome was found free of obvious defects while all coating applied to these surfaces remains having good adhesion value.

Vent

This vent is located in the center of the domed rooftop having a 24" inside diameter and standing 20" tall.

A 42" outside diameter cap was found properly installed over this vent and all perimeter screening remains in place preventing access to the tank interior.

Hatch

One 40" by 40" inside diameter hatch provides good access to the reservoir interior through the roof dome. This aluminum hatch was found in good working condition and properly secured with a lock.

INTERIOR INSPECTION:

The entire interior of this reservoir (and components) was inspected to include sediment accumulations, floor, piping, walls, overhead, overflow, and aesthetic water quality.

Sediment Accumulations

A uniform layer of precipitate was found on all floor surfaces ranging from a film to 2" in depth.

Upon completing this inspection, all floor surfaces were vacuumed.

Floor

After removing all accumulated precipitate, these concrete floor surfaces were inspected.

All floor surfaces were found free of cracks, spall, or other failures at the time of this inspection.

Piping

The inlet/outlet pipe penetrates up from the floor of a 26" by 26" by 7" deep sump in the tank floor located 19" in from the reservoir wall. This 16" inside diameter pipe is bolted to the sump floor and stands 10" tall.

Flow was entering the tank through this pipe at the time of this inspection.

A 3/4" inside diameter copper pipe also penetrates up from the reservoir floor 6" in from the wall. This pipe stands 3" tall and was found without indications of flow.

Walls and Coating

All interior wall surfaces were inspected beginning at the floor and spiraling the circumference up to the water surface.

These interior wall surfaces were found with very sound conditions.

All concrete walls are free of cracks, spall, and other obvious failures, and with no signs of ice scour.

All wall slots are uniformly coated at this time.

The 12" tall by 10" wide curb stop, located at the junction where the walls and floor meet, was found sound and free of failures.

A mild stain extends the entire circumference of the reservoir extending from 6' below the overflow down to the tank floor.

Overhead

The entire overhead of this reservoir was inspected from the water surface.

These poured-in-place concrete surfaces were found without any obvious failures and in very good condition at the time of this inspection.

Overflow

A formed concrete overflow box measuring 36" by 36" extends from 6" below the roof dome down and transitions to a 24" by 28" concrete box terminating 6' above the floor.

An aluminum ladder having a fall prevention device extends the length of this overflow box providing good access to the reservoir floor.

Aesthetic Water Quality

The aesthetic water quality within this reservoir was found to be fair. This condition caused our visibility during this inspection to be somewhat limited due to suspended particulate at all reservoir elevations.

CONCLUSION:

It is the opinion of Underwater Solutions Inc. that this reservoir remains in good condition.

All exterior walls were found without obvious structural fatigue while numerous tight shrinkage cracks exist within the shotcrete cover coating within the lowest 8' of the ground. These tight shrinkage cracks were each found free of voids while no indications of exposure of the underlying pre-stressing wires were seen.

All roof dome surfaces are very sound at this time.

All components affixed to this structure to include the hatch, vent, and overflow were found properly installed.

All interior floor, walls, and overhead surfaces were found without obvious fatigue or failures and with very good conditions at the time of this inspection.

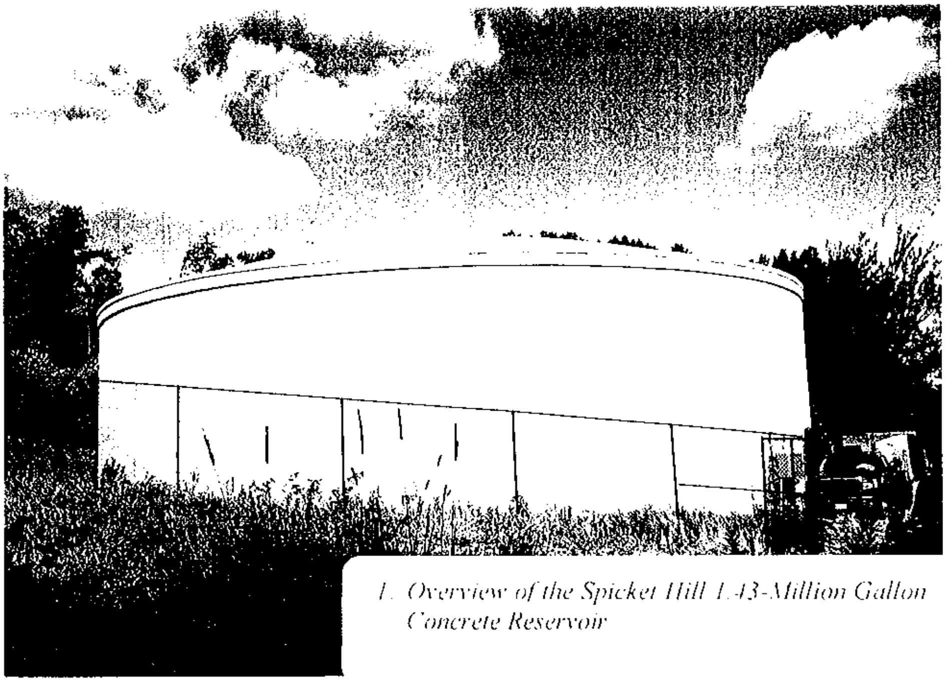
Upon completing this inspection, all floor surfaces were vacuumed.

As always, we recommend re-inspection and cleaning of all water storage facilities in accordance with A.W.W.A. Standards and local guidelines.

UNDERWATER SOLUTIONS INC.
Christopher A. Cole, Project Manager

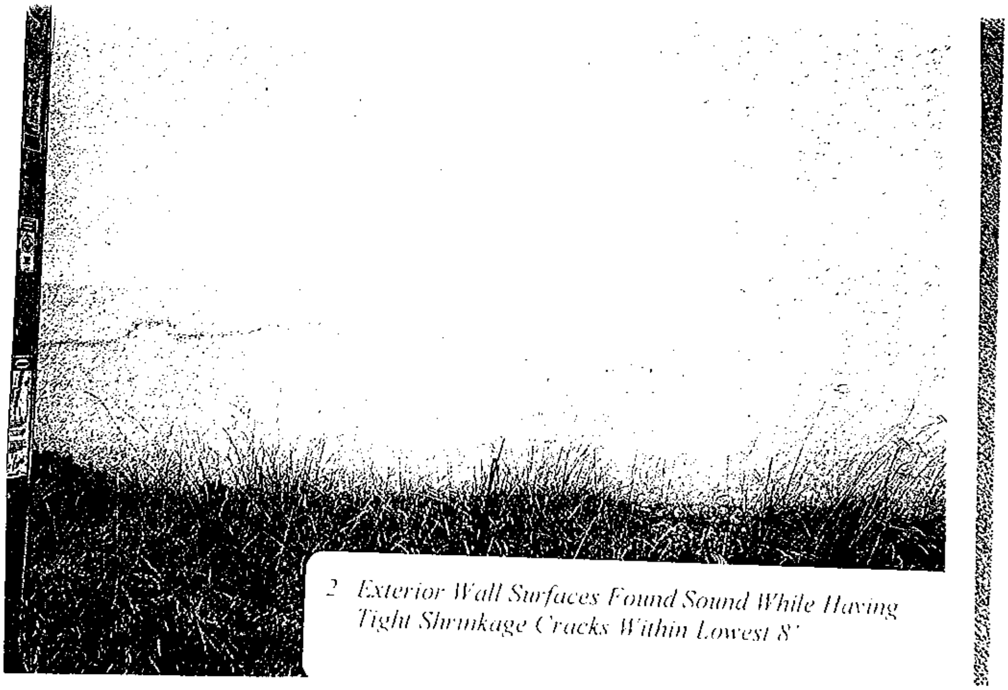
This report, the conclusions, recommendations and comments prepared by Underwater Solutions Inc. are based upon spot examination from readily accessible parts of the tank. Should latent defects or conditions which vary significantly from those described in the report be discovered at a later date, these should be brought to the attention of a qualified individual at that time. These comments and recommendations should be viewed as information to be used by the Owner in determining the proper course of action and not to replace a complete set of specifications. All repairs should be done in accordance with A.W.W.A Standards.

