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Town of Exeter, New Hampshire

Water Supply Alternatives Study – Final Report

January 2010

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Town of Exeter, New Hampshire Water Supply Alternatives Study – Final Report January 2010

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This study was a team effort and we would like to acknowledge and thank all of those that helped with data collection, analysis and input regarding this report:

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EXECUTIVE SUMMARY

The Town of Exeter is now facing many tough water resource decisions, a number of which are focused on an early 20th century dam, known locally as the Great Dam. To assist in this decision making process, the National Oceanic and Atmospheric Administration (NOAA) Restoration Center, through the New Hampshire Department of Environmental Services (NHDES) Coastal Program funded a study to assess the impact to the Town's primary source of water supply; the Exeter River Pump Station which withdraws water from the impoundment created by the Great Dam.

In an effort to evaluate the necessity of the dam in its function to provide this source of drinking water, Weston & Sampson assessed the consequences to the impoundment if the dam were to be removed and provided options with respect to the mitigation of the water supply lost as a result of this potential removal.

This study included the following major components:

1. Investigate surface water intake alternatives at the Exeter River Pump Station.
2. Investigate impact on other effected major withdrawals from Exeter River (Exeter Mills Condominium Complex and Phillips Exeter Academy)
3. Assess the viability of increasing the withdrawal potential of Skinner Springs (an existing groundwater source)
4. Evaluate water system demand trends and efficiency potential.
5. Develop integrated water system supply management operational plan.
6. Develop cost estimates to mitigate lost drinking water supply.
7. Report and Present Findings in Public Forum/ Media/ Press Releases

As part of the study, an in-depth review of the Exeter River, including its watershed, impoundments and history, illustrates the potential changes to the river from an engineering (e.g., supply source/dam removal) and environmental (e.g., fisheries, fluvial geomorphology) perspective which would result if the Great Dam were to be removed. Safe yield assessments for the existing Skinner Springs, Lary Lane Well and Exeter Reservoir sources and proposed reactivated sources (Gilman and Stadium Wells) provide the framework for a revised management plan that integrates each source into a year-round supply system, thereby reducing reliance on individual sources and ultimately mitigating potential lost withdrawal from the river as a result of dam removal. The results of the study provide scientific validation that:

- Some loss of drinking water supply from the Exeter River is imminent (seasonal) due to the dam removal and/or water quality and quantity regulations.
- Lost supply can be mitigated with demand management efforts in conjunction with reactivation and development of additional groundwater supplies.
- An integrated water system supply management operational plan can supply the Town with current and future water demands.

The following recommendations are a result of this study and are intended to provide the Town of Exeter with a more robust source of drinking water supply for the foreseeable future.

- Finalize the reactivation process and groundwater treatment design for the new groundwater sources (Gilman and Stadium wells).
- Continue investigation of other potential groundwater sites as identified in the Groundwater Matrix Study.
- Utilize the Integrated Management Plan to optimize river withdrawals to the Exeter Reservoir in order to keep the Reservoir full as dry periods approach.
- Improve the Exeter Reservoir's water quality by the installation of a more comprehensive aeration system.
- Develop a scope of work to clean and redevelop the six wells at Skinner Springs in order to optimize their water withdrawals.
- Upgrade the existing Exeter River pumping station to accommodate a deeper intake at the existing station if the Great Dam is lowered and/or removed.
- Finalize the water conservation/demand management plan.
- Develop a conceptual plan to address the water withdrawals that may be impacted by the Great Dam removal; 1) the Phillips Exeter Academy, 2) the Exeter Mills Apartments, and 3) the fire hydrant in Founders Park.
- Work with the environmental regulators, legislatures and other interested parties to leverage resources such that the Town's capital infrastructure costs can be offset if dam removal becomes a reality.

Potential capital upgrades for the water system follow a phased approach, to allow for study and analysis of the success of each step prior to proceeding with additional work in the next phases. The recommended phasing is as follows:

- Step 1 would diversify the Town's water sources and provide the opportunity to start implementing an integrated management plan as discussed in Chapter 7.
- Step 2 addresses the Town's long-term supply needs via additional groundwater sources.
- Step 3 focuses on modernizing the Town's water treatment facilities in support of their long-term supply needs.

The following table summarizes the cost estimate for these capital improvements:

Capital Upgrades For Water System	Cost Estimate (2009 dollars)	
Reservoir Aeration Upgrade	$0.015 to $0.025 mil.	Step 1
Gilman, Stadium, Lary Lane Equipment and Piping Connection	$1.67 to $2.0 mil.	
Groundwater Treatment (1.5 MGD Facility)	$4.0 to $5.0 mil.	
Additional 0.5 MGD Groundwater Source in Southeast area of Town	$1.9 to $2.8 mil.	Step 2
Additional Hydrogeologic Study for Groundwater Supplies	$0.1 to $0.2 mil.	
Skinner Springs Well Cleaning, Redevelopment and Water Level Monitoring	$0.05 to $0.075 mil.	
River Intake and Station Upgrades	$0.75 to $1.0 mil.	Step 3
Upgrades to Existing Surface Water Treatment or New Facility altogether	$10.6 mil. *	

In addition, capital cost estimates were developed regarding anticipated upgrades to replace water utilized by others. The following table summarizes those estimates.

Capital Upgrades For Other Water Users	Cost Estimate (2009 dollars)	
Replace Founders Park Dry Hydrant by installing secondary fire system upstream	$0.125 to $0.250 mil.	* Only if Great Dam is Removed
Lower Phillips Exeter Academy Intake and pump station	$0.10 to $0.25 mil.	
Exeter Mills - Retrofit irrigation, fire suppression and cooling system *Fire system could be integrated with Founders Park System	$0.25 to $0.50 mil.	

Table 7-2 of this report summarizes the hypothetical scenario for the overall integrated management of the Town of Exeter's water supply sources with the integration of more groundwater and management of surface water sources to optimize their withdrawals:

Table 7-1: Hypothetical Integrated Management of Water Supply Sources

Hydrologic Trend	River	Reser-voir	Wells	Demand Mgmt	Notes
Very High					Surface water quality may be compromised or flooding may be occurring
High					Utilize surface water, rest wells to allow for optimum recharge
Above Normal					Utilize surface water, rest wells to allow for optimum recharge
Normal					Utilize all sources
Below Normal					Pump from river to reservoir to keep reservoir full, voluntary restrictions
Low					Switch back to reservoir, start implementing restrictions
Extremely Low Flow					Utilize wells and implement mandatory water restrictions
Emergency					Emergency conditions (utilize all available sources and notify public)

In summary, a more diverse water supply would provide the Town of Exeter with more options for source water than they currently have available. With the integration of more groundwater the Town would also have a source of supply that has more consistent water quality and is easier and less expensive to treat than surface water sources.

TABLE OF CONTENTS

LIST OF FIGURES

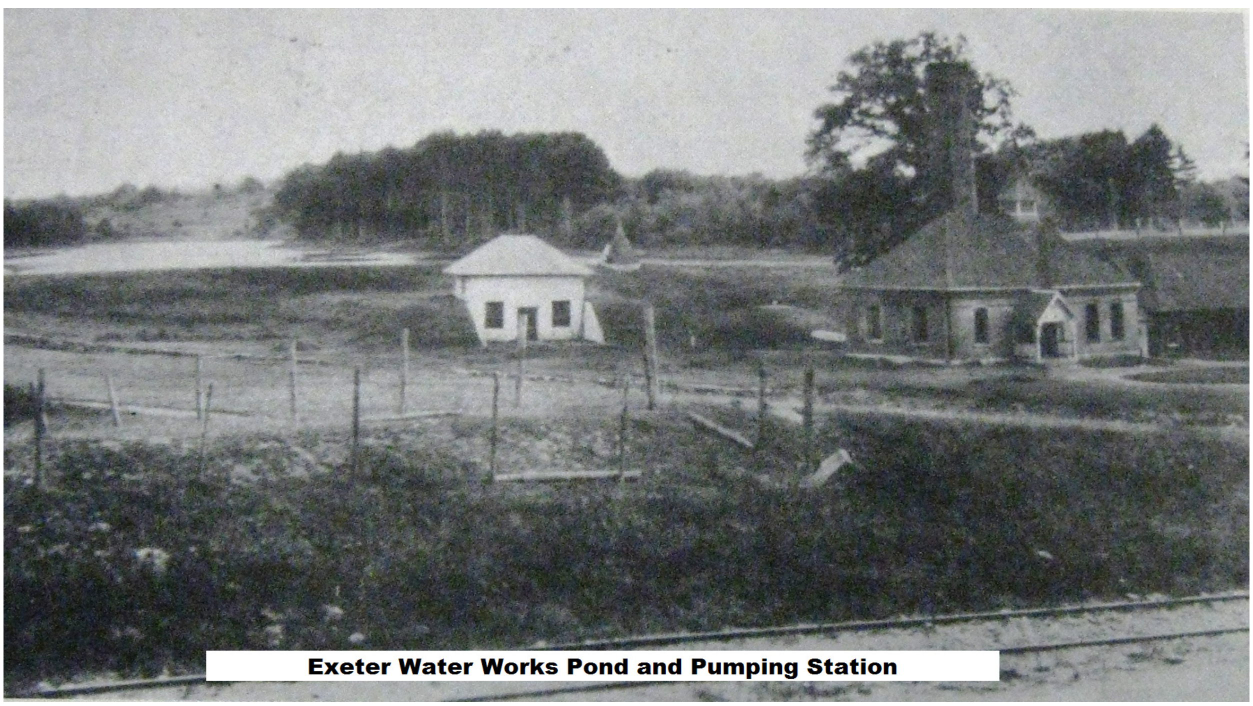
LIST OF TABLES

LIST OF APPENDICES

1.0 WATER SYSTEM HISTORY

The Town of Exeter, New Hampshire was one of the earliest public water systems formed in the State of New Hampshire. According to Pierce Atwood; “In Ch. 179 of the Laws of 1885, the Exeter Water Works was chartered to bring water into the Village of Exeter. The corporation thus created was given expansive authority to “appropriate” and “streams” for the purpose of obtaining and providing water for the Exeter Water Works. Eight years later, in Chapter 220 of the Laws of 1893, the Legislature authorized the Town of Exeter to own and operate a water system, assuming the franchise and property of the former Exeter Water Works Corporation.” The report goes on to add that, “the Town was also authorized to appropriate any streams in the Town of Exeter and Stratham to carry out the purpose of the law.”

According to a history of the Town of Exeter (“Exeter, New Hampshire 1888-1988”) the Waterworks Pond was constructed in 1885 and water began flowing from the pumping station in 1886. The following photograph is shows the pumping station facilities and reservoir.



Exeter Water Works Pond and Pumping Station

The History of Exeter provides other insight regarding the development and operation of Exeter’s public water system. For the purpose of background, excerpts from those sections are provided here:

> **1885:** Developing the little stream off Portsmouth Avenue that eventually runs into Wheelright’s Creek for the town’s water system was a large undertaking. This venture involved a tremendous amount of hand-digging and hours-hauling. It was reckoned that when the area was flooded, it encompassed almost twenty-three

acres, with a depth ranging from nine to twenty feet, and held twenty to thirty million gallons of water.

1928: Gen. Elbert Wheeler sold the Exeter Water Works in 1928 to the New England Water, Light, and Power Association with its executive offices in Providence, Rhode Island.

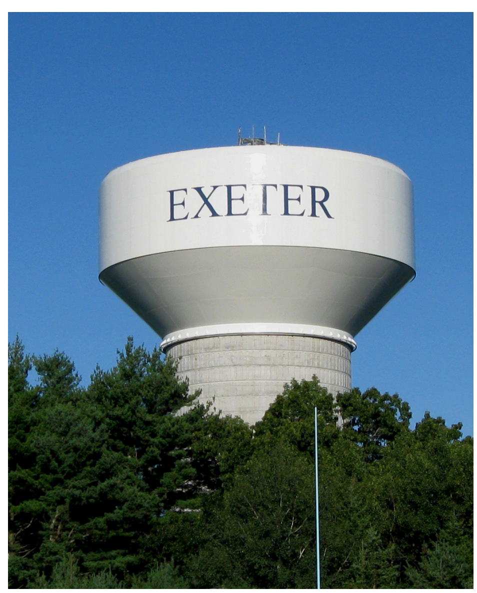
June 30, 1950: The town made the long-debated purchase of the Exeter Water Works by approving a $400,000 bond issue ($200,000 for the utility and $200,000 for needed improvements.)

1951: A million-gallon standpipe was erected on Epping Road (the standpipe was replaced in 2008 by a new storage tank). By mid-October 1951, a new gravel-packed well was in operation on Daniel Gilman's land near Gilman Park. During 1950 and 1951 new water mains were laid in a number of streets. The water mains were also cleaned, greatly facilitating the flow of water.

1958: The new well on Lary Lane (named for Selectman John E. Lary) was in operation by October 1958 and the new standpipe was filled the next month.

The Town's Annual Report for 1950 noted that, "With the purchase of the Exeter Water Works by the Town of Exeter on June 30, 1950, every effort has been made to carry out the important program of improvements as rapidly as possible." The report also noted that these upgrades included the installation of many new water mains in town, the construction of the Epping Road standpipe and the drilling of a number of test wells that eventually lead to the installation of the Gilman Park Well.

The Kingston Road Standpipe



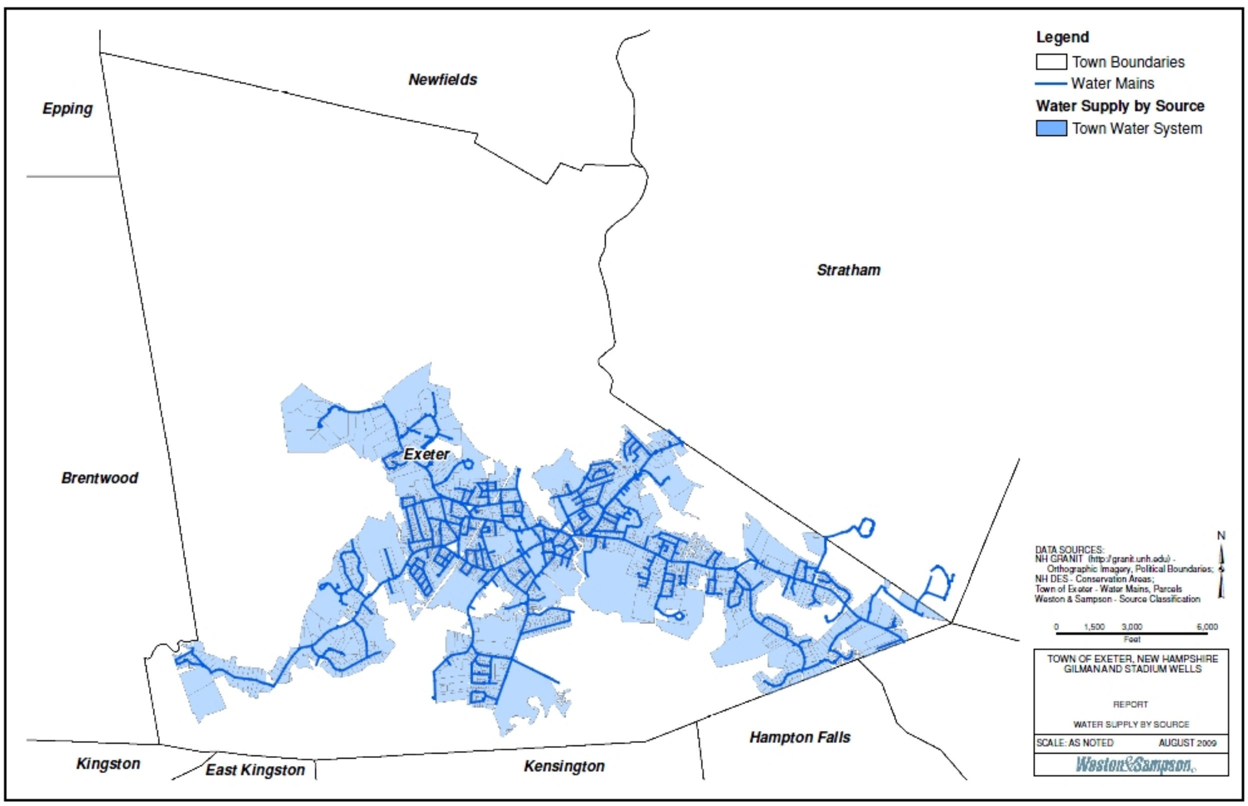
New Epping Road Water Tank
Installed in 2008

Since the 1950's the Town has continued to perform water system improvements. In the early 1960's the Stadium Well went into operation. In 1974, after securing water rights from the Exeter Mills, a river pumping station was installed near the Philips Exeter Academy. This station utilized a transmission main to deliver water to the Portsmouth Avenue water treatment facility. This facility was upgraded at that time and became the major source of supply. This will be discussed further in the next section of this report.

Currently, the Town's water system serves approximately 3,300 customers. These customers are primarily residential with a few larger commercial customers. There are no water intensive industries currently connected to the water system. Water use demographics and a detailed description of the current and historical water demands will be discussed later in this report.