CAC/cmk

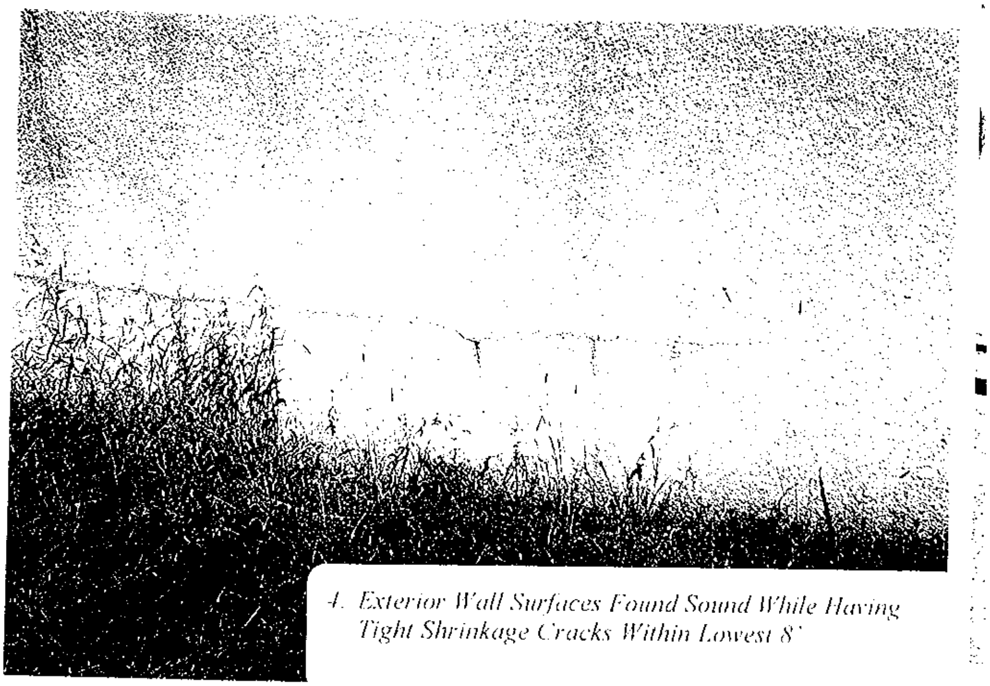


1. Overview of the Spicket Hill 1.43-Million Gallon Concrete Reservoir

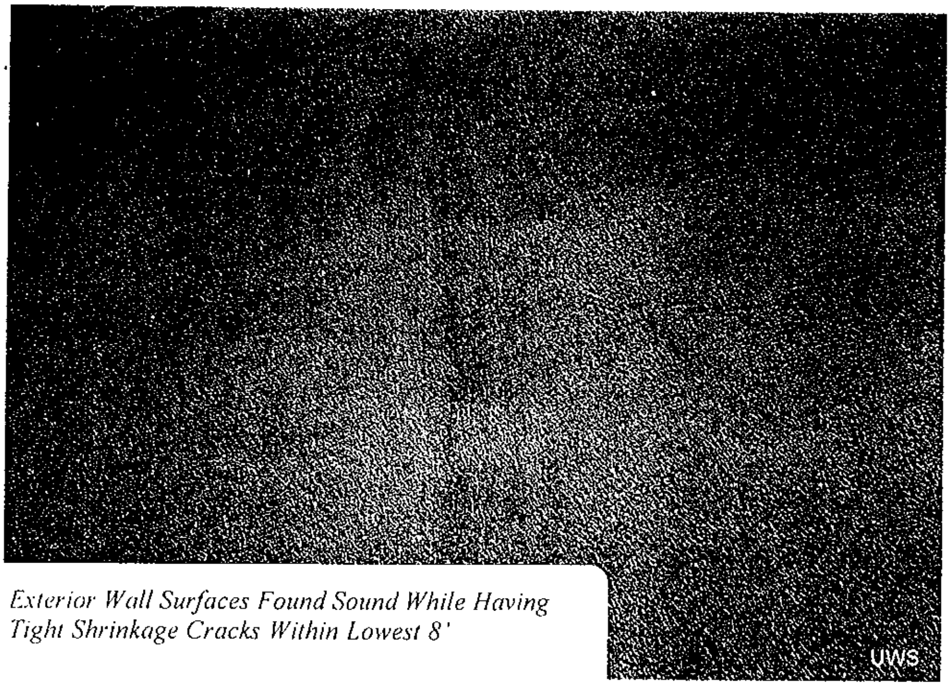
3. Exterior Wall Surfaces Found Sound While Having Tight Shrinkage Cracks Within Lowest 8'



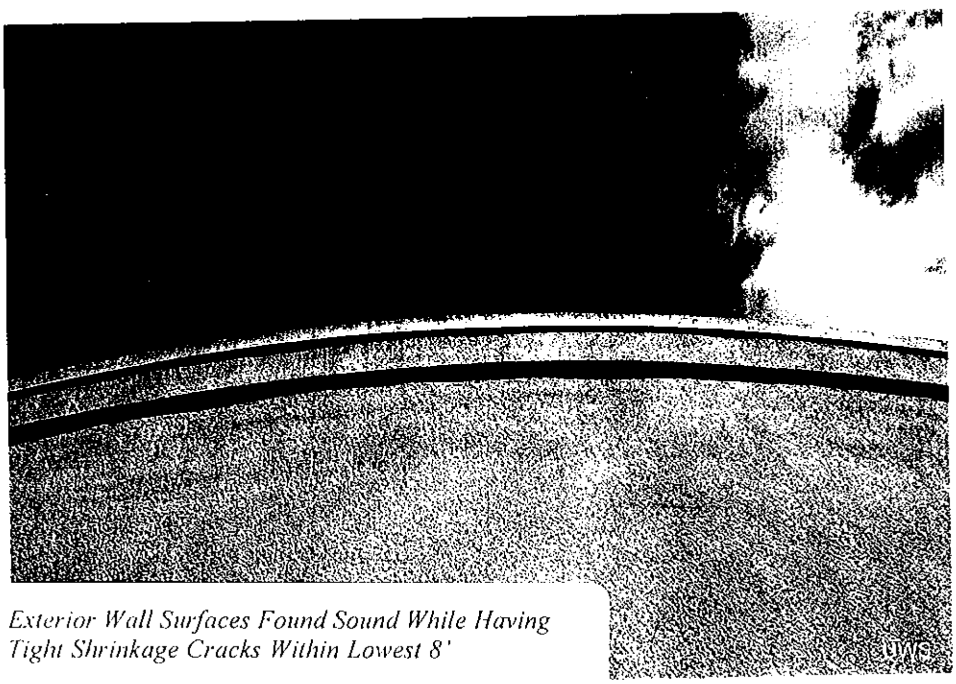
2. *Exterior Wall Surfaces Found Sound While Having Tight Shrinkage Cracks Within Lowest 8'*



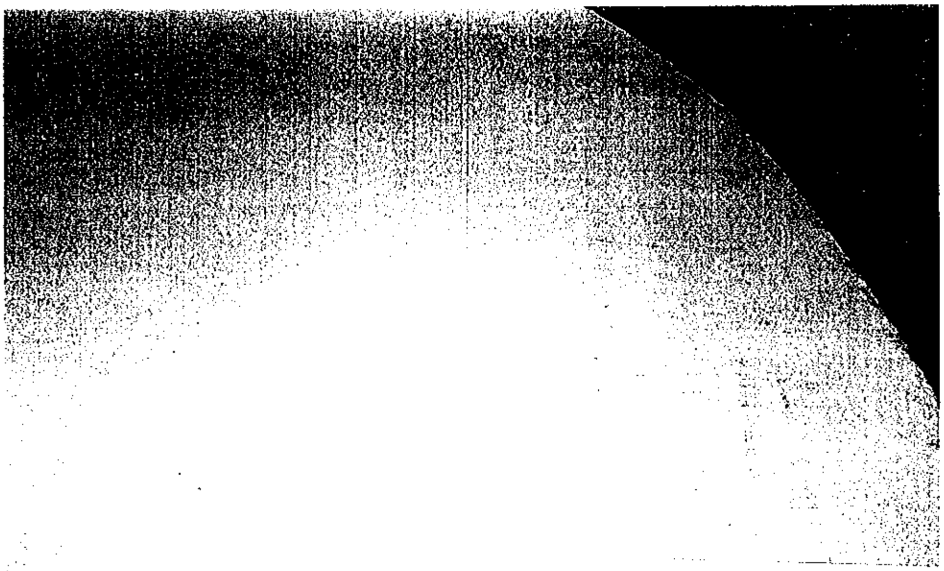
4. *Exterior Wall Surfaces Found Sound While Having Tight Shrinkage Cracks Within Lowest 8'*



8. *Exterior Wall Surfaces Found Sound While Having Tight Shrinkage Cracks Within Lowest 8'*

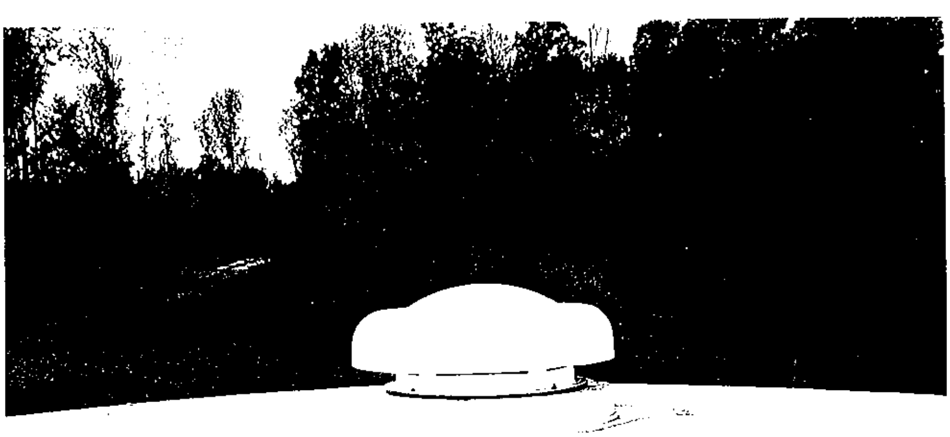


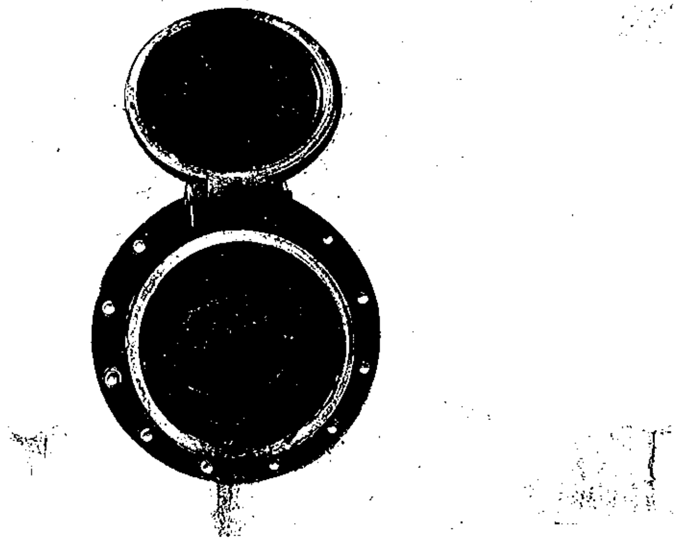
10. *Exterior Wall Surfaces Found Sound While Having Tight Shrinkage Cracks Within Lowest 8'*