The Town's municipal water system does not serve the entire municipal boundaries of town, rather, it serves the town center and concentrated population areas. The other regions of the town are either served by their own community water system or by individual wells. This will be discussed in further detail in the water use and demand projection section of this report. The following map shows the current service territory of the Town's municipal water system.

Figure 1-1: Town of Exeter Municipal Water System Service



The age of the water system's pipes and other infrastructure varies, but a good portion of the system is nearly 100 years old. With that in mind, the Town continues embark on annual capital improvements which include water main upgrades and replacement of aging infrastructure.

Exeter's Public Works and Surface Water Treatment Facilities

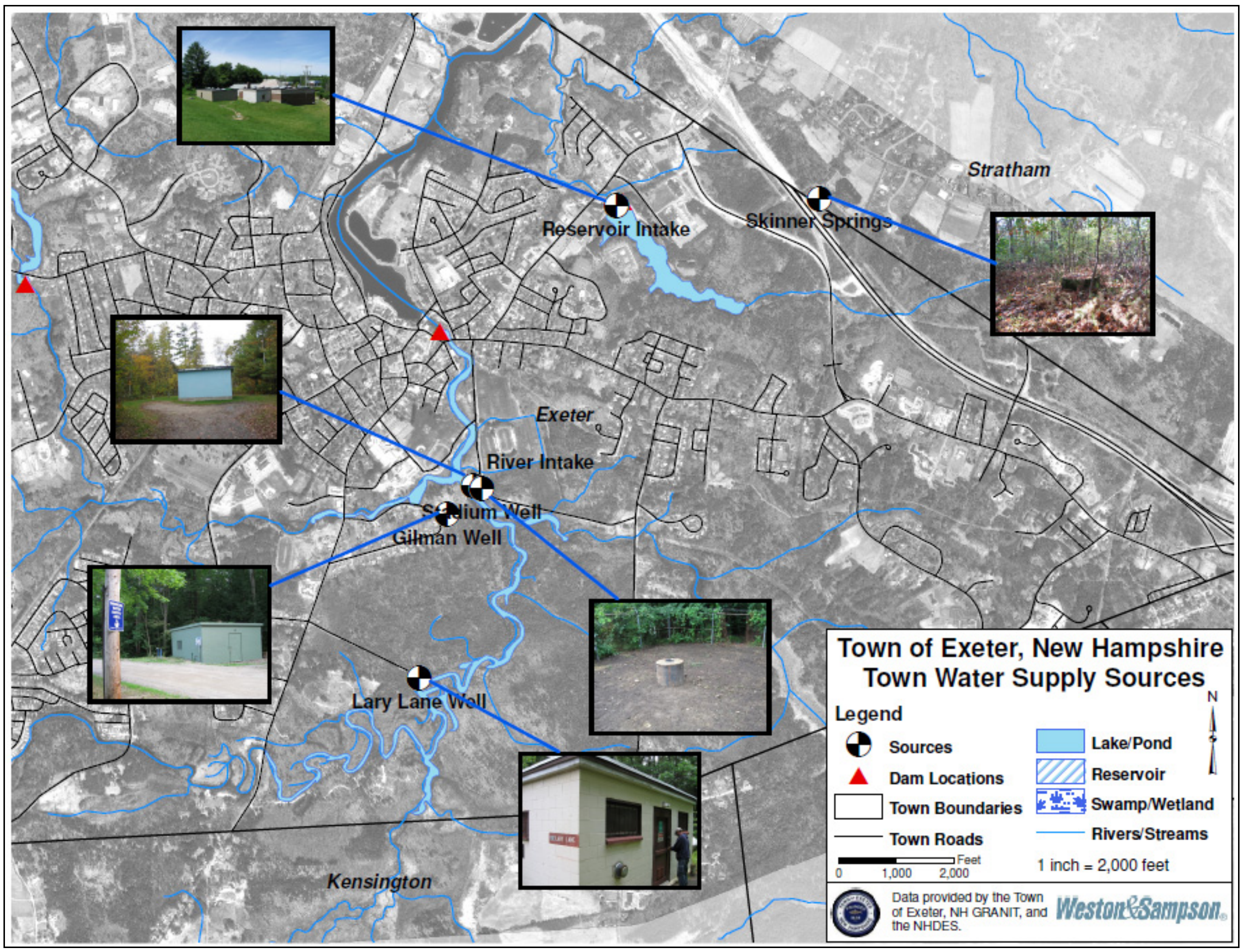
The Town's Public Works Department manages the water system from their offices on Newfields Road. Town crews maintain the distribution system, read meters and perform some of the capital upgrade projects. Certified water system operators run the water system from the water treatment facility located on Portsmouth Avenue. Billing is performed on a quarterly basis with combined water and sewer bills going out based on metered usage. Some of the larger system users have radio read capabilities on their meters with the town getting data from the rest of the users via hand held reading of other user accounts.

2.0 WATER SUPPLY HISTORY

2.1 Overview

As described in the previous section, the Town of Exeter's public drinking water system has been in operation since 1886, when the Exeter Reservoir (Waterworks Pond) and pumping station went on line. Over the years a number of additions to the Town's water supply sources have occurred. These have included the Skinner Springs, the installation of three wells and finally, the construction of a river pumping station which delivers water to the Town's water treatment facility on Portsmouth Avenue. The following figure shows all of the Town's water supply sources, both past and present:

Figure 2-1: Map of Water Supply Sources

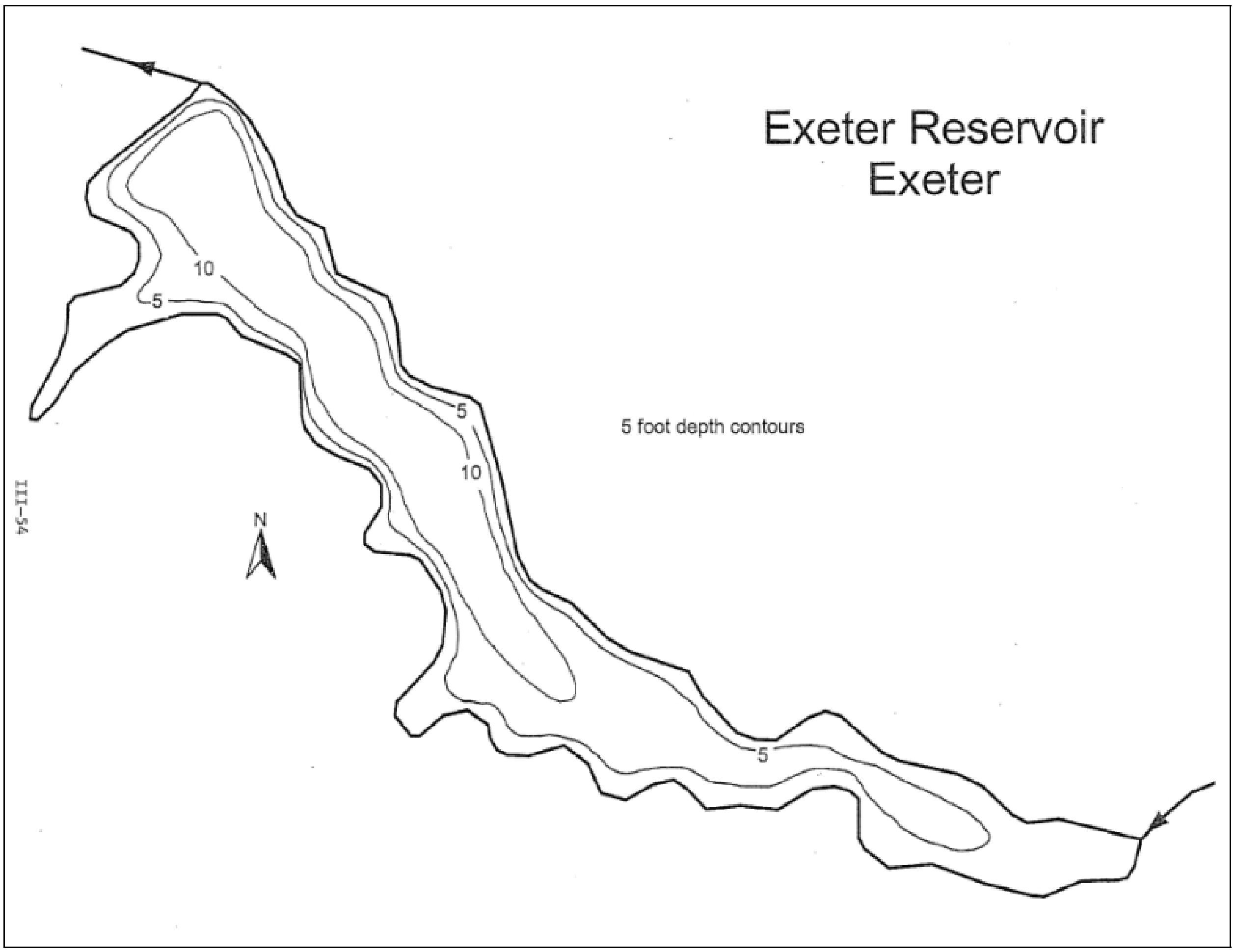


The following section describes the history and components of the Town's water supply sources:

2.2 Water Supply Sources

2.2.1 The Exeter Reservoir

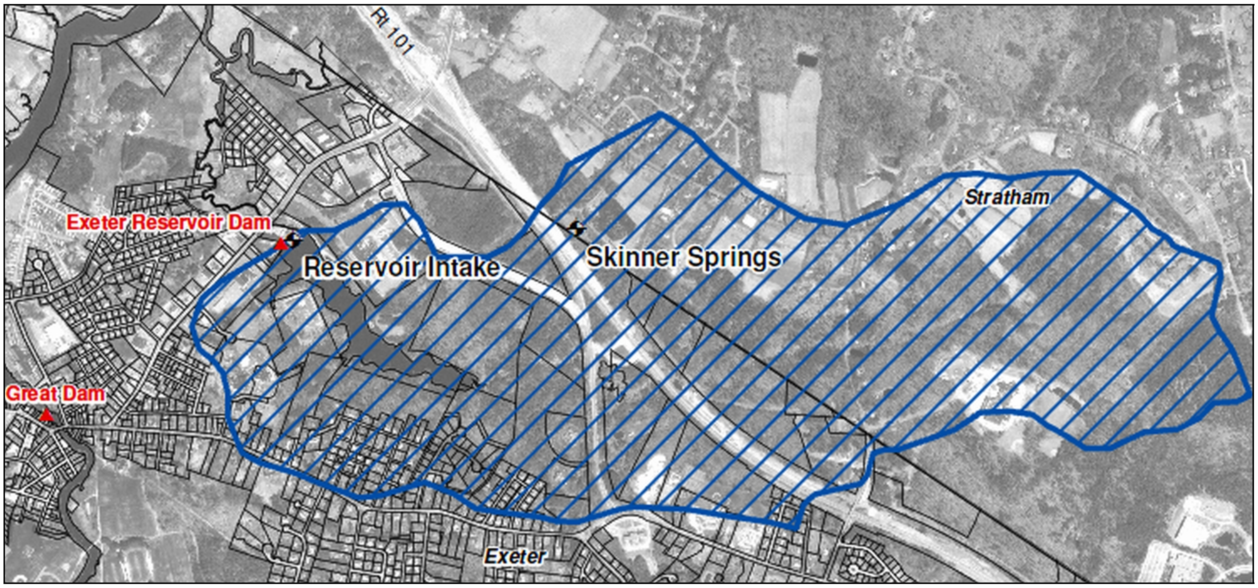
As mentioned in the previous chapter, the Exeter Reservoir was "hand dug by 100 laborers and went on line in 1886." The reservoir was originally referred to as "Waterworks Pond," but has since been referenced as the Exeter Reservoir. The submerged land encompasses approximately 23 acres and impounds approximately 30 million gallons of water. The Town owns and protects the shoreline from unauthorized uses. Fishing from the shore is allowed but no other recreation is permitted. A detailed bathymetry of the reservoir has not been performed, but a general map of the area has been developed by the New Hampshire Department of Environmental Services:



New Hampshire Department of Environmental Services Sketch of Exeter Reservoir

The Exeter Reservoir is located in the bottom third of the Dearborn Brook Watershed, which drains approximately 1.7 square miles. Dearborn Brook begins as a series of springs in the highland area of southern Stratham and runs underneath Rt. 101 before entering the Reservoir and ultimately emptying into the Squamscott River approximately one mile downstream of the Great Dam on the Exeter-Stratham town line as shown in the following figure.

Figure 2-2: Map of the Exeter Reservoir Watershed



The Town utilizes this water source seasonally due to temperature fluctuations during the summer months which cause treatment facility upsets. When air temperature rises in the late spring, the Reservoir water warms quickly during the day, which causes rapid changes in water quality and is difficult for their existing surface water treatment facility to treat. An aeration system has improved the town's ability to take water from the reservoir and also blend it with the river source at the facilities intake, shown below. However, as will be discussed later in this report, the water operators generally use the reservoir as a source of supply during the winter and spring period. They shift over to the river source during the summer.

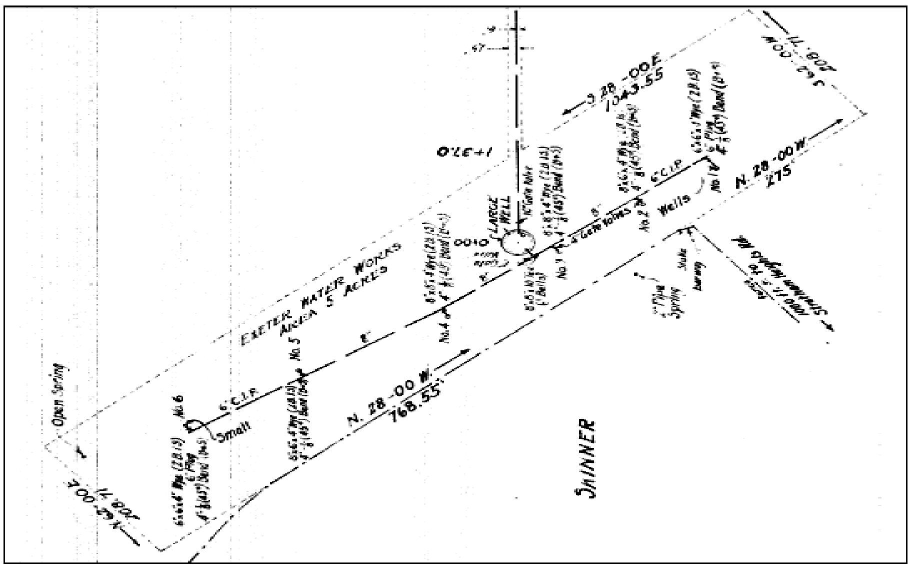
Exeter Reservoir

Reservoir Dam and Intake Chamber

While the potential removal of Great Dam would have no direct impact on the hydraulics or hydrology of the Exeter Reservoir, it would require a greater reliance on the Town's water supply strategy with regard to the Reservoir. This will be discussed further in Section 7.

2.2.2 Skinner Springs

The Skinner Springs are located on the Exeter/Stratham border. These springs were purchased from the Skinner farm and constructed in 1929. The engineer's report at that time summarized the future source of supply as "consisting of six small wells collecting water over a given area, feeding this into a large well of about 200,000 gallons capacity, which in turn feeds by gravity through a 10" pipe to a deep well at the Pumping Station, some 4000' away."



Original Skinner Springs Design

The springs are considered to be a groundwater source of supply in the State of New Hampshire. However, in reality they are treated as surface water because the water from the springs is piped to the head of the water treatment facility and combined with the surface water. Therefore, it is chlorinated, filtered and treated in the same manner as the surface water. This practice does not significantly increase operating costs as the groundwater is blended with surface water prior to treatment and generally improves water quality.

Since the springs flow by gravity to the water treatment facility, their yield varies from season to season and year to year. Generally, flows are greater in the springtime than in the late summer. All of the water is metered at the treatment plant and can be controlled by a valve in the filter building.


One of Six Spring Wells


Manifold Pipe in Collector Well

2.2.3 <u>Gilman Park Well</u>

According to the 1950 Exeter Town Report:

> On August 2, 1950, a contract was made with the Layne-New York Company, Inc., to drive test wells and install a permanent well and pump of at least 500 gallons per minute capacity. Test wells were driven during August and September in Gilman Park, on the property of Daniel Gilman, near Court and Crawford Streets, and back of Pine and Court Streets. The most promising site was in Gilman Park and work on permanent gravel packed well was started in November.
>
> The formation of the ground consists of ten (10) feet of topsoil and sand, thirty-seven (37) feet of clay which will prevent any surface water from entering the well, and twelve (12) feet of water bearing sand and gravel.