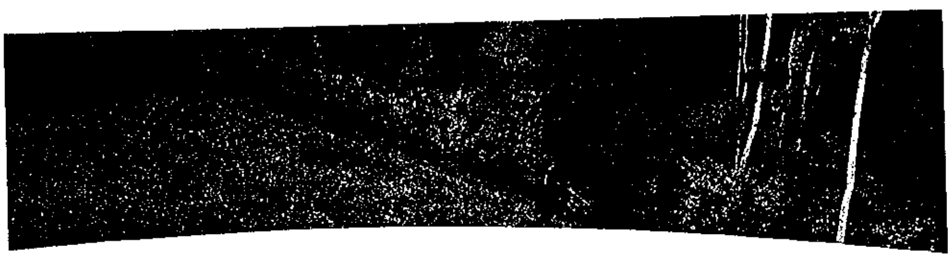
14. Sound Roof Surfaces

16. Sound Roof Surfaces

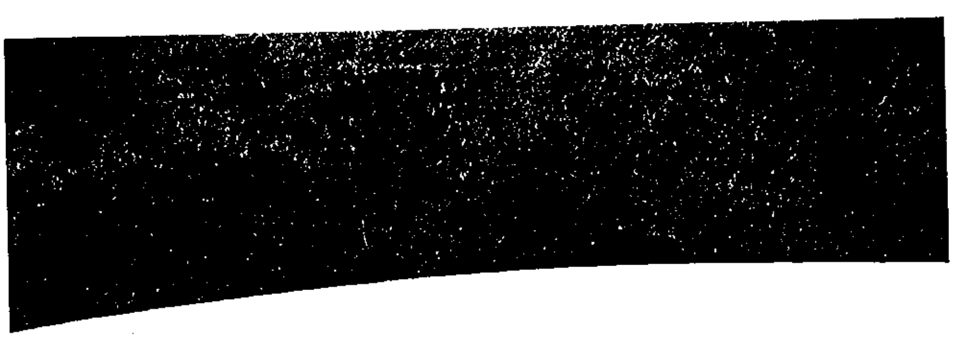


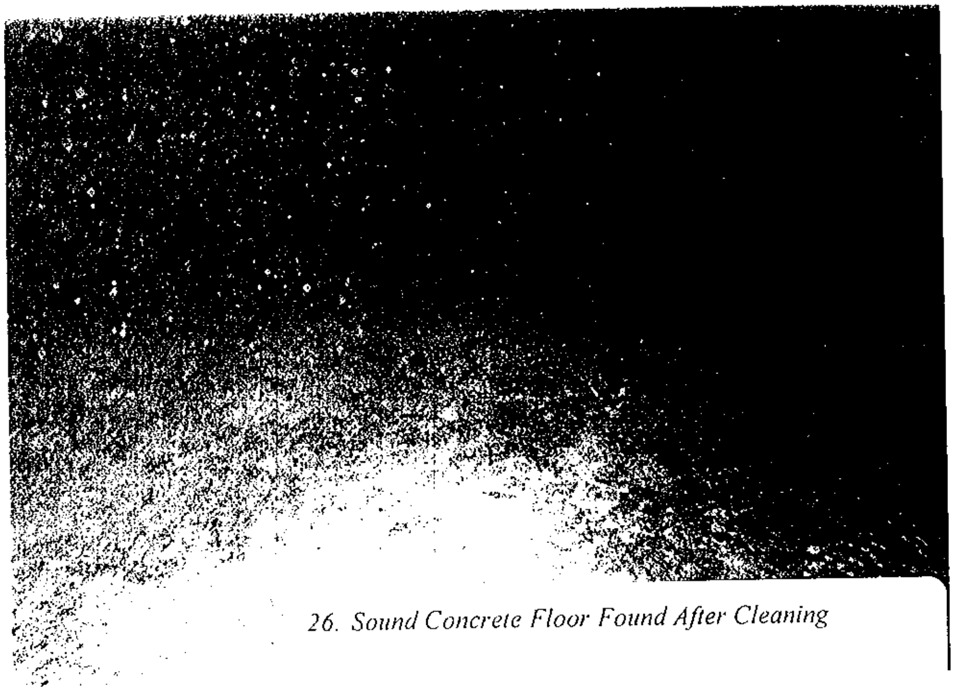


13. Overflow

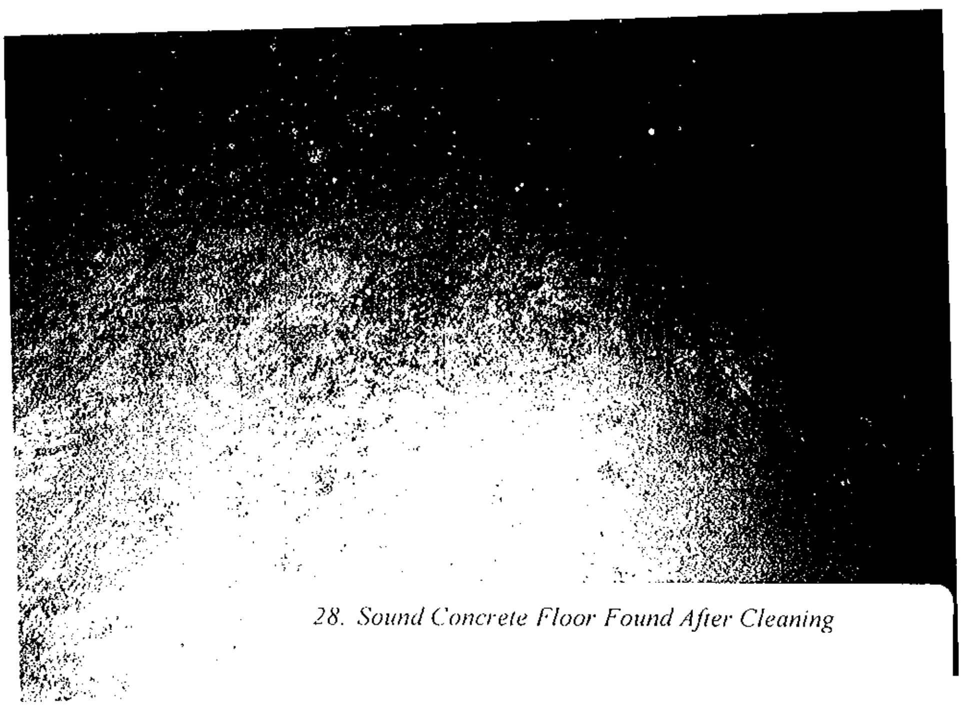


15. Sound Roof Surfaces

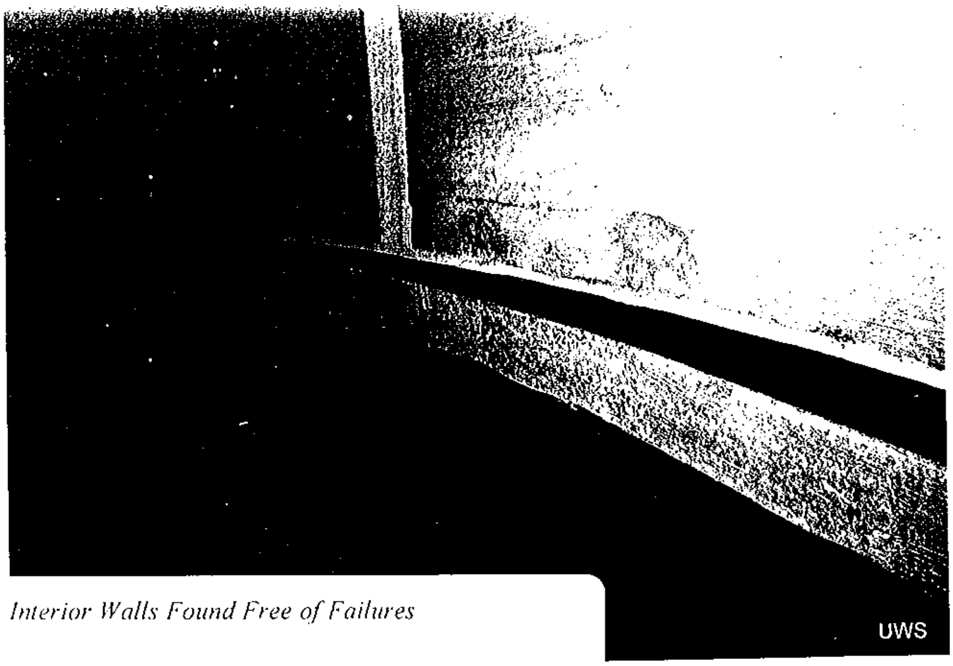




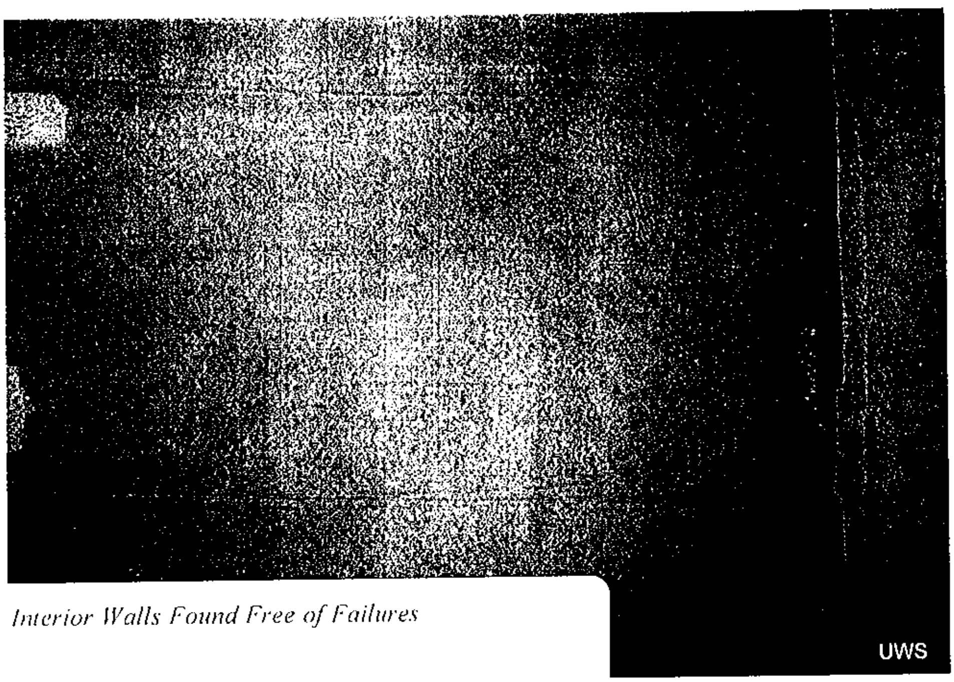
26. Sound Concrete Floor Found After Cleaning



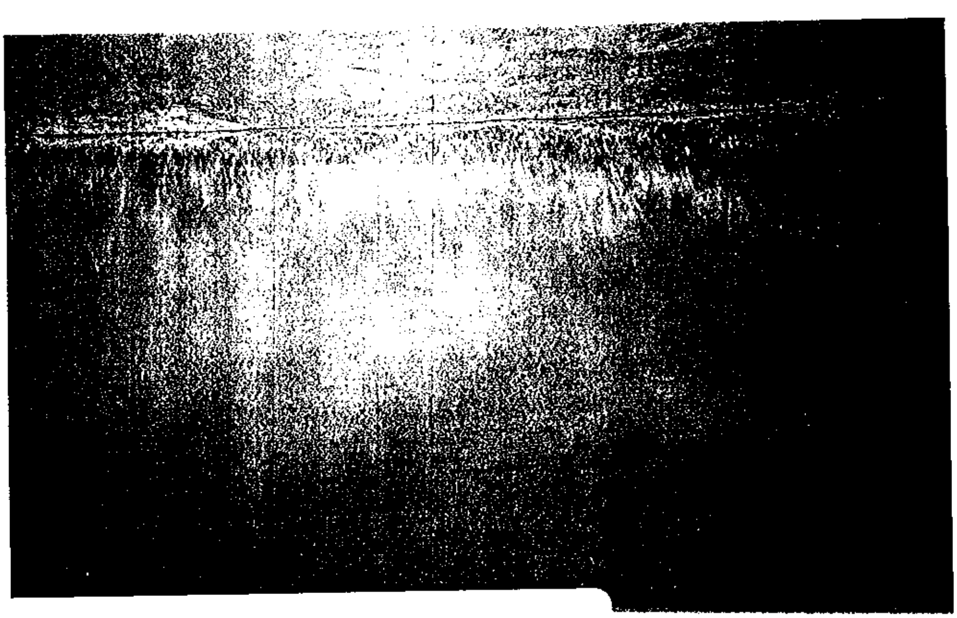
28. Sound Concrete Floor Found After Cleaning