Gilman Park Well Pumphouse in 2009


Installing a New Screen and Casing in 2009

Information from the well log during installation of the well details its construction and is as follows:

Well Log:

- 0 to 6 inches – topsoil
- 6 inches to 10 feet – layers of sand and clay
- 10 feet to 47 feet – gray and blue clay
- 47 to 48 feet – fine sand
- 48 to 56 feet – sand and gravel

Well Construction:

- 24-inch diameter well, 56-feet deep
- Sanitary seal from 0 to 13 feet (installed 3 feet into clay layer)
- 15.5 feet of 36-inch steel pipe, welded
- 54 feet of 24-inch steel pipe, welded
- 5 feet of 24-inch Everdur screen

Subsurface lithology information collected during drilling of monitoring/observation wells in the Stadium wellfield, across the Exeter River from the Gilman well, indicates the presence of a 15' clay confining unit at approximately 5-10' bgs. Brown sand and gravel extending to refusal were identified below the confining unit.

The well pump and controls were housed in a block building with a flat slab roof. The well was operated and supplied drinking water to the Town from 1951 until 1959 when it was taken off-line by the Town due to increasing iron content and taste and odor complaints due to hydrogen sulfide. According to a 2002 Camp, Dressor & McKee, Inc. report, "New pumping equipment [was] specified and installed at the Gilman Park and Stadium groundwater wells in 1972-1974."

While in use, the well produced between 0.25 and 0.44 mgd or 173 to 305 gallons per minute. According to a 1990 Whitman & Howard report, "the original specific capacity was 11.8 gpm/ft at a pumping rate of 517 gpm in 1951." A summary of information gathered from Exeter's Annual Town reports regarding the well yield during the years this well was in service is as follows:

- 1951 – In service (no annual data)
- 1952 – 149.1 million gallons
- 1953 – 134.1 million gallons
- 1954 – 122.8 million gallons
- 1955 – 138.7 million gallons
- 1956 – 149.1 million gallons
- 1957 – 167.7 million gallons
- 1958 – 144.3 million gallons
- 1959 – 74.2 million gallons

Currently, the well is off-line and considered to be an approved drinking water source listed as "inactive" by the New Hampshire Department of Environmental Services. The Town is considering reactivation of the well in conjunction with the adjacent Stadium Well. Preliminary studies show that water quality is acceptable and that the aforementioned taste and odor issues may be treated by an iron/manganese treatment system.

A Preliminary Report was submitted to the New Hampshire Department of Environmental Services by Weston & Sampson in November 2008. Specifications were also developed for the Town to hire a well contractor to install a new wellscreen and casing inside the well because the existing screen had collapsed. This work was performed in July 2009 and was followed by a five-day pumping test and water treatment pilot effort. The results of both the pumping test and the piloting were promising and will be discussed further in this report.

2.2.4 Lary Lane Well

The EPA's "Information Regarding the Phase I Delineation of the Source Water Protection Area for Exeter's Lary Lane Public Supply Well," provides a very good summary of the development and operation of this well:

> The location of the Lary Lane municipal supply well was selected after test well exploration by the R.E. Chapman Company in May and June, 1957. Because of these results, a 24" X 18" gravel-packed well was completed on April 21, 1958 to a depth of 94 feet. Well construction records show that the Johnson Everdure screen is 15 feet in length, 18 inches in diameter, and set at a depth of 79 to 94 feet. The supply well was then pump tested for three days from April 21st to 24th at 520 gpm. The maximum drawdown was 39 feet for a specific capacity of 13.3 gpm/ft.
>
> Over its 50 year history, the Lary Lane well has been periodically rehabilitated. In 1977, the well was cleaned, overhauled and redeveloped. The drawdown was reduced to 17.9 feet below a static depth of 17.1 feet while pumping at 310 gpm.
>
> Geologic materials encountered during drilling were 0 to 10 feet of 'brown sand', 10 to 50 feet of 'gray, soft clay', 50 to 58 feet of 'coarse grave, stones', 58 to 80 feet of 'medium gray sand', 80 to 94 feet of 'gravel', and 94 to 97 feet of 'hardpan' (till). Bedrock refusal was not described in the log, but bedrock (mapped as the Eliot Formation) is probably not far below this depth. The basal sand and gravel aquifer is apparently highly confined at this location by approximately 40 feet of soft marine clay.

The Lary Lane Well Pumphouse

Lary Lane Well Pump and Controls

The Lary Lane recently experienced violations of the Arsenic Rule by discharging water with arsenic concentrations in excess of the 0.010 mg/L maximum contaminant level (MCL). The contaminant level had been reduced from 0.050 to 0.010 mg/L. Prior to this regulatory change the well was in compliance with the standard. According to a March 2007 Underwood Engineering report, "Since 2001, the median arsenic concentration has been 0.0112 mg/L with a maximum of 0.0128 mg/L. The New Hampshire Department of Environmental Services (NHDES) issued a Letter of Deficiency to the Town on September 22, 2006, directing the Town to submit a plan for arsenic mitigation at Lary Lane including a schedule of actions the Town proposes to bring the well into compliance with the Arsenic Rule. Lary Lane has traditionally produced between 150,000 and 300,000 gallons per day to supplement production at the water treatment plant. Lary Lane is the only groundwater supply source and is an important supplement to the water treatment plant."

Subsequent to the issuance of this Letter of Deficiency the Town began using the well only as an emergency backup source, however, they continued to sample quarterly to keep in compliance with the water quality regulations. Recent samples have been below the standard leading to an issuance by the DES of a letter on August 18, 2009 determining "that the level of Arsenic has been below the MCL of 0.010 mg/L for two consecutive quarters and that the system has not installed treatment for Arsenic. Therefore, DES hereby closes Letter of Deficiency #WSEB 06-143, dated September 22, 2006." This notice went on to note that "the Letter of Closure does not provide relief or otherwise address any future exceedance of the Arsenic MCL. Should the level of Arsenic again rise above the MCL, DES will request that the Exeter Water Dept pursue a permanent corrective action."

There is no clear evidence why the Arsenic concentration has dropped below the MCL, however, it most likely attributed to the wetter than normal weather conditions and minimal operation of the well. Both of these factors are most likely causing the well to obtain water from upper zones of the aquifer that may contain lower arsenic concentrations than water coming from near the bedrock. With this in mind, the Town authorized a water treatment pilot of the wells to determine if removal of Arsenic would be possible if a treatment system were installed. This pilot was performed in conjunction with the Gilman and Stadium well pumping test and will be discussed further in this report.

Per a February 28, 2007 Town work session memorandum, "The Town records show a pump test run at 500 gpm when the well was first installed, but the 2001 rehab indicates a maximum flow rate of approximately 350 gpm. The current safe yield is not known, but it is thought to be much less than 500 gpm. The Town reports that continued pumping at 350 gpm has resulted in undesirable drawdown." Considering the analysis of others and our review of the available hydrogeological data for the area, we are utilizing a yield of 0.250 million gallons per day from this well for planning purposes.

2.2.5 Stadium Well

The Stadium well is located southwest of the Phillips Exeter Academy's (the "Academy") Football Stadium and adjacent to the hiking trails on Academy property. The property is owned by the Academy. The Town of Exeter has an agreement and utility easement with the Academy to operate a public water supply well on the property.

According to historical reports, seven test wells were installed in 1959 on Academy property. A seven-day pumping test at a combined pumping rate of 300 gallons per minute was performed from November 26 to December 3, 1962. The test well logs noted 28 feet of clay over the water-bearing gravel. Water level data from that pumping test was not available for review.

The production well at the Stadium site was installed in 1963. The well is a 36 x 24-inch diameter, gravel-packed well with a depth of 54 to 59 feet (reported depths vary). The well reportedly yielded 0.86 mgd (597 gpm). A new test well was constructed in 1984 next to the Stadium well to reevaluate the site. The well log indicated till from approximately zero to five feet bgs, clay from five to 22 feet bgs and sand and gravel from 22 to 49 feet bgs.

Stadium Well Pumphouse in 2009

Well Inspection Prior to Rehabilitation in 2009

According to historical records and consultant reports, the well was operated by the Town as their primary source of drinking water from 1963 until sometime in 1969 when the Town shifted their supply over to a combination of sources, including the Stadium well, treated water from the Exeter Reservoir, the Exeter River, the Skinner Springs and the Lary Lane well.

A summary of information gathered from Exeter's annual Town reports regarding the well yield during the years this well was in service is as follows:

- 1963 – 11.0 million gallons
- 1964 – 164.0 million gallons
- 1965 – 148.3 million gallons
- 1966 – 153.8 million gallons
- 1967 – 142.6 million gallons
- 1968 – 115.0 million gallons
- 1969 – 164.0 million gallons
- 1970 – 194.4 million gallons
- 1971 – 171.9 million gallons
- 1972 – 130.9 million gallons
- 1973 – 208.8 million gallons

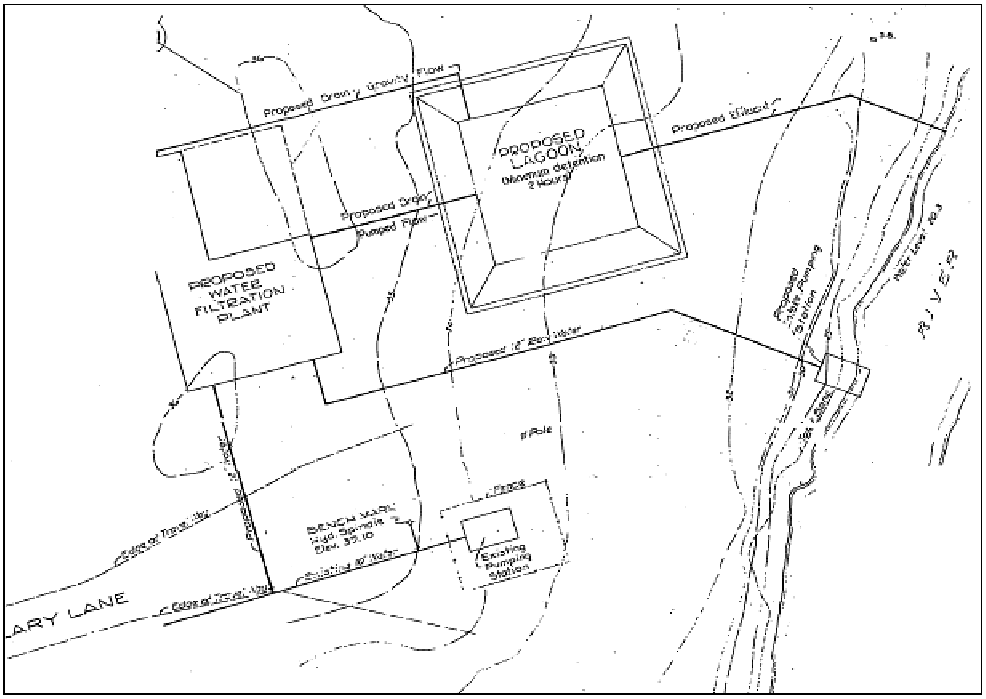
The current groundwater source/station has been out-of-service since approximately 1986. The well was located in a block building located approximately 150 feet from the Exeter River pump station and 700 feet from the Gilman Park Well. Piping still exists to connect to a 12-inch force main that enters the Exeter Reservoir water treatment plant.

Currently, the well is off-line, although still considered an approved drinking water source listed as "inactive" by the New Hampshire Department of Environmental Services. During January 2008, three test wells were advanced near the Stadium production well. A four-hour pumping test was conducted at one of the test wells and water quality samples were collected. A recommendation was put forth by Weston & Sampson in July 2008 for refurbishment and reactivation of this well, together with the Gilman Park Well. Further discussion of this work and subsequent data analysis is covered later in this report.

2.2.6 Exeter River Pumping Station

Water quality issues with the elevated level of iron and manganese from the Stadium and Gilman Park wells prompted the town to look at water supply alternatives. Though treatment of the wells was recommended and would have been a fairly straightforward process the town sought other alternatives. Their efforts to secure additional water sources led them to pursue supplemental water from the Exeter River.

The Town commissioned a study in 1961 to determine available supply sources (Whitman & Howard, December 1961). That study concluded that "the most logical source of supply suitable for present and future needs is the Exeter River." That report went on to recommend that the Town negotiate with the Exeter Mills to secure some water rights in order to pump water from the river. The report went on to recommend that a new 2 million gallon per day surface water treatment facility could be built next to the river, adjacent to the Lary Lane Well. In review of this recommended site it appears that their choice of location was fairly good; the land is undeveloped and on high ground (35 feet) and adjacent to the Lary Lane well. The proposed river intake area appears to be in a deep spot in the river (8 feet) according to available bathymetric data. The following graphic is an excerpt from that report showing the proposed layout:



River Pumping Station Layout

Whitman & Howard then prepared an assessment of the safe yield of the Exeter River. They applied a watershed mass balance approach utilizing data from the Oyster River to project water flow values in the Exeter River watershed (note that that Haigh Road gauge had not been installed, so there was not specific data available regarding flows on the Exeter River yet). Their assessment concluded that the dry weather flow of the River was 3.5 million gallons per day. Based on this analysis and recommendations the Town approached the Exeter Manufacturing Company regarding their potential use of the Exeter River as a water source.

In April 1962, the Exeter Manufacturing Company engaged the services of Camp, Dresser & McKee (CDM) to review the Town’s request to obtain water from the Exeter River. Their report reviewed the Whitman & Howard report and analyzed the Company’s water use and also projected their future needs. At CDM’s request, the Company installed a meter to determine their actual water use through their facility. This data revealed that, “from May 21 until August 8, eliminating the two week vacation shutdown period, the average daily water use at the mill was 940,000 gallons per day. During the same period, the average daily water use during the 5 day work week was 1,250,000 gallons per day and the maximum water used in any one 24 hour period was 1,790,000 gallons per day.” The report went on to add that the mill was only operating at 40 percent of capacity at the time and that, “it is possible that water consumption could increase to about 2-1/2 times the present use if the mill were operating at 100 percent capacity.”

CDM concluded that "the only means by which the Town can make full use of the Exeter River for its future needs, without infringing upon the rights of the Exeter Manufacturing Company, is to construct an adequate dam and storage reservoir [above the Pickpocket Dam]." Their recommendation was that "unless the Town is able to provide storage facilities to meet its needs, we recommend that the Exeter River be retained for the sole use of the Exeter Manufacturing Company."

In response to this report, the Town then commissioned Whitman & Howard to perform a preliminary assessment of the feasibility of constructing a new dam, to be located ¼ mile above the Pickpocket Dam near the Exeter-Brentwood town line. This report notes that the proposed reservoir would extend about 3 miles up the Exeter River and would impound approximately 300 million gallons of water.

This dam was never built, nor are there any clear records of what steps were taken by the Town beyond this preliminary assessment. It is most likely that they anticipated a lot of regulatory and public hurdles and therefore, turned their attention back to completing the installation of the Stadium Well for additional source of supply. However, the Town did not abandon the concept of getting water from the River. Negotiations with the Exeter Manufacturing Company continued throughout the 1960's and eventually ended up with the Company allowing the Town access to the river for water supply purposes.

Once water rights had been obtained from Company the Town initiated design of a river pumping station and transmission main to the water treatment facility in 1972. This design effort also included upgrades to the Portsmouth Avenue water treatment facility. In 1973 the Town put this system on line and was able to supplement reservoir water with river water at the upgraded water treatment facility (Figure 2-1).