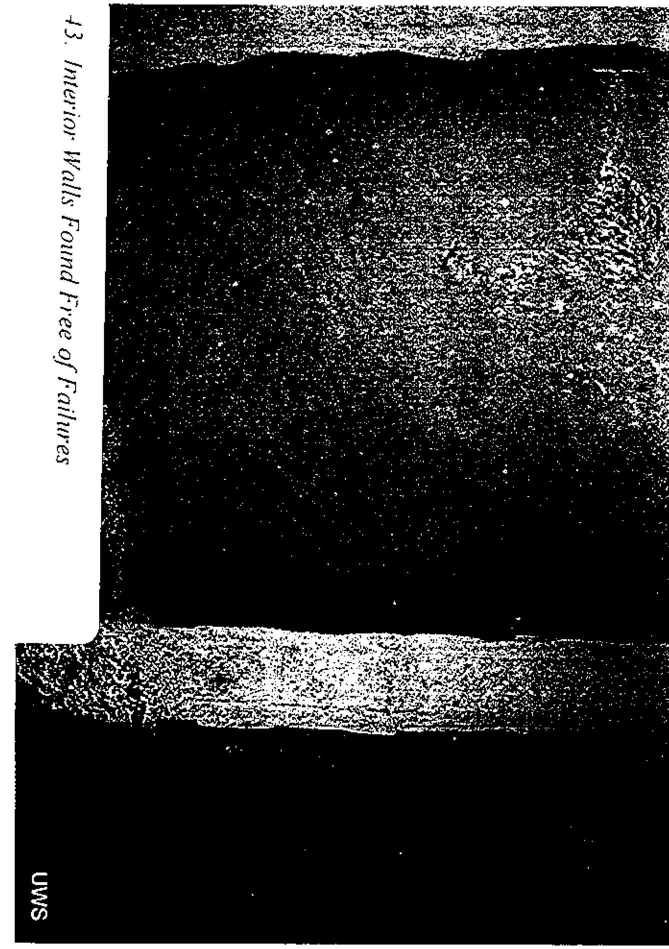


32. *Interior Walls Found Free of Failures*

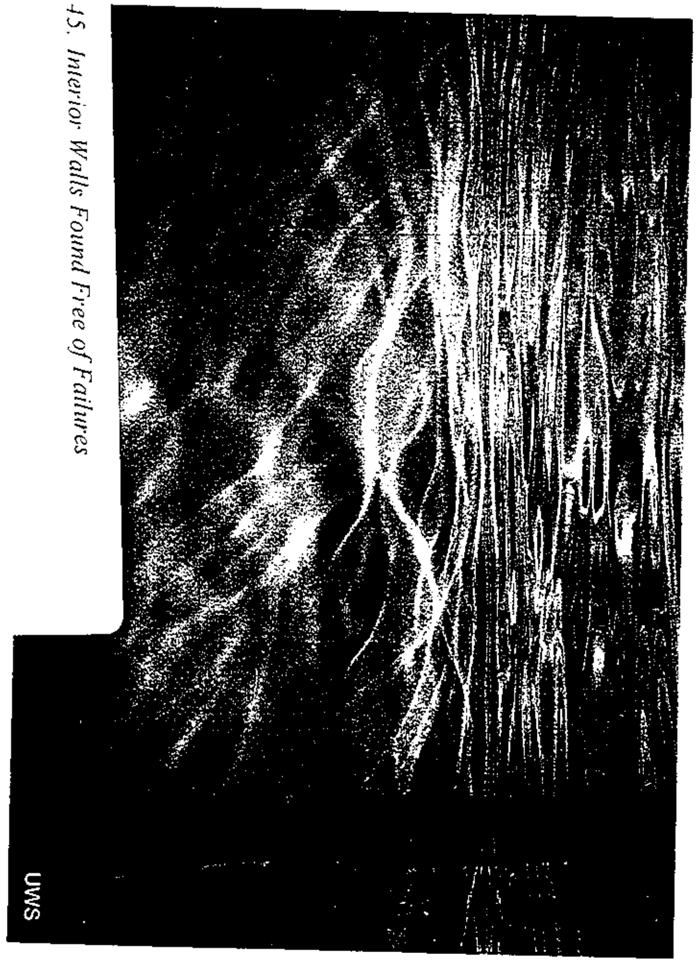


34. *Interior Walls Found Free of Failures*

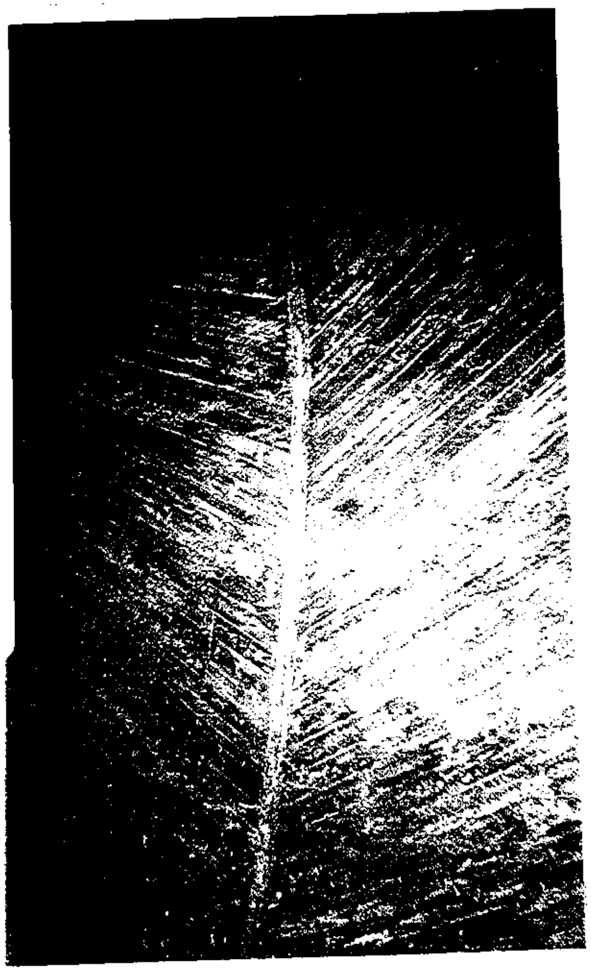


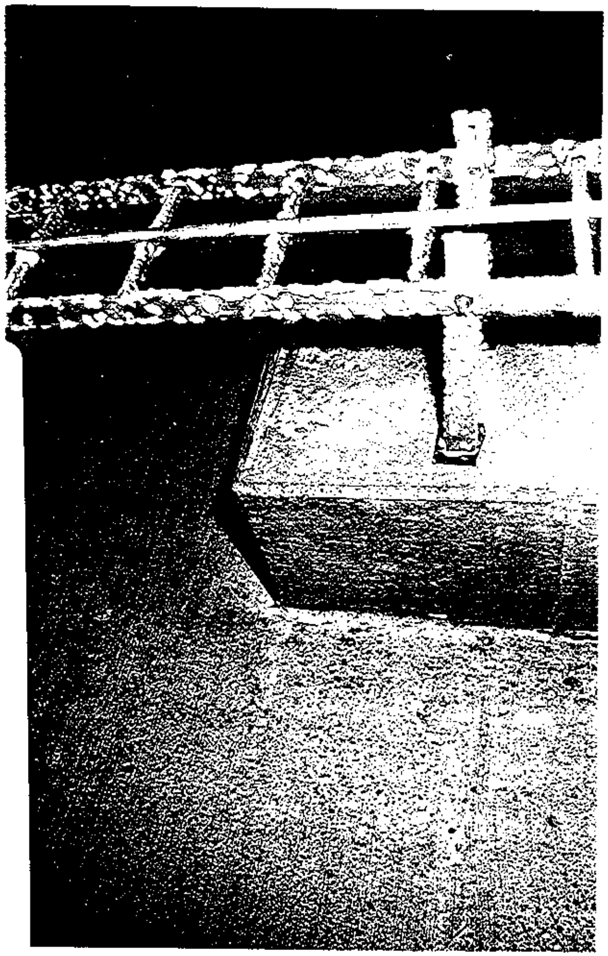


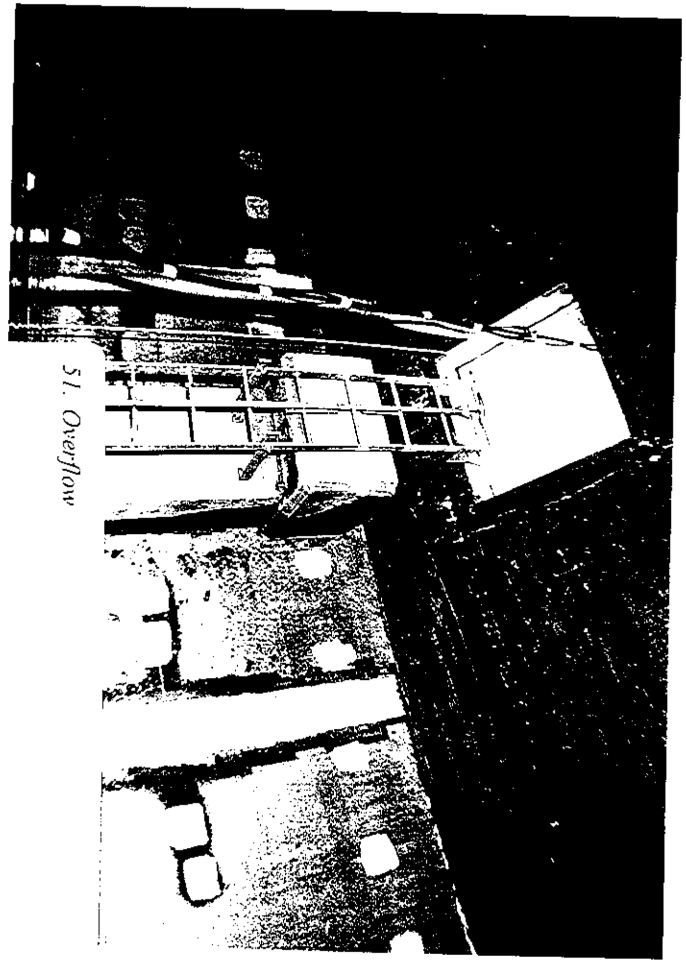
43. Interior Walls Found Free of Failures



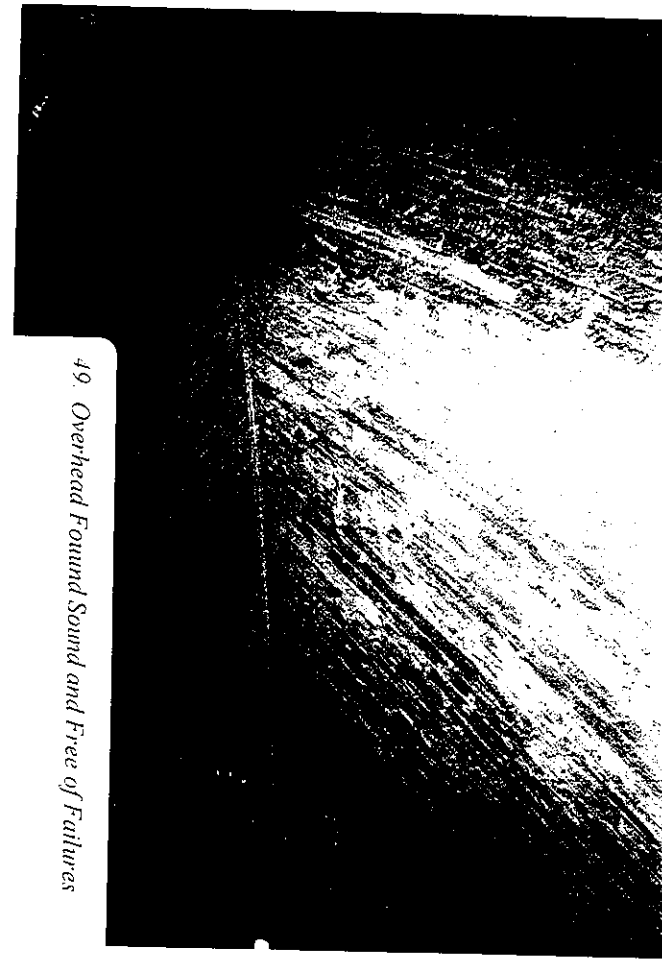
45. Interior Walls Found Free of Failures







51. Overflow



49. Overhead Found Sound and Free of Failures

Appendix D
Agreement between Methuen and Salem, 1985

CB #4

AGREEMENT
FOR
SALEM/METHUEN WATER SYSTEMS INTERCONNECTIONS
FOR EMERGENCY SALE OF WATER

WHEREAS, the Town of Salem, New Hampshire (hereinafter "Salem") has experienced potable water supply shortages and emergency conditions have existed, and, an acute danger of supply shortfall has been experienced; and

WHEREAS, Salem seeks to establish safeguards against future water supply emergencies; and

WHEREAS, the existing water distribution system of the Town of Methuen, Massachusetts (hereinafter "Methuen") is in close proximity to the Salem distribution system; and

WHEREAS, the Town of Methuen has completed an engineering analysis of the impacts to Methuen's water system of the delivery of water to Salem, and that delivery of water at various locations would have acceptable impacts on the Methuen water system; and

WHEREAS, interconnections of the Salem and Methuen water systems would serve to relieve potential emergency water supply conditions in Salem; and

WHEREAS, said interconnections could provide emergency water supply from Salem to Methuen for fire-fighting purposes;

NOW THEREFORE, the Town of Salem, New Hampshire and the Town of Methuen, Massachusetts mutually agree as follows:

1. Construction of Temporary Pipes and Other Works

The Town of Salem, New Hampshire agrees to construct, at its own expense, temporary pipes and other facilities required to establish water system interconnections in accordance with the Town of Methuen and Commonwealth of Massachusetts specifications for the purpose of delivering water from Methuen to Salem.

2. Use of Temporary Lines

Salem may draw water from Methuen, if and when, one of the following conditions is met:

(a) When and if the quality of water from any of the Town of Salem's supply sources is not acceptable for consumption; or

(b) When and if the total quantity of water available from the Town of Salem supply sources is not adequate to meet the Town's needs; or

(c) To meet fire or other public safety needs.

3. Use Restrictions

(a) Any such use of the emergency water connection by Salem shall be limited to a total period of not more than six months in any year.

(b) The interconnected facilities may be operated for a period of two to six hours at regular monthly intervals to insure satisfactory operating conditions of the facility, and will be operated for a one week trial period immediately after completion of construction.

4. Methuen's Agreement

The Town of Methuen, Massachusetts agrees to sell potable water through connections to Salem's system in response to emergency conditions in Salem, as stated above. Metered consumption will be the basis of this sale. Salem will be assessed a minimum charge per month which will apply to any period.

5. Operation and Maintenance

Operation and maintenance of the intereonnections will be the joint responsibility of both the Town of Salem and the Town of Methuen in accordance with the following conditions:

(a) Salem shall maintain, and bear the cost of maintaining, all facilities located within its Town borders, including booster pumping stations, metering equipment, chlorination equipment, water mains, and electrical services.

(b) Methuen shall maintain, and bear the cost of maintaining, water mains, water meters, service connections, and hydrants constructed within its Town borders, such that delivery through the water systems interconnections remain possible.