2.3 Source of Supply Timeline

The following graphic shows the timeline for the Town's various sources of supply and their years of operation. One source, the Exeter Reservoir, has been active since the water system began pumping water in the late 1880's:

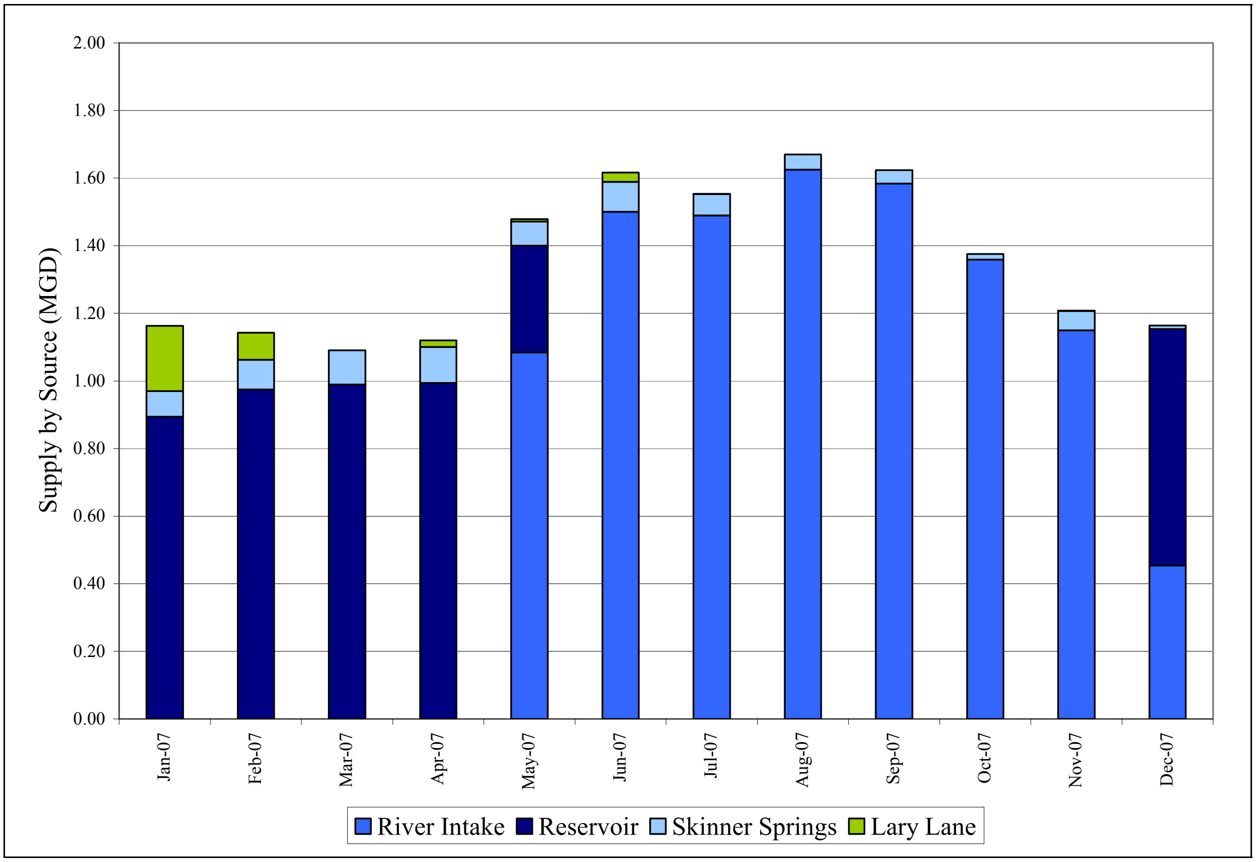
Source of Supply Timeline

	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2009
Reservoir	x	x	x	x	x	x	x	x	x	x	x	x
Skinner Springs				x	x	x	x	x	x	x	x	x
Gilman Park Well						x						
Lary Lane Well							x	x	x	x	x	x
Stadium Well							x	x				
River								x	x	x	x	x

2.4 Typical Water System Operations

The following graphic shows how the town's water system has typically operated since the upgrades to the surface water treatment facility in 1974. Basically, the reservoir and springs provide surface water during the winter and the spring, while the river is utilized during the summer and fall. The Lary Lane well was used sporadically during this time period due to the arsenic letter of deficiency, however, according to operational staff it has historically provided 10 to 15% of the system's supply.

Figure 2-3: Current Water Supply by Source Breakdown



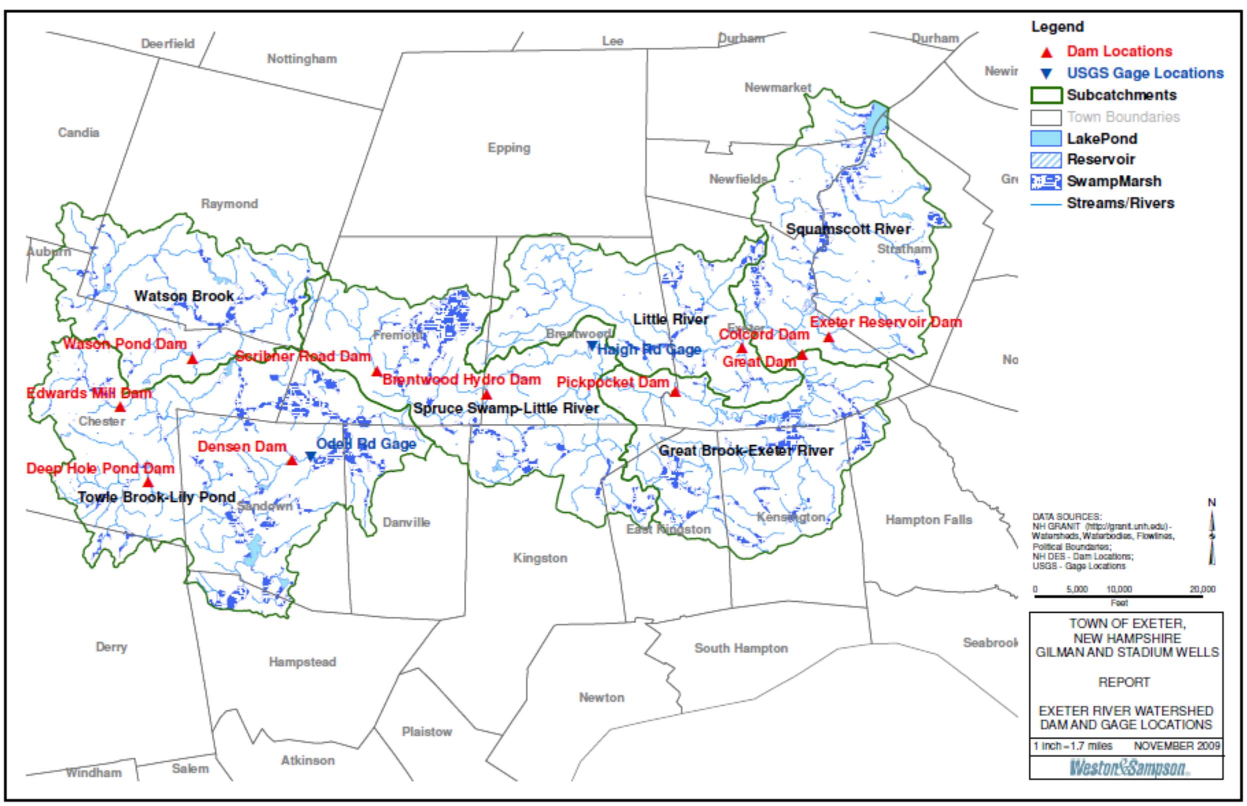
3.0 EXETER RIVER FLOW ANALYSIS AND REGULATORY ISSUES

3.1 Exeter River Watershed

3.1.1 Watershed Description

The Exeter River Watershed, located in the southeastern corner of New Hampshire, is bordered to the South and to the West by the Merrimack River Watershed, to the North by the Lamprey, and to the East by various coastal drainages. The freshwater portion of the Exeter River drains approximately 108 square miles, as it flows 33 miles from its spring-fed headwaters before it goes over the Great Dam into the tidally-influenced Squamscott River, a primary tributary of Great Bay (Figure 3-1). Typical of coastal systems in the area, the Exeter River system contains relatively little vertical relief with a peak elevation of 649 feet and an average slope of 0.25%. With the exception of a few short stretches of rapids in Brentwood, the shallow slopes of the Watershed cause the River to meander and double back on itself frequently, resulting in a significant wetland presence.

Figure 3-1: Exeter River Watershed Map



The Exeter River Watershed can be readily broken down into three sub-watersheds based primarily on its topology and geomorphology: the Upper, Middle, and Lower. The Upper Exeter River sub-watershed consists of the headwater Towle Brook-Lily Pond and Watson Brook drainages shown in Figure 3-1. The Upper Exeter is the steepest of the sub-watersheds, covering approximately 50 square miles across the towns of Raymond, Chester, and Sandown. The history of the region is quite evident in the Upper Exeter, as the sub-watershed is scattered with old mill dams. Most have been abandoned long ago, although some remain standing such as the Edwards Mill, Wason Pond, Deep Hole Pond, and Densen Dams. Both the existing dams and the remnants of fallen ones continue to serve as grade controls in the River, shaping the river channel and valley landscape and serving as barriers to the passage of aquatic organisms (NHDES, 2009). The Upper Exeter also contains USGS streamflow gage 010735562, installed in September 2008 to provide discharge information for a more natural portion of the larger Watershed (Richard Kiah, USGS, 2009, personal communication; Sally Soule, NHDES, 2009, personal communication).

The Middle Exeter River sub-watershed contains approximately 23 square miles in area and consists of the Spruce Swamp-Little River catchment shown in Figure 3-1 and is located primarily in the Towns of Fremont, Brentwood, and Kingston. The Middle Exeter is characterized by large wetland areas and the significant impoundments behind Scribner Road Dam and Brentwood Hydro Dam. These dams and a few short stretches of rapids in Brentwood, particularly Crawley Falls, represent the majority of vertical drop in the River over this sub-watershed. The Middle Exeter also contains USGS streamflow gage 01073587 (often referred to as the Haigh Road Gage), the primary source of discharge data for the Watershed since its installation in 1996.

Lastly, the Lower Exeter River sub-watershed consists of the Little River and Great Brook-Exeter River catchments shown in Figure 3-1. The Lower Exeter covers approximately 35 square miles across the Towns of Brentwood, East Kingston, Kensington, and Exeter. The hydraulic character of the Lower Exeter is varied, ranging from large wetlands in the Great Brook catchment to spring-fed ponds in the upper tributaries of the Little River to the largest impoundment within the larger Watershed, the Great Dam impoundment. The Great Dam and Pickpocket Dam, also in the Lower Exeter, represent two of the most significant hydraulic barriers in the larger Exeter River system due both to their size and downstream location within the Watershed.

At the Great Dam in downtown Exeter, the River plunges into the tidally-influence Squamscott River, a primary tributary of Great Bay. According to one recent Nature Conservancy publication, Great Bay is a unique estuarine system often noted for being less impacted by human activity than other estuaries along the eastern seaboard. However, human activity along the Exeter River and other tributaries, have served to alter and decrease the water quality of the Bay (NHDES, 2009).

The Exeter River Watershed is located across portions of 15 different communities, including significant portions of Chester, Sandown, Danville, Fremont, Raymond, Brentwood, East Kingston, Kingston, Kensington, and Exeter. These communities are some of the fastest developing towns in New Hampshire. According to the US Census Bureau, between 1990 and 2000, the Towns of Danville, Chester, and Fremont experienced population increases of 59, 41, and 36% respectively (NHDES, 2009). The altered water quality of Great Bay has prompted many communities along the Exeter River and other tributaries to become involved and take steps to improve watershed characteristics through outreach and mitigation measures. The Exeter River Local Advisory Committee, known as ERLAC, was established in 1996 to oversee the development and implementation of a river management plan. Committee members are residents from watershed communities working to protect and maintain the river's natural character (ERLAC website). The committee works under the auspices of the Rockingham County Planning Commission and completed the Exeter River Corridor and Watershed Management Plan in 1999 and since that time has designed many public education and outreach programs to increase awareness of the natural resources in the watershed.

3.1.2 Watershed Impoundments

To assess the impact of the potential dam removal on the Town's water supply, a review of the Town's key surface water resources was conducted. The Town currently maintains two dams on the Exeter River: Great Dam and Pickpocket Dam, located approximately six miles upstream of the Great Dam. The dams were built in the early 1900's to supply water for the Exeter Mills in downtown Exeter. The Town acquired both the Great Dam and the Pickpocket Dam from the mills in 1981. Both dams impound a significant volume of water and have been considered a water resource to the Town's water system for the last thirty years. The Town also operates the Exeter Reservoir Dam and its impoundment located within the adjacent Dearborn Brook Watershed. While outside the larger Exeter River Watershed, the Exeter Reservoir plays an important role in the Town's water supply system, combining with the Great Dam impoundment to satisfy approximately 80 to 85% of the Town's water demand. Lastly, the Town also operates the Colcord Pond Dam, located on the Little River approximately two miles upstream of its confluence with the Exeter River near Gilman Park. However, due to its insignificant volume, Colcord Pond is not considered a significant surface water resource by the Town and was not investigated further in this study.

In assessing the impact of the potential removal of Great Dam on the Dam's impoundment and consequently on the Town's water supply system, the area of interest is limited to the "backwater" area of the River, the area where river level is raised and impounded due to the Dam. This impounded area was analyzed as part of a 2007 Wright-Pierce/Woodlot study, which employed a United States Army Corps of Engineers HEC-RAS model to assess the Exeter River. That study concluded the following:

> The upstream limit of the Great Dam impoundment will vary depending on the flow of the river. In addition, the definition of the upstream limit of the impoundment is subject to interpretation. One impoundment definition is to define the "level pool", that is, the area defined by extending the Great Dam crest elevation (22.53') to where the bottom of the river is 22.53 feet. Based on this definition, the impoundment would extend approximately 31,000 feet upstream, to approximately where the Boston and Maine railroad bridge crosses the Exeter

River. In comparison, the bathymetric data indicated the natural high point on the bottom of the river between Great Dam and the Court Street Bridge is located approximately 1,000 feet downstream of the Lary Lane well (or 8,500 feet upstream of Great Dam). This location is confirmed from hydraulic modeling of the dam removal condition as river flow speed abruptly increases at this location. Hydraulic analysis of river flows, produced by storms of various magnitudes, indicate the impoundment limits extend upstream of the Court Street bridge during high flows.

Based on this assessment, Weston & Sampson will assume an upstream watershed extent to the Court Street Bridge, approximately 20,000 feet upstream of the Great Dam. This extent accounts for observed river bathymetry and nearly all of the storage inherent in the "level pool" impoundment definition.


The Pickpocket Dam and Pickpocket Dam Impoundment Area

Although the potential removal of Great Dam would have no direct physical impact on the Pickpocket Dam impoundment, it is a significant surface water resource for the Town of Exeter. Estimates of the storage capacity of the Pickpocket impoundment have varied from as low as 11 million gallons (CDM, 2003) to as high as 45 million gallons (Whitman & Howard, 1961). One past study even indicated that if a dam were placed approximately one quarter mile upriver of Pickpocket Dam, an additional 250 million gallons could be impounded (Whitman & Howard, 1963). A review of the most recent survey of the impoundment suggests a storage capacity of approximately 15 million gallons. This estimate corresponds well to the dam geometry and to the geomorphology of the River upstream and downstream of the impounded area.

While the Town does not currently withdraw surface water from the Pickpocket Impoundment, the site has long been viewed as a potential water supply source (Whitman & Howard, 1961, 1963; CDM, 1962). And in fact, some infrastructure is already in place: the Town owns land at the closed Town landfill which is located in the immediate vicinity of the dam. The Town's municipal water system was extended out to the landfill when it was found to be causing contamination of some neighboring residential wells. At the current time the Town has no plans to withdraw water from the Pickpocket Dam impoundment. If the Great Dam were removed, there would be no direct impact at Pickpocket Dam as it is several miles upstream of Great Dam's hydraulic influence.

3.1.3 Previous Studies

In assessing the impact of a potential removal of Great Dam to the Town of Exeter's water supply system, Weston & Sampson conducted an extensive review of the many past studies regarding the Town's water supply resources. A brief summary of the most relevant studies is provided here in reverse chronological order.

In March 2009, the consulting firms Bear Creek Environmental and Fitzgerald Environmental Associates published a report under contract to the NHDES and the Town of Exeter, titled the "Exeter River Geomorphic Assessment and Watershed-based Plan." This Geomorphic Study provides a comprehensive assessment of Watershed conditions, highlighting those factors impacting the health of its aquatic ecosystems. The study also made several recommendations to address those impacts, including the potential removal of Great Dam.

A 2007 report conducted by Wright-Pierce (now Stantec) and Woodlot Alternatives, "Exeter River Study – Phase I Final Report," focused on the hydraulics of Great Dam. The report discussed the structure and features of the dam, the hydraulic grade and bathymetry of its impoundment, the relatively minor significance of the Dam compared to that of the High Street Bridge with regard to hydraulic control of the River during high flow events, and assessed several proposed means with which to address the dam's inability to pass the 50-year flood with one foot of freeboard.

In 2003, CDM produced a study titled "Safe Yield Analysis – Exeter Water Supply System," in support of a proposed interconnection with the Aquarion water system of Hampton, New Hampshire. The report examined the Town's water demand trends as well as the capacity and reliability of the Town's surface water supply resources.

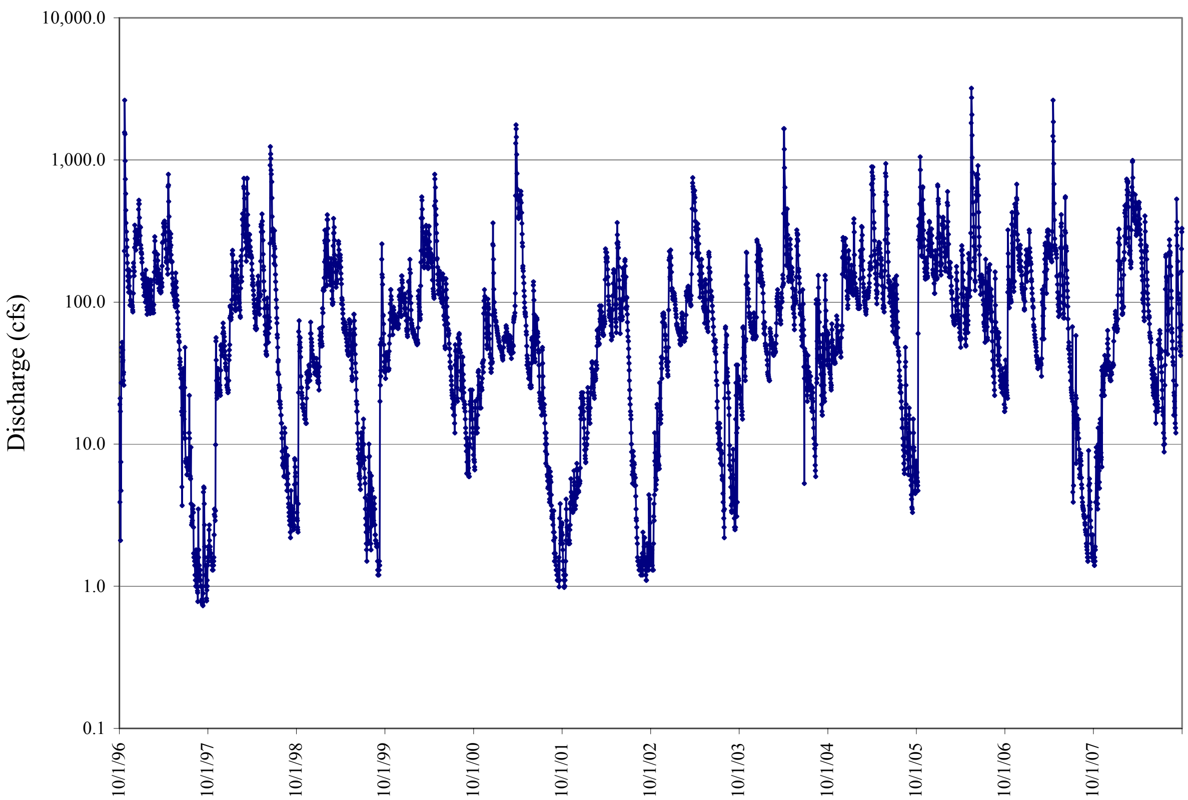
In addition to these more recent reports, a number of studies from the 1960s and 1970s examined various aspects of the Town's water supply system and surface water resources, including the placement and capacity of the Pickpocket Dam, the water supply needs of the Town and of Exeter Mill, and potential modifications to the Exeter Reservoir among others. All of these past studies provided Weston & Sampson with valuable information regarding the surface water resources of the Town of Exeter.

3.2 River Flow History

3.2.1 Haigh Road Gage Data

To fulfill the project scope, namely to assess the impacts of the potential removal of Great Dam on the existing surface water intake and hydrogeology of the Great Dam impoundment and to develop an integrated water management plan for the Town of Exeter, Weston & Sampson extensively studied historical flow records for the Exeter River. The longest record of daily streamflow in the Exeter River is derived from USGS gage 01073587, located on Haigh Rd in Brentwood, New Hampshire. Installed in the summer of 1996, the USGS gage provides over 13 years of continuous streamflow measurements that can be used to assess the hydrology of the Exeter River.

Figure 3-2: Historical Flows on the Exeter River



3.2.2 Basin Averaging for Great Dam/River Intake Flows

The USGS streamflow gage on the Exeter River is located approximately at the midpoint of the Watershed, draining close to half of the 108 square miles. In assessing the reliability of flows at various other locations within the Watershed, the Haigh gage data was scaled up or down based on the relationship between the drainage areas of the USGS gage and those of the other locations. It was assumed that the contribution of all areas of the Watershed to the total streamflow was spatially homogenous; therefore all scaling factors were linear. The drainage areas of those key locations within the Watershed are shown in Table 3-1.

Table 3-1: Drainage Areas of Key Locations within the Exeter River Watershed

Location	Drainage Area (mi^2)
Great Dam	106.9
River Intake	91.1
Pickpocket Dam	74
Haigh Rd. Gage	62.4
Brentwood Hydro Dam	59.6
Scribner Rd. Dam	53.5
Odell Rd. Gage	16.2
Densen Dam	15.8
Colcord Pond Dam (Little River)	13.7
Deep Hold Pond Dam	5.4
Edwards Mill Dam	3.1
Wason Pond Dam	2.5

3.2.3 Correlation with Parker River Data

A review of previous studies revealed that Exeter River design flow estimates should be revised to reflect a longer period of record. It appears that estimates based solely on the peak annual discharge record at USGS 01073587 have tended to significantly over-predict design flows due to the gage's relatively short (13 years) length of record. For instance, one previous study reports a 10-year flow of 2,900 cfs and a 100-year flow of 4,949 cfs at the Exeter River gage. However, according to USGS records, streamflow at that location peaked at 3,520 cfs during the May 2006 storm, a storm shown to produce peak flows on rivers throughout the coastal New Hampshire area in excess of the 100-year or even 500-year recurrence interval (Olson, 2007). According to Wright-Pierce design flows, the May 2006 event on the Exeter River was only moderately greater than the 10-year event.

The LeBlanc method, a regional regression method frequently used by the USGS to predict design flows in un-gaged or under-gaged watersheds, was also deemed insufficient. Due to the regional nature of the LeBlanc method, it is susceptible to high error rates, ranging from 32% for 2-year flows and 58% for 100-year flows (LeBlanc, 1978).

Therefore, Weston & Sampson developed a more rigorous flow distribution and subsequent design flow estimates for the Exeter River by extending the flow record of the Exeter River gage with a streamflow gage on the nearby Parker River, USGS 01101000. Several gages located in nearby watersheds with records of greater than 20 years were examined for cross-correlation (Salas, 1993) with the Exeter gage. The Parker gage was most closely correlated to the Exeter gage for both peak annual streamflow and mean daily discharge datasets, with correlation coefficients of 0.908 and 0.975 respectively. Given the close correlation of the two gages, the Exeter gage records were extended based on the Parker gage records (Salas, 1993). Fitting the extended Exeter peak streamflow record to the Log-Pearson Type III distribution (Stedinger, 1993), the USGS standard distribution, revealed the following design flows at the Exeter River gage location.

Table 3-2: Exeter River Design Flows

Recurrence Interval	*(yr)*	1	1.5	2	5	10	25	50	100	200
Design Flow	*(cfs)*	239	597	754	1253	1681	2351	2954	3660	4484

While the two streamflow records do correlate remarkably well for both peak annual streamflow and mean daily discharge datasets as shown in Figure 3-3 and Figure 3-4 respectively, the daily streamflow record does show some differences during periods of low flow, which is the focus of this study. These differences are primarily due to the operation of dams upstream of the Haigh Rd. gage. For this reason, the historical flow record was used during analyses of past events while the extended flow record was used when various options for future management of water resources were compared.

Figure 3-3: Correlation of Historical and Extended Daily Streamflow Records

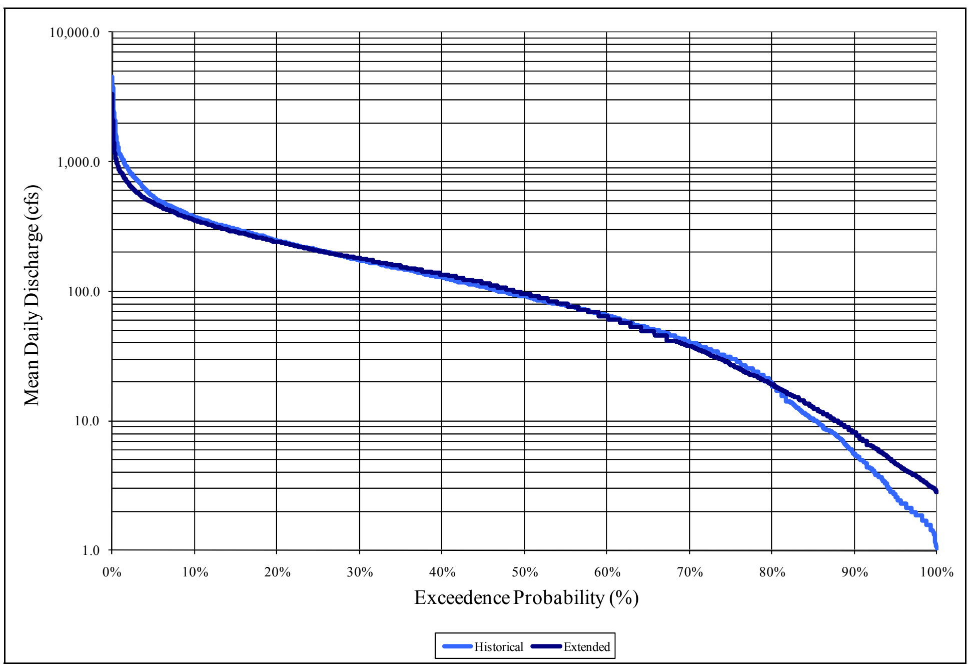
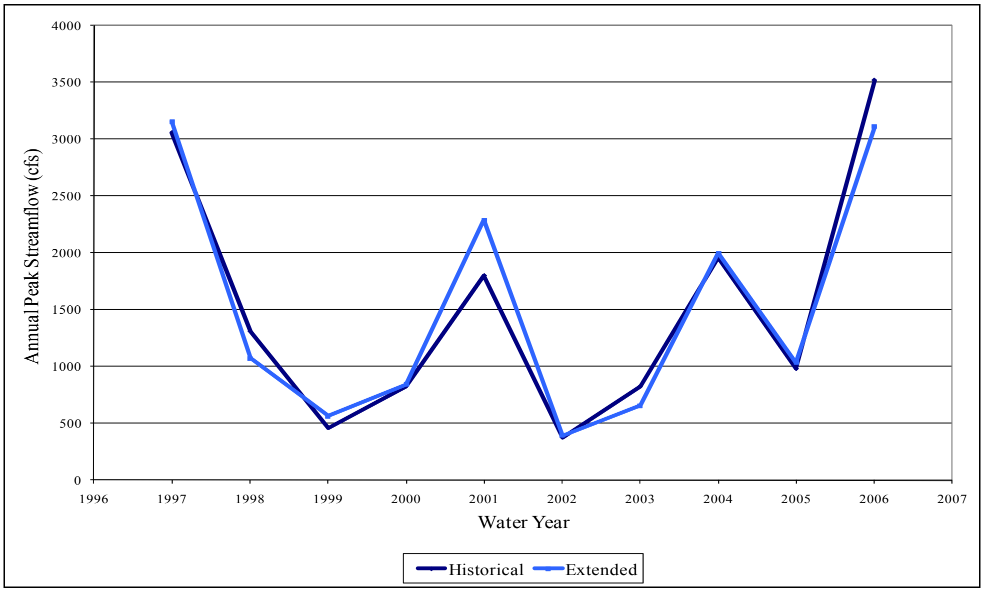


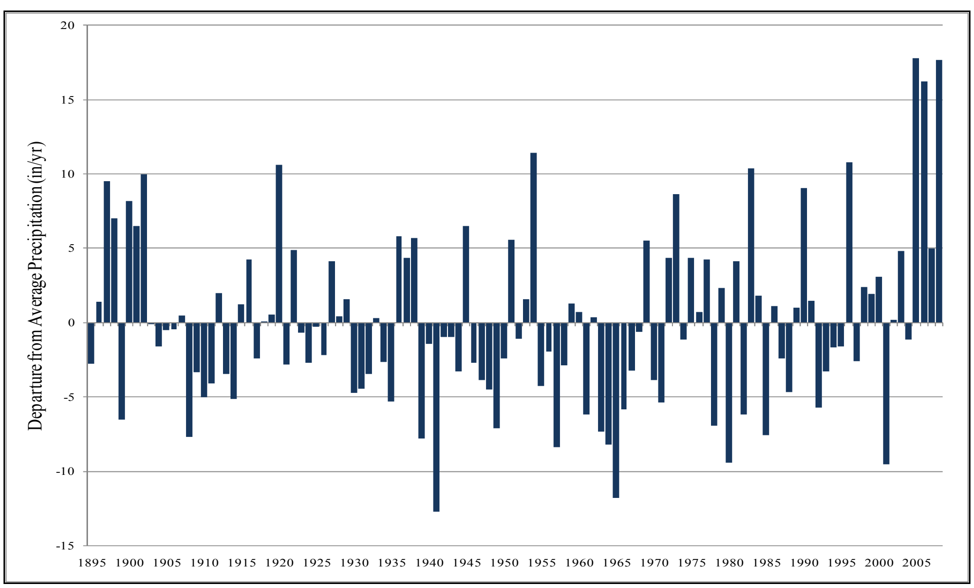
Figure 3-4: Correlation of Historical and Extended Annual Peak Streamflow Records



3.2.4 Precipitation, Climate, and Watershed Changes

Like the rest of New England, the Town of Exeter is blessed with relatively abundant precipitation with which its surface water and groundwater sources are refreshed. The variability of that precipitation on yearly and monthly time scales has important impacts on water supply throughout the region. Figure 3-5, reproduced from the NHDES's 2008 *Water Resources Primer* provides an historical perspective of the annual variability of precipitation in New Hampshire.

Figure 3-5: Departure from NH Average Annual Precipitation



This variability can impact public water systems, during both wet and dry periods. Excessive precipitation can cause significant physical damage to water supply infrastructure as well as overwhelm water treatment facilities. One period of intense precipitation in October 1998 caused the Exeter Water Treatment Plant to be flooded by two feet of water as shown in the adjacent photo. This flooding caused the water system to be out of service for eight days. A similar flooding incident occurred during Hurricane Edna in 1954.

Periods of relatively little precipitation can impact the water supply capabilities of Exeter and other New England towns as well. These impacts are expected to intensify due to changes in larger scale climate patterns. According to a summary prepared by the Union of Concerned Scientists on *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions,* "In this historically water-rich state, rising summer temperatures coupled with little change in summer rainfall are projected to increase the frequency of short-term (one- to three-month) droughts. By late-century for example, these droughts are projected to occur annually under the higher-emissions scenario, compared with once every two to three years historically, increasing stress on both natural and managed ecosystems across the state." Seager, *et al*. (2009), also note in their study of droughts that, "even though eastern parts of the United States do not, in general, experience multiyear intense droughts, short periods of a year to a few years do occur when precipitation reductions place serious stresses on water resources." Their report goes on to add that, "increased evapotranspiration is an important component of future projected climate change." According to a G. Tracy Mehan article in the Summer 2008 Energy & Environmental Export News, "scientists suggest that the global climate cycle will become more intense, resulting in heavier but less frequent periods of precipitation. They point to the possibility of longer periods of drought alternating with spells of heavy rainfall and runoff." Mehan goes on to add that the "greater variability in runoff would make maintaining optimal reservoir levels more difficult and would reduce the reliability of water storage." These points highlight the need for water supply planners to account for these projected fluctuations in their sources of supply, especially those dependent on surface water.

3.3 Regulatory Issues Regarding Flow and Quantity

3.3.1 Flow Requirements at Great Dam per Town's Management Plan

Two Views of the Great Dam Discharge Gate:
The Left Photo Shows the Intake Chamber - The Right Photo Shows the Outlet

The Town, as owner of the Great Dam, is responsible for the management and operations of the dam. As such, they developed an Operation and Maintenance Plan in 2006 which developed guidance for maintaining the water level of the Great Dam impoundment during different periods of the year. The following excerpt summarizes those parameters:

Period	Operational Goals & Considerations
April 1 through June 30	The water level will be maintained at approximately 6 inches above the concrete spillway crest, insofar as reasonable and diligent monitoring, gate operations and gate capacity will allow. This period is the primary upstream migration period for anadromous fish. NH Fish & Game recommends that the water level be maintained approximately 6 inches above the elevation of the concrete spillway for efficient migration. May is also typically the month when the river becomes the primary source for drinking water supply. The heavy spring rains associated with snowmelt generally provide the greatest susceptibility to upstream flooding, so diligent monitoring and timely operations are crucial.
July 1 through October 30	The water level will be maintained at approximately 2 inches above the concrete spillway crest, insofar as reasonable and diligent monitoring, gate operations and gate capacity will allow. Try to maintain an adequate pool level for drinking water supply, recreation and downstream fish passage. Generally, two inches of flow over the spillway will provide the necessary flow for downstream passage. Heavy rains associated with hurricanes or severe thunderstorms can cause flooding; however, extensive periods without rainfall can cause drought.
November 1 through March 31	The water level will be maintained at approximately the level of the concrete spillway crest, insofar as reasonable and diligent monitoring, gate operations and gate capacity allow. Drinking water, recreation and fish passage considerations are less important during this period. Operations should be geared toward keeping the water level at or near the elevation of the spillway crest, although ice formation on the gate outlet or stem may prevent gate operations.

2006 Great Dam Operation and Maintenance Plan

Town highway department personnel perform daily site visits to the dam and monitor weather patterns and flow utilizing the Haigh Road Gage data. They make adjustments to the dam's gate according to these operational goals and considerations. Records of these operational adjustments are also kept by Town staff.

It is important to note that these procedures were developed following the flooding events in 2005 and 2006, therefore, they generally provide guidance for the town to operate the Great Dam's gate to allow passage of water from the impoundment in order to try and mitigate small flooding events. The amount of water necessary for fish passage through the fish ladder has only been generally established. No regulatory scheme is in place that sets an exact volume of water that must be in the impoundment during low-flow conditions. The next section of this report describes the issues and potential for such regulation to be implemented in the future.