(c) Methuen shall be responsible for the monthly reading of the meters and the preparation of the monthly invoices to the Town of Salem.

(d) The water lines, as established in Methuen, may be used by Methuen and its residents for water line connections and shall, for that purpose, be common lines.

6. Charge for Sale of Water

The sale price initially established for water shall be based on the cost to produce and deliver one million gallons of water to the points of entry to the Town of Salem, plus the administrative costs involved, as set by the Town of Methuen. Changes in the sale price of water shall be made only upon mutual agreement of the parties.

7. Methuen First Policy

This agreement is entered into with the explicit understanding that the production and distribution of water priority shall be to the citizens and residents of the Town of Methuen. To that extent, the Methuen First Policy shall exist such that, if levels of water must be reduced in order to supply Methuen first, then a commensurate reduction, as necessitat shall be made to the supply which would be delivered to the Town of Salem and its inhabitants.

In any instance, the water supply shall not, in any one month, exceed an average of 500,000 gallons per day.

8. Conditions Precedent to Sale

This contract and the right of sale of water shall be subject to the prior approval, if applicable, of the following business or governmentc units: Lawrence Hydroelectric Associates; Essex Company; the Commonwealth of Massachusetts, by and through its Water Resources Authority, and/or Department of Environmental Quality Engineering, or other applicable agenc and, applicable agencies of the United States Government.

9. Bond

The Town of Methuen may, at any time when it feels public necessity so requires, issue, as a pre-condition to the sale of any further water, an order to the Town of Salem to post a bond adequate to secure the full performance and payment of all obligations of the Town of Salem, including the costs and charges associated with the sale of said water. Such bond shall be posted within a period of fourteen days from the order of the Town of Methuen.

10. Indemnification

The Town of Salem shall save the Town of Methuen harmless from any loss, cost, or damage that may arise out of or in connection with the sale of water, construction, refurbishment, maintenance, and/or disconnection of facilities or lines, by the act or omission, in whole or in part, of any employee, agent, servant, contractor, or like individual of the Town of Salem.

11. Reconstruction and Maintenance of Facilities

The Town of Methuen reserves the right to order Salem to reconstruct or refurbish the lines which will be constructed under this agreement, and further, to disconnect its facilities and lines if, in the opinion of the Town of Methuen, the same is necessary to protect the citizens of said Methuen.

12. Terms of Contract

This contract shall be in effect for a period of one year from the date hereof, and, may be extended at one year terms by mutual agreement of the parties.

13. This agreement, and all acts performed or required to be performed hereunder, shall be interpreted under the laws of the Commonwealth of Massachusetts and jurisdiction shall vest in the Massachusetts courts.

WITNESS our hands and seals this day of 1985.

TOWN OF METHUEN

By ______________________

Richard M. Gladstone
Town Manager

TOWN OF SALEM

By ______________________

Michael J. Valuk
Town Manager

Approved as to Form:

____

Solicitor for Town of Methuen

Approved as to Form:

____

Town Counsel for Town of Salem

Appendix E
Memorandum of Understanding between Methuen and Salem, 2005

MEMORANDUM OF UNDERSTANDING
BETWEEN
THE CITY OF METHUEN, MASSACHUSETTS
AND
THE TOWN OF SALEM, NEW HAMPSHIRE

WHEREAS the City of Methuen, Massachusetts (hereinafter "Methuen"), pursuant to Chapter 106 of the Acts and Resolves of 1985 is authorized to sell water to the Town of Salem, New Hampshire (hereinafter "Salem"), and

WHEREAS the Town of Salem and the City of Methuen are parties to an agreement dated May 13, 1985 for the emergency sale of water by Methuen to Salem, and

WHEREAS Methuen has planned for the improvement of its water system by constructing a water tower on land near Methuen's border with Salem, and

WHEREAS access to the site of Methuen's new water tower through Salem and over land owned by the Town of Salem is convenient and would be less expensive for Methuen to construct, and

WHEREAs the parties have agreed to the terms of an easement from Salem to Methuen to facilitate Methuen's water tower construction and agreed to improve the connection of Methuen's and Salem's water systems by the installation of a 12 inch main in Hitchingpost Lane in Salem, and

WHEREAS Salem seeks the amendment or revision of the parties 1985 agreement to secure an increase in the quantity of water available to Salem from Methuen in the case of an emergency water supply condition in Salem (when that additional capacity is available from Methuen);

NOW THEREFORE, the Town of Salem and the City of Methuen agree as follows:

1. The parties will cooperate to negotiate and adopt amendments/revisions to their 1985 agreement for the "emergency sale of water" to:

   a. Increase the quantity of water available from Methuen to Salem on an emergency basis to 2.2 million gallons per day (as soon as that quantity is available),

   b. Clarify that the cost to Salem of water supplied under the agreement will be equal to Methuen's then present water charges to its city customers, and

   c. Make such other revisions to the agreement as the parties in good faith determine are necessary.

IN WITNESS WHEREOF, the parties have executed this Memorandum of Understanding on this 13th day of Sept., 2005.

City of Methuen

By ______________________
Sharon M. Pollard, Mayor

Town of Salem

By ______________________
Henry LaBranche, Town Manager

Appendix F
Questionnaire Results

Salem NH Water Master Plan
Confidential Employee Questionnaire
PLEASE RETURN TO CDM IN PRE-ADDRESSED STAMPED ENVELOPE

MULTIPLE CHOICE SECTION

Rank each of the following aspects of the Utilities Division based on your opinion of how well the Division meets these criteria: (1/2 point increments can be utilized)

5 Points	Superior Ranking	Surpasses all expectations
4 Points	Above Average Ranking	Exceeds industry standards
3 Points	Average Ranking	Meets minimum industry standards
2 Points	Below Average Ranking	Below acceptable industry standards
1 Point	Unacceptable Ranking	Failure situation

1. Overall employee productivity and effectiveness. 3.07__
2. Employee satisfaction with working conditions. 2.88__
3. Your individual contribution to overall department productivity. 3.58__
4. Division management effectiveness for "doing things right". 2.50__
5. Division leadership effectiveness for "doing the right things". 2.75__
6. Management/employee cooperation in meeting common mission objectives. 2.38__
7. Division management effectiveness for employee coordination in day-to-day activities. 2.50__
8. Your opportunity for professional development. 1.85__
9. Safety program effectiveness. 2.77__
10. Purchasing and procurement of needed supplies and services 2.96__
11. Environment to openly discuss personal suggestions and recommendations. 2.54__
12. Training needs assessment and training opportunities. 1.77__
13. Staff communication and team building. 2.00__
14. Your level of pride in your work and career gratification. 3.12__
15. The feeling of personal responsibility and commitment to Division objectives. 3.35__
16. Compensation rates and benefits package. 3.23__
17. Rewards and recognition program. 1.85__
18. Plant cohesiveness during emergency or conflict situations. 3.46__
19. Trust and confidence between employees. 2.65__
20. Your employment experience with the Town 2.80__