3.3.2 Discussions with NHDES and NH Fish and Game

During the course of this study, the project team held meetings and site visits with staff from the New Hampshire Department of Environmental Services and the New Hampshire Fish and Game to discuss flow issues on the Exeter River near the Great Dam. The following bullet points are a summary of those discussions and issues:

Diadromous Fish Migration

- As diadromous fish migrate upstream, individuals will tend to follow the hydraulic path with the greatest flow rate.
- If an individual is faced with an obstacle, such as a dam or impoundment, it will generally attempt to bypass the obstacle by following the hydraulic path with the greatest flow rate.
- At the String Bridge, migrating fish would consequently tend towards the river right side channel to bypass the Bridge.
- In addition, migrating fish are generally attracted towards the fish ladder at Great Dam because greater flows pass through the ladder than over the Great Dam spillway and downstream fish weir. However, the Town's operation of the Dam's low level sluice gate, particularly during lower flow periods, may disrupt this migration pattern and reduce the effectiveness of the fish ladder.
- Fish populations that are relevant to the Exeter River include: Rainbow Smelt (though they would likely be unable to move upstream of the natural rock ledges below the dam), American Shad, Herring, American Eel, Lamprey Eel, and various freshwater fish.
- Fish migrate near the surface of a river. The low level gate of the Dam is relatively inaccessible to them and is not considered a satisfactory path for upstream migration. However, the downstream end of the fish ladder is located at the water surface and represents an attractive hydraulic path to migrating fish.

Dissolved Oxygen (DO) Issue

- DO levels below 2.0 mg/L are deadly to fish. Levels above 5.0 mg/L are preferred.
- DO levels between 2.0 and 5.0 mg/L are "growth inhibiting," stunting fish maturation and ultimately hurting individuals' survivability later in life.
- Dams prohibit the ability of fish to escape those "growth inhibiting" environments.
- Removal of Great Dam would seem to remove any responsibility the Town has to DO levels, with the exception of withdrawals at the pump station. Withdrawals for public water supply during low flows would most likely be reduced or cut off during low flow periods. This may be the case in the future if the dam is repaired. Wayne Ives from DES noted that Town would benefit from having diverse water supplies such as groundwater sources to utilize during dry periods.
- The Town may have to mitigate and/or manage periods of low DO if the Dam is repaired. This could be achieved by aeration or some other mechanical means to get oxygen into the water.
- In the future DES will look to Fish & Game for a determination of low flow requirements to support aquatic life needs. For now, the DES is referring to the Town's current Dam Management Plan regarding flow requirements.

Existing Structures

- According to Cheri Patterson, a senior biologist from Fish & Game that visited the Great Dam site, the existing fish ladder is adequate, though only moderately effective. Flows coming out of the low level gate may impact effectiveness of the fish ladder by reducing its relative flow rate and attractiveness to migrating fish.
- The downstream fish weir is in place to slow flow and funnel fish towards the faster water coming down the fish ladder.
- The State owns all fish passage structures.
- By removing one foot of the spillway and installing a one-foot bladder dam on top of the concrete spillway that could be lowered during high flows, the Town could meet high flow standards while maintaining the current water level of the Impoundment.
- If the Town lowers the Impoundment a foot or more, the fish ladder may become ineffective.

Transitional Zone between Great Dam Fish Weir (blue line) and Tidal Zone (red line)

<u>Habitat Issues and Flow Needs</u>

- Both sides of the transitional zone are spawning habitat for Herring and American Shad. The slackwater areas under some of the building pilings on river left (facing downstream) are most likely egg-laying locations.
- Various freshwater fish as well as Lamprey and other eels likely move through the transitional area and may reside there for parts of the year.
- The existing trees on the upstream end of the island supporting String Bridge appear to be 20-25 years old.
- Fish migrate upriver from the first spring floods to early July. Fish migrate downriver from July to late October. The prime out-migration period is August and September.
- The influence of upriver impoundments and controls was discussed. There may be some potential for management of these impoundments to mitigate low flows. However, as previously mentioned, the State does not have a clear policy on this matter for the Great Dam impoundment.
- At a minimum, river flows would most likely need to be maintained through the river right (facing downstream) channel of near the String Bridge during these low flow periods.

3.4 River Water Quality Sampling and History

3.4.1 River Sampling History

In addition to the issue of water quantity, the Exeter River has been the subject of several water quality assessments, including the annual NHDES Volunteer Assessment Program (VRAP), the NHDES Ambient River Monitoring Program (ARMA), and the Wright-Pierce/Woodlot study. These assessments have recognized dissolved oxygen content, an important measure of a watershed's ability to sustain populations of fish and other aquatic organisms, as a particularly relevant water quality issue for the Exeter River.

The VRAP reports, published annually, summarize data taken by a network of trained volunteers up and down the Exeter River Watershed. Water quality samples taken by the volunteers are analyzed for temperature, pH, turbidity, and specific conductance as well as dissolved oxygen (DO) content and DO saturation (NHDES, 2007, 2008, 2009b). The 2007 ARMA study tracked similar water quality metrics, but employed several automatic data loggers spread throughout the Watershed to capture daily fluctuations and spatial variations. Lastly, the 2005 Wright-Pierce/Woodlot report focused on the Great Dam Impoundment, assessing the variability of temperature, DO content, and DO saturation along the length and depth of the Impoundment. Table 3-2 summarizes the results of these three water quality assessments in the vicinity of the River Intake.

Table 3-3: Previous Water Quality Assessments near River Intake

		Water Quality Metric					
Study	**Percentile**	Temperature *(deg. C)*	pH	Turbidity *(NTUs)*	Specific Conductance *(uS/cm)*	DO Content *(mg/L)*	DO Saturation *(%)*
VRAP[1]	Max	26.20	6.47	5.50	239.90	8.15	98.90
	Median	22.10	6.32	4.20	147.30	7.13	85.20
	Min	11.40	6.02	1.81	130.20	6.12	68.10
ARMA	Max	23.48	7.13		211.00	7.48	86.20
	Median	23.00	6.82		192.00	6.31	73.60
	Min	22.07	6.68		181.00	4.95	57.50
W-P/W	Max	25.10				9.58	91.00
	Median	21.70				5.65	62.65
	Min	9.70				3.18	36.20

[1] 2006, 2007, 2008 VRAP publications only.

3.4.2 River Sampling during Study Period

During the summer of 2009, Weston & Sampson conducted water quality sampling of the Exeter River to verify the assessments of the NHDES Volunteer River Assessment Program (VRAP), Wright-Pierce/Woodlot Alternatives, and others. Samples were taken biweekly from mid-June to the end of August at five locations: Pickpocket Dam, the Linden St. Bridge, the River Intake, the Gilman Park footbridge over the Little River, and the Exeter Reservoir. The samples were analyzed at the Exeter Water Treatment Plant for pH, alkalinity, color, turbidity, hardness, chloride, iron, manganese, and specific conductance. Table 3-3 summarizes the results of those analyses at the River Intake location.

River Sampling at Pickpocket Dam and Little River Adjacent to Gilman Park in Exeter

Table 3-4: Summer 2009 Water Quality Assessments near River Intake

		Water Quality Metric				
		Temperature	pH	Turbidity	DO Content	DO Saturation
Study	**Percentile**	*(deg. C)*		*(NTUs)*	*(mg/L)*	*(%)*
W&S	Max	24.90	6.86	5.86	6.31	94.00
	Median	21.50	6.76	3.68	4.64	64.50
	Min	17.00	5.93	3.29	2.96	35.90

The water quality assessment conducted during this study corroborated many of the results of previous assessments. In particular, the total DO content and DO saturation levels measured during the summer of 2009 are consistent with the summertime results of previous studies. The ARMA program, the Wright-Pierce/Woodlot study, and the current study all suggest that DO levels regularly drop below 5.0 mg/L for at least portions of the mid-late summer period, confirming that low summertime DO levels are a relevant issue for the Exeter River. While the water quality of the Exeter River is an issue of interest and continued study and may impact the

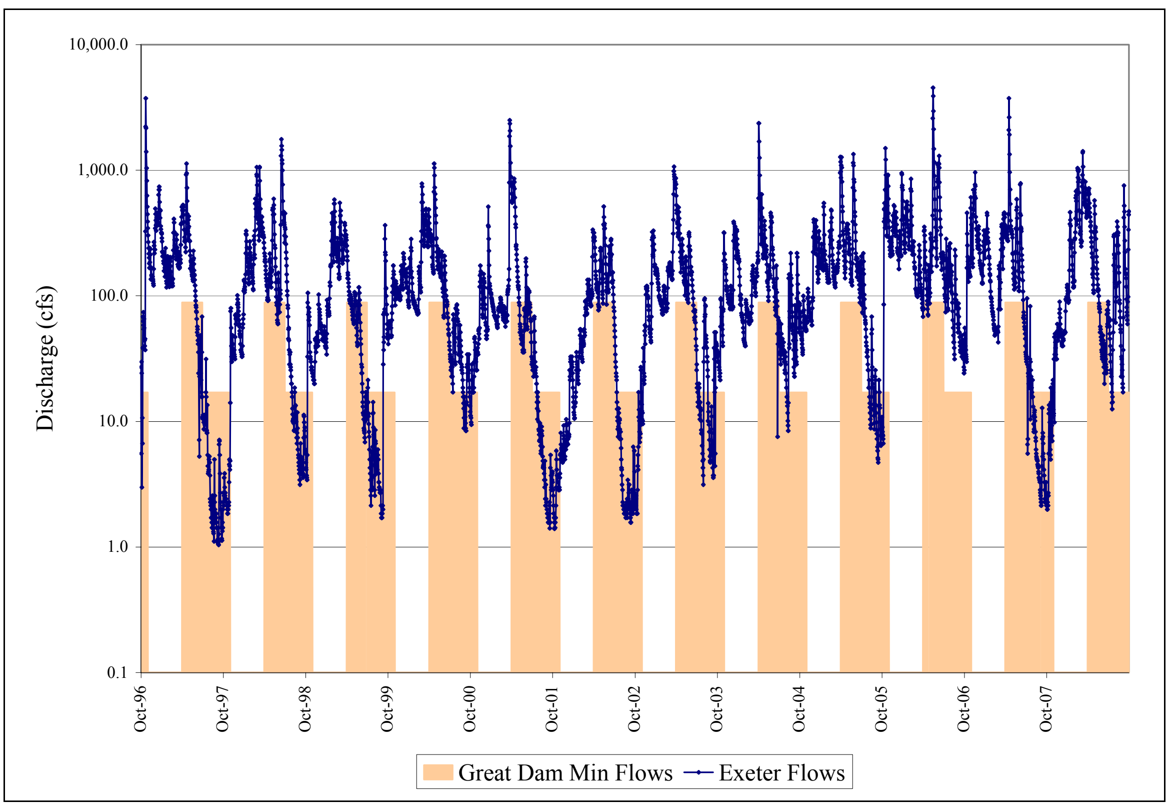
Town's ability to withdraw water from the River in the future, it is not prohibitive at the current time.

3.5 River Withdrawal Scheme and Timeline

3.5.1 River Flow during 13-year Record

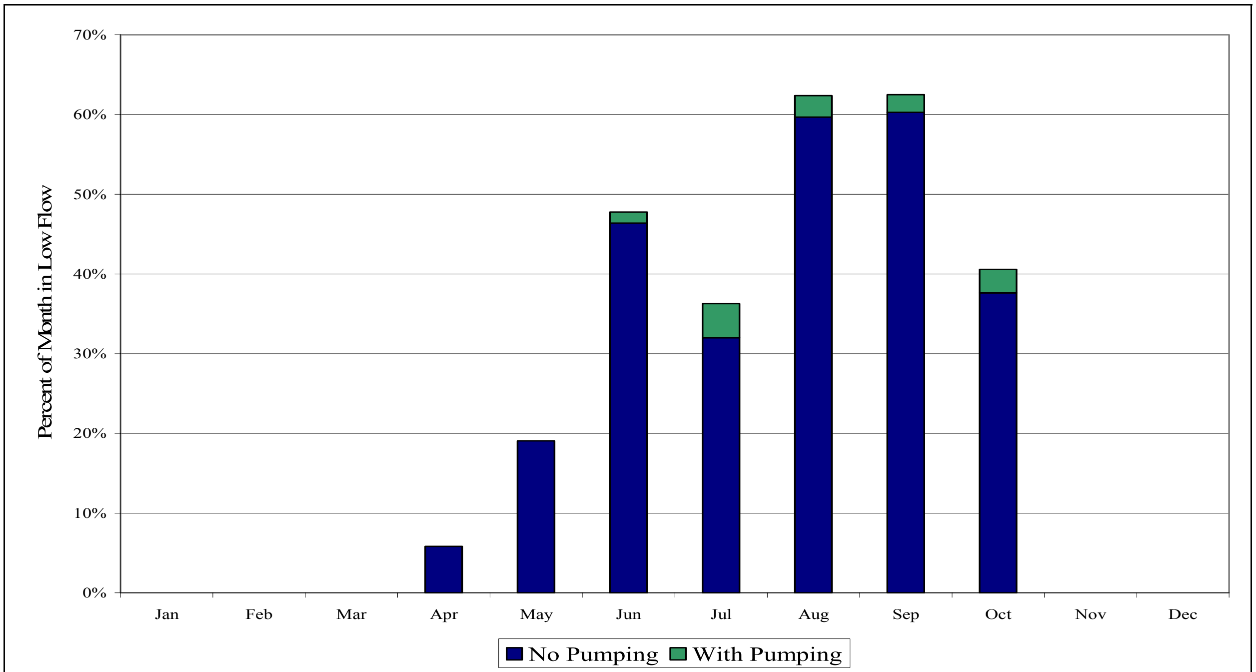
Regulatory issues regarding water quantity, as described in Section 3.3, may have a more immediate impact on the Town's capability to withdraw water from the river at certain periods, regardless of any modifications to the Great Dam. As noted, the Town's Great Dam Management Plan currently has goals set to maintain a minimum water level over the Great Dam spillway of six inches from April through June and a minimum of two inches from July through October. If the Great Dam spillway is modeled as a broad-crested weir with a width of 81 feet, as indicated in a recent study (Wright-Pierce/Woodlot, 2007), these water levels are approximately equivalent to 88 and 17 cfs respectively. Recent discussions with the NHDES and NH Fish and Game confirmed that these flows are required to support anadromous fish migration. As shown in Figure 3-6, there are periods of every year on record in which the streamflow at the River Intake falls below minimum flow goals.

Figure 3-6: Dam Management Plan Flow Goals versus Streamflow at the River Intake



These low flow periods occur precisely when the Town has historically withdrawn water from the Exeter River to satisfy the town's water supply needs, generally April/May to November. It should be noted, however, that the Town's withdrawals have a relatively minor impact on the frequency and duration of low flow periods. The blue bars in Figure 3-7 indicate the percentage of each month during the period of record in which streamflow at the River Intake have dropped below minimum flow requirements. The green bars indicate the incremental impact of the Town withdrawing 1.5 MGD from the River, approximately its maximum 1-week average withdrawal.

Figure 3-7: Impact of Town Withdrawals on Exeter River Low Flow Periods



Clearly, as evidenced by this graphic, the incremental impact of the Town's water withdrawals has a relatively minor impact on the River low flow periods. However, the minimum flow requirements outlined in the Great Dam Management Plan and likely to be implemented in future regulations will most likely impact the Town's ability to withdraw water from the Exeter River from April through October during dry periods.

Table 3-5 examines the duration of low flow periods during the 13 year streamflow record for various minimum flow scenarios at Great Dam. Six different minimum flow scenarios were considered:

- The seven-day low flow average with a 10-year recurrence interval - 2.9 cfs.
- The equivalent of one inch overtopping the Great Dam spillway - 6.0 cfs.
- The equivalent of two inches overtopping the Great Dam spillway - 17.0 cfs.
- The average discharge during the November 2009 drawdown - 60.0 cfs.

- The physical limit of water stored in the Impoundment with the Great Dam.
- The physical limit of water stored in the Impoundment without the Great Dam.

Table 3-5: Low Flow Periods during Various Minimum Flow Scenarios

	Pumping Limit Scenario					
	Regulatory				Physical	
	7Q10	*1-inch*	*2-inch*	*Drawdown*	*With Dam*	*No Dam*
	Days per Year Below Min Flow					
Min	0	0	0	45	0	0
Median	27	41	69	106	0	0
Mean	34	45	67	101	0	15
Max	94	103	122	123	0	61
	Percent of July 1 - Nov 1 Below Min Flow					
Min	0%	0%	0%	37%	0%	0%
Median	22%	33%	56%	86%	0%	0%
Mean	28%	37%	54%	82%	0%	13%
Max	76%	84%	99%	100%	0%	50%

The results of this analysis are rather instructive. Obviously, as minimum flow requirements increase, the likelihood of meeting those requirements decreases. For instance, over the 13 years that streamflow records have been kept for the Exeter River, a minimum flow of 6.0 cfs was not satisfied for an average of 45 days per year. However, there is a great deal of variability; one year never saw flows drop below 6.0 cfs, while another year experienced low flows for 122 days. Similar patterns have been shown for all six minimum flow scenarios. This variability surely challenges the reliability of the Exeter River as a public water supply during dry periods if strict minimum flow guidelines are implemented in the future.

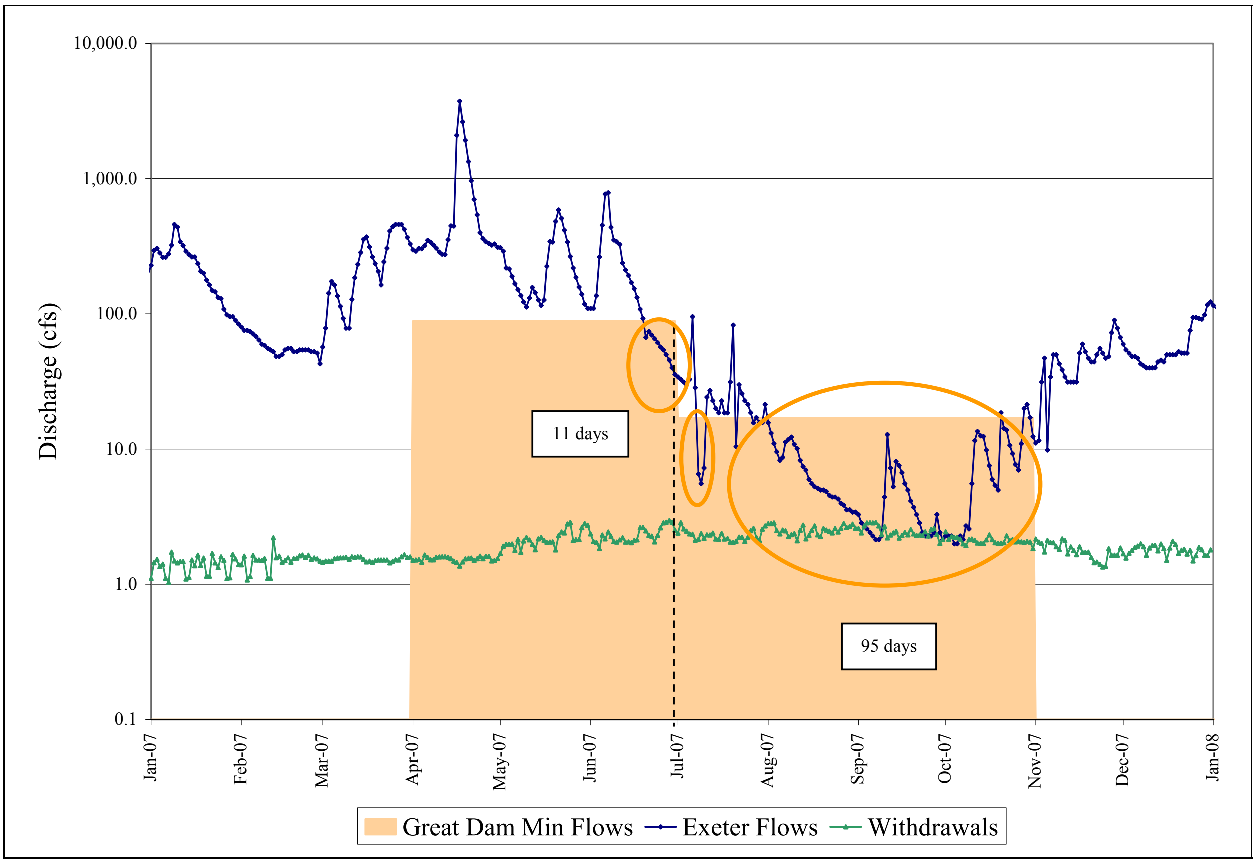
In addition, even a minimum flow as low as the seven-day average low flow, was not exceeded 28% of the time during the July 1 – November 1 time period. This rather high rate of non-exceedence is very likely due to the influence of upstream dams, such as the Brentwood Hydro Dam. Though not directly a focus of the scope of this study it must be noted that the influence of this dam presents another challenge to the reliability of the Exeter River as a public water supply source during dry periods.

3.5.2 River Flow during 2007

To more clearly illustrate the impacts of the minimum flow guidelines on the Town's ability to withdraw water from the Exeter River, the streamflow, minimum flow guidelines, and water supply demand were examined for 2007, which despite a couple of large storms, was a relatively typical year with regard to streamflow, precipitation, and water demand. As shown in Figure 3-8, during the 2007 spring, streamflow at the River Intake fell below the minimum flow guidelines for Great Dam for the final 11 days in June. The start of June saw the minimum flow guidelines drop from 88 to 17 cfs. Consequently, during much of July, daily variations in streamflow saw the Exeter River pass in and out of low flow conditions for much of the month. However, at the beginning of August, the Exeter River fell into low flow conditions and remained that way for approximately 95 days until the minimum flow guidelines changed once again on November 1st. And in fact, for approximately ten days in September, the Town's water supply needs exceeded the Exeter River discharge.

During periods of low flow, such as much of the summer of 2007, the Town would be seriously challenged to meet their own minimum flow guidelines specified in the Great Dam Operation and Maintenance Plan. While those guidelines are, in fact, just guidelines, any future regulation of minimum flows at Great Dam to address water quantity or water quality concerns, would present a serious challenge to the Town's ability to withdraw water from the River during the periods of the year when they have historically relied on the River as a primary water supply source.

Figure 3-8: Minimum Flow Goals versus Streamflow at the River Intake for 2007



From a review of 13 years of streamflow records and by focusing on a relatively typical year in more detail, it is evident that the minimum flow guidelines of Great Dam Management Plan and any future minimum flow requirements may impact the Town's ability to withdraw water from the Exeter River during dry periods. These impacts would be exacerbated by the variability of river flows in the Exeter River and the influence of upstream dam operations.

3.6 Potential Effect of Lowering the Impoundment on the Town's River Intake

3.6.1 Intake Location and Description

While the Town's ability to withdraw water from the Exeter River may already be hindered by minimum flow goals, the River Intake is additionally vulnerable to impacts from the potential removal of Great Dam. The River Intake and adjacent Pump Station are located on the right bank of the Exeter River, across from the Gilman Park boat launch and approximately 1000 feet upriver of the Great Dam.

As noted in the Wright-Pierce/Woodlot study, the river intake has an invert of El. 15.0' NVGD and requires a water surface elevation in the Impoundment of approximately El. 16.0' NVGD to maintain gravity-fed flow to the wet well of the adjacent Pump Station. It is likely that even higher water surface elevations are required for the safe operation of the Pump Station equipment. The current normal pond elevation of the Great Dam Impoundment, approximately El. 22.75' NVGD is sufficient to satisfy the head requirements of the Intake and pumping equipment.


River Intake Area and Pumping Station

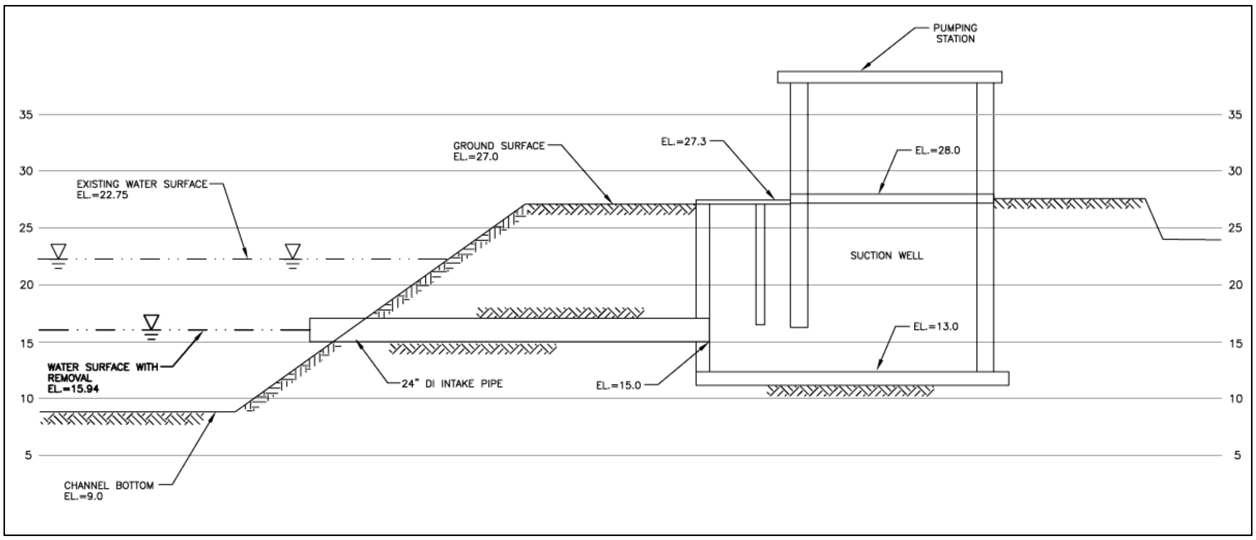
An elevation view of the river intake pipe as originally installed is shown in Figure 3-9. Based upon the original drawings created by Weston & Sampson Engineers and dated January 1972, the following parameters may be assumed:

Intake pipe diameter - 24 inch
Intake pipe invert in river - 15.0 feet
Intake pipe invert at pump house - 15.0 feet
Floor of the intake chamber - 13.0 feet
River bottom elevation (at time of install) - 9.0 feet

Two pumps located in the River Pumping Station convey raw water from the wet well to the water treatment facility (WTP) via a ten inch diameter raw water transmission main. There are two vertical turbine pumps installed in the wet well. One pump is equipped with a variable frequency drive, the other is a fixed speed pump capable of delivering approximately 1000 gallons-per-minute to the WTP. The pumps are operated as needed to supplement the supply at the water treatment plant reservoir. Typical daily pumping volume is approximately 1.5 million gallons per day.

The original design of the intake pump house and intake pipe took advantage of a natural occurring impoundment within the river as well as the additional volume impounded by the dam. If the dam were removed, the impounded water level and volume available for withdrawal would likely be reduced.

Figure 3-9: Cross-section of the River Intake Location

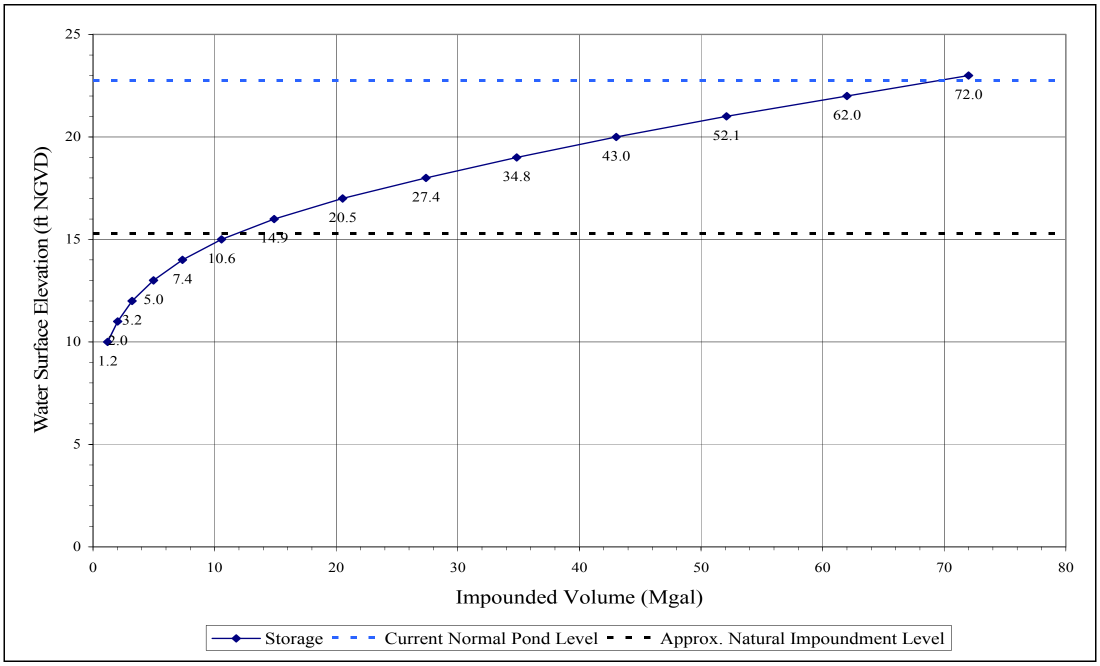


As noted in the Wright-Pierce/Woodlot study, the river intake has an invert of El. 15.0’ NGVD and requires a water surface elevation in the Impoundment of approximately El. 16.0’ NGVD to maintain gravity-fed flow to the wet well of the adjacent Pump Station. It is likely that even higher water surface elevations are required for the safe operation of the Pump Station equipment. The current normal pond elevation of the Great Dam Impoundment, approximately El. 22.75’ NGVD is sufficient to satisfy the head requirements of the Intake and pumping equipment.

3.6.2 Current Impoundment Elevation, Area, and Volume

Changes to the Impoundment, due to the potential removal of Great Dam, may impact the Impoundment’s ability to satisfy those head requirements. To evaluate potential changes to the geometry of the Great Dam Impoundment, Weston & Sampson first evaluated the current geometry of the Impoundment. To determine the volume of the Impoundment, Weston & Sampson developed a stage-storage relationship, Figure 3-10, based on the bathymetry data and HEC-RAS model of the Wright-Pierce/Woodlot study.

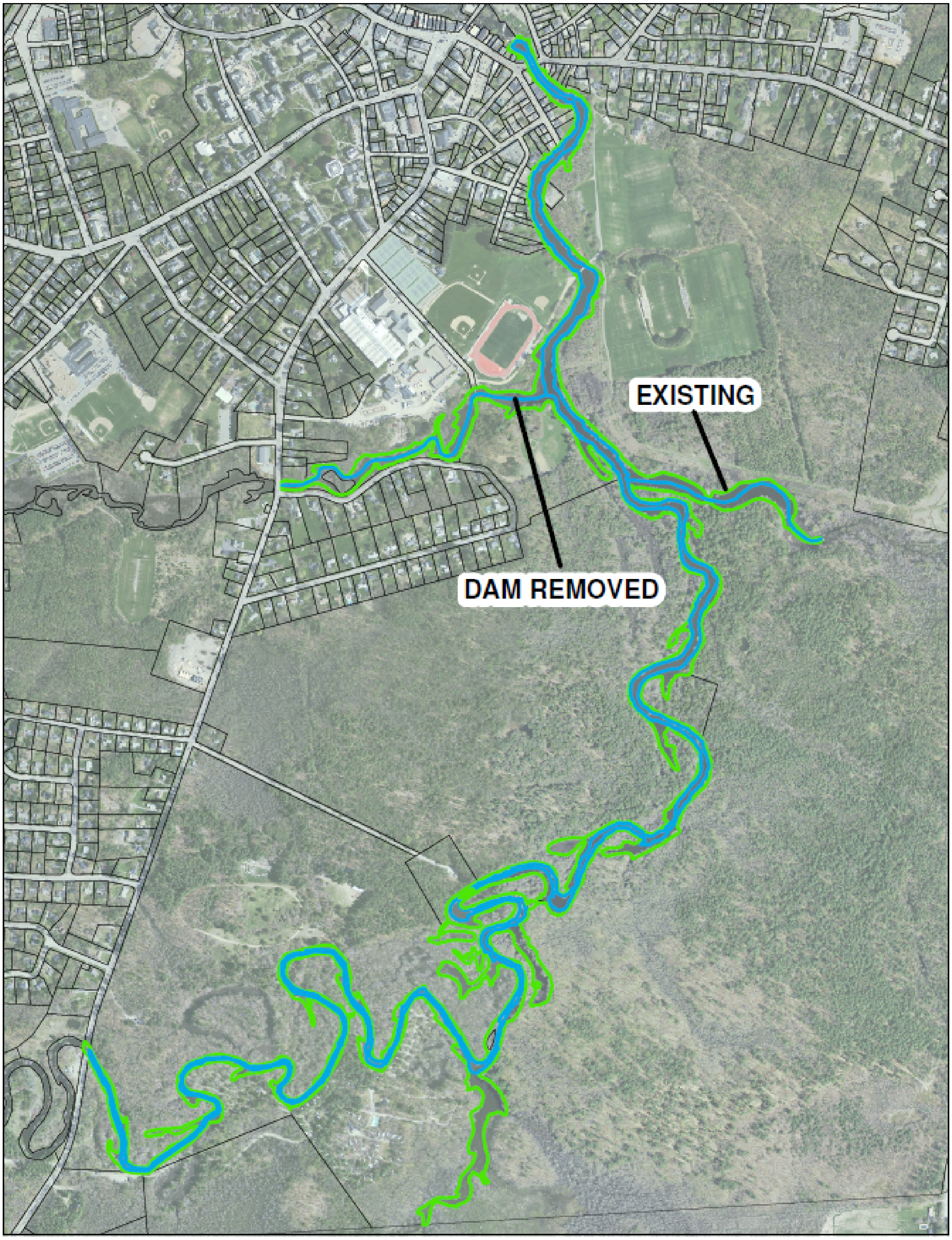
Figure 3-10: Stage-Storage Relationship of the Great Dam Impoundment



As indicated by the stage-storage relationship, with the current normal pond level of El. 22.75' NGVD, the Great Dam impoundment holds approximately 70 million gallons, approximately 59 million of which are stored above the invert of the River Intake. This compares favorably to the 63 and 62 million gallon estimates from the 2003 CDM and 2007 Wright-Pierce/Woodlot reports respectively.

The current surface area of the Impoundment was determined by interpolating the two contours representing El. 22.0' NGVD and El. 23.0' NGVD from the bathymetric survey data. This analysis revealed a current normal pond surface area of approximately 56 acres, shown in Figure 3-11. To determine the impact of a potential dam removal on the Impoundment's surface area, as well as on its elevation and volume, and consequently on the Town's ability to continue use of the existing River Intake, the current geometry was compared to the approximate geometry of the Impoundment with the removal of Great Dam.

Figure 3-11: Aerial View of the Impoundment



3.6.3 Approximate Impoundment Elevation, Area, and Volume with Dam Removal

The potential removal of Great Dam would take away the hydraulic control that creates the Impoundment. However, based on historical accounts that the "Great Dam" was named because it resides in the area formally known as "the Great Falls" and the bathymetric survey of the Impoundment, it appears that the Dam was built upon a bedrock outcropping. This construction technique is common place today and is certainly consistent with engineering practices of the 1700s. In addition, this bedrock outcropping is clearly visible in the few hundred feet between the Dam and the tidally-influenced Squamscott River, as shown in the following photo.

Bedrock Streambed Area Downstream of the Great Dam and String Bridge

Based on the bathymetric survey, this bedrock appears to have a peak elevation of approximately 15.0 feet. Under these circumstances, the removal of Great Dam would not entirely eliminate the Great Dam Impoundment. The hydraulic control of the bedrock outcropping would create a smaller, natural impoundment in its place with a normal pond level at approximately El. 15.3'.

According to the stage-storage relationship of Figure 3-10, the volume of the Impoundment would decrease from 70 million gallons to approximately 12 million gallons, nearly all of which would be stored below the invert of the River Intake. Modifications would be required to the River Intake pipe and adjacent Pump Station to ensure sufficient head for pumping. These will be discussed further in this report.

While modifications would be required to the River Intake and Pump Station, much of the character of the Impoundment would be retained. In many places near the existing River pumping station the channel bottom of the Impoundment is as low as El. 8.0' or even 4.0'. The Impoundment would remain at least approximately five feet deep from the downtown area nearly up to the confluence of Great Brook with the Exeter River. In addition, while removing Great Dam would narrow the Impoundment, this impact would be limited in the main channel. Based on the bathymetric survey, the surface area of the Impoundment would be reduced from 56 acres to approximately 16 acres, as shown in Figure 3-11.

Most of this decrease, however, would be seen in the backwater areas of the Exeter River rather than in the main channel. Areas such as the Little River from the Bell Avenue Bridge to its mouth, the Cove, and the mouth of Great Brook would return to a more riverine environment while the character of the main channel would experience less drastic change.

3.7 Impoundment Drawdown

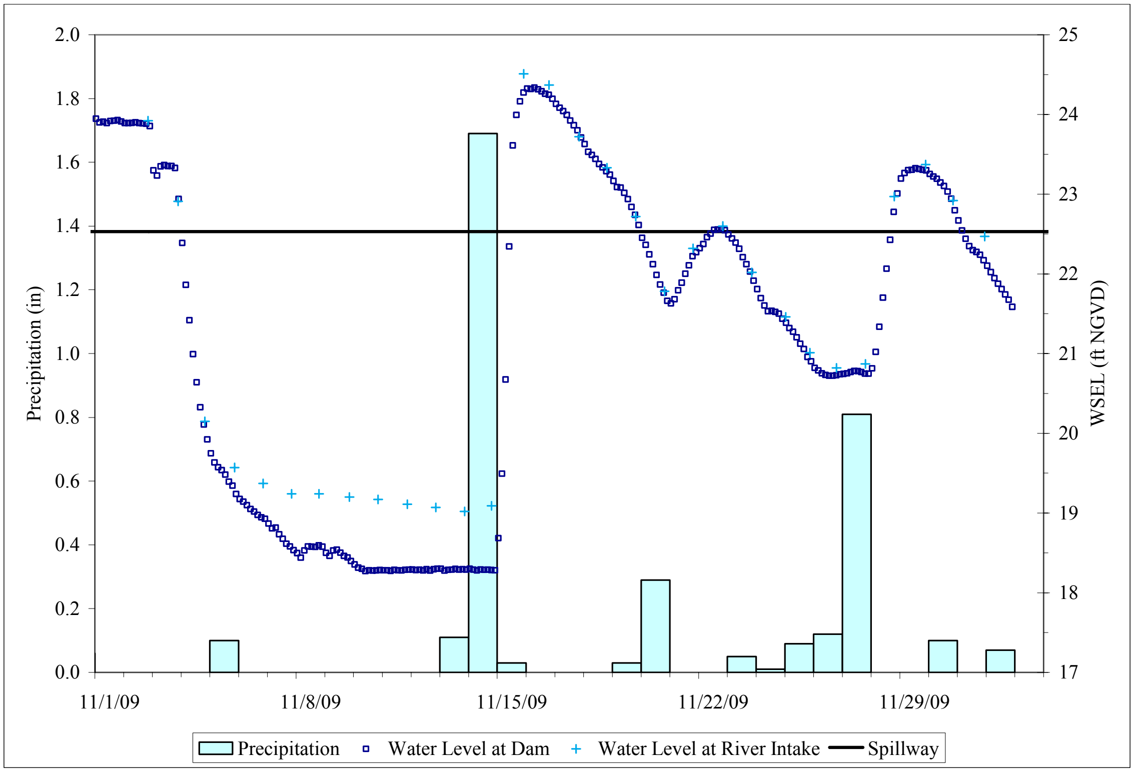
In November 2009, the Town of Exeter conducted a month-long "drawdown" of the Impoundment behind Great Dam to confirm the presence of a natural bedrock ledge within the Impoundment and to answer a number of questions regarding the potential removal of Great Dam, namely:

- What would the natural impoundment be without Great Dam?
- What would a lower river look like?
- What effect would lower water levels have on the Town's ability to withdraw water at the pumping station?
- What effect would a lower impoundment have on the nearby groundwater?

The Drawdown began on November 2nd when the low level outlet gate in Great Dam was fully opened. Water levels were measured daily by hand at the Dam and River Intake by Town personnel. Town personnel also measured water levels in two wetlands and two observation wells near the River Intake. In addition, Weston & Sampson employed electronic transducers to measure water level changes on an hourly basis at six strategic locations near the Impoundment. These measurements, in addition to the streamflow record at the USGS gage on Haigh Road, provided the data with which to judge the success of the Drawdown.

Fortunately, the commencement of the Drawdown roughly coincided with an approximately two-week period of little to no precipitation within the Exeter River watershed and correspondingly low river discharge. High discharge at the Dam, roughly 180 cfs, coupled with low inflow, between 30 and 50 cfs during that two-week period, resulted in a significant drop in water level within the Impoundment. As shown in Figure 3-12, a water level of approximately El. 18.25' was sustained at Great Dam from November 7th to November 14th, representing a drop of 4.5 feet from the Dam's normal pond level of El. 22.75'.

Figure 3-12: River Water Levels during November 2009 Drawdown



This significant drawdown allowed Weston & Sampson to begin answering some of the broad questions posed by the potential removal of Great Dam. The Drawdown largely confirmed the presence of a natural bedrock ledge immediately upstream of Great Dam.

While the ledge was partially obscured by the continued discharge of approximately 180 cfs as well as rocks, bricks, logs, leaves, and other debris, it is clear that the ledge extends the width of the River. Also, the ledge does appear to be located somewhat higher than El. 15.3’ as estimated in previous studies. Based on visual observations from the Drawdown, the natural impoundment would be more likely to appear between El. 16.0’ and 18.0’ at the Great Dam location.

In addition to confirming the presence of a natural impoundment, the Drawdown also showcased what such a natural impoundment may look like. Prior to the Drawdown, Weston & Sampson hypothesized that the natural impoundment would appear significantly more riverine than the current Impoundment. This hypothesis was largely confirmed during the Drawdown as shown in the photos below. Generally, the river was slightly narrower and faster. Overbank areas were significantly more distinguished from the river channel and floodplain. As hypothesized, these changes were most obvious near the confluences of the many tributaries, such as the Little River, the Cove, and Great Brook.

The more riverine nature of the Exeter River was also obvious in the Impoundment's hydraulic grade line. Typically, Great Dam impounds the River to such an extent that the water levels at the Dam and River Intake are nearly identical. During the Drawdown, however, this relationship changed. When the water level at Great Dam was sustained at approximately El. 18.25', the water level at the River Intake was nearly one foot higher as shown in Figure 3-12. Combined with the higher-than-expected bedrock ledge, this hydraulic grade line yielded surprising and encouraging results regarding the Town's ability to withdraw water at the River Intake pump station. Additional photographs of the Great Dam and ledge above the Great Dam during the drawdown are shown below:

Great Dam Water Level and Gate – 11/13/2009

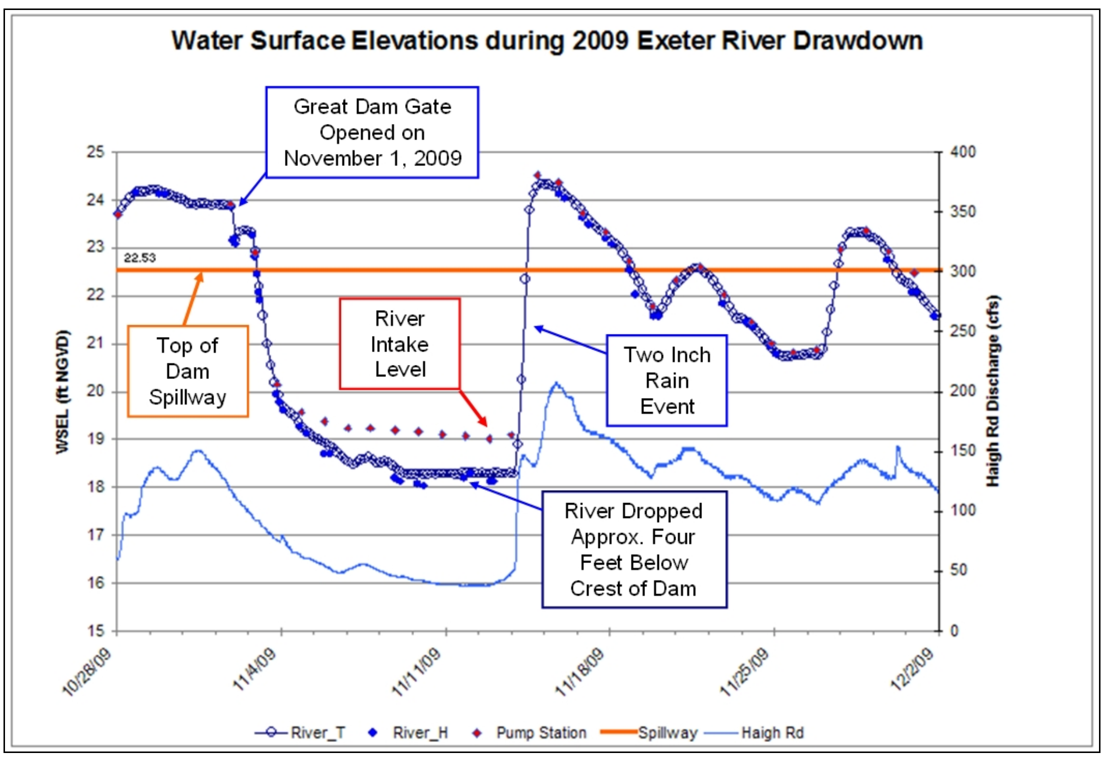
Ledge Appearing Above Great Dam – 11/12/2009

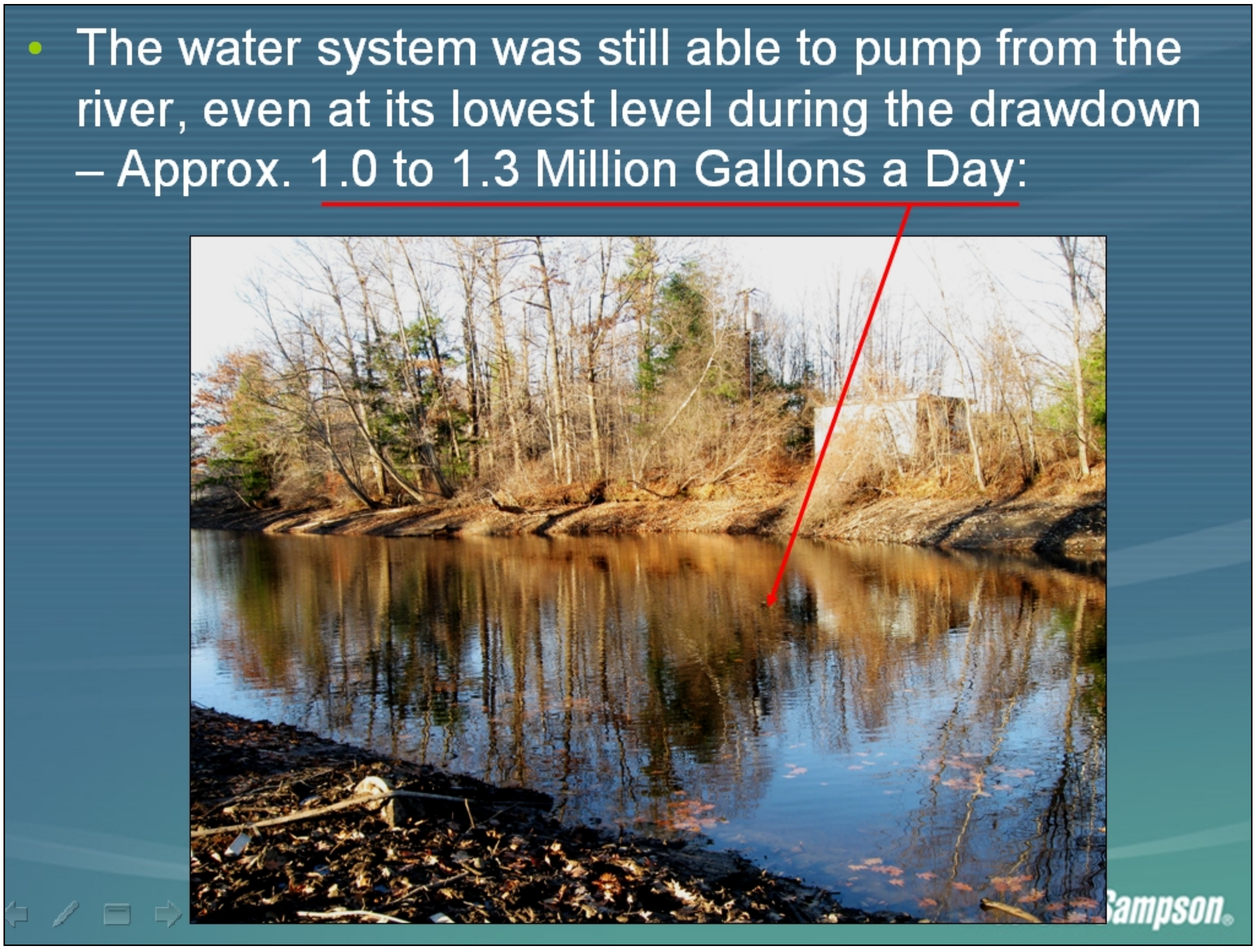
As discussed in Section 3.6, one concern regarding the potential removal of Great Dam is the potential impact the corresponding lower water level would have on the Town's ability to withdraw water from the River Intake. Prior to the Drawdown, Weston & Sampson hypothesized that the River Intake would require a minimum water surface elevation of approximately El. 16.0' based on previous studies, with even higher minimum water levels likely. Previous studies suggested that a natural impoundment might have a normal pond level of only El. 15.94' as shown in Figure 3-9, suggesting a potential problem for water withdrawals during low flow periods.

However, the results of the recent Drawdown indicate this issue may not be as severe as previously hypothesized. The bedrock ledge that would likely form a natural impoundment following a potential dam removal appears to be located 1 to 3 feet higher than anticipated. In addition, the shift in the hydraulic grade line without Great Dam would cause water levels to be approximately one foot higher than those at the Dam location. These two factors, revealed during the Drawdown, suggest that while modifications to the River Intake might be required if Great Dam were removed, these modification would not be as substantial as previously hypothesized. It is very likely that normal water withdrawals would still be possible for much of the year even without any modifications. In fact, the Town pumped between 1.0 and 1.3 million gallons a day from the River throughout the entire Drawdown. It must be noted that the availability of having a variable speed drive pump in the station was also very helpful, as the Town was able to reduce the pumping rate as the river dropped during the Drawdown.

The following graphic shows the water levels of both the Great Dam and the River pumping station during the Drawdown. As the river dropped lower, the effect that the hydraulic gradient had on the river pumping station became more evident, as shown by this figure:

Figure 3-13: River and Pumping Station Water Levels during November 2009 Drawdown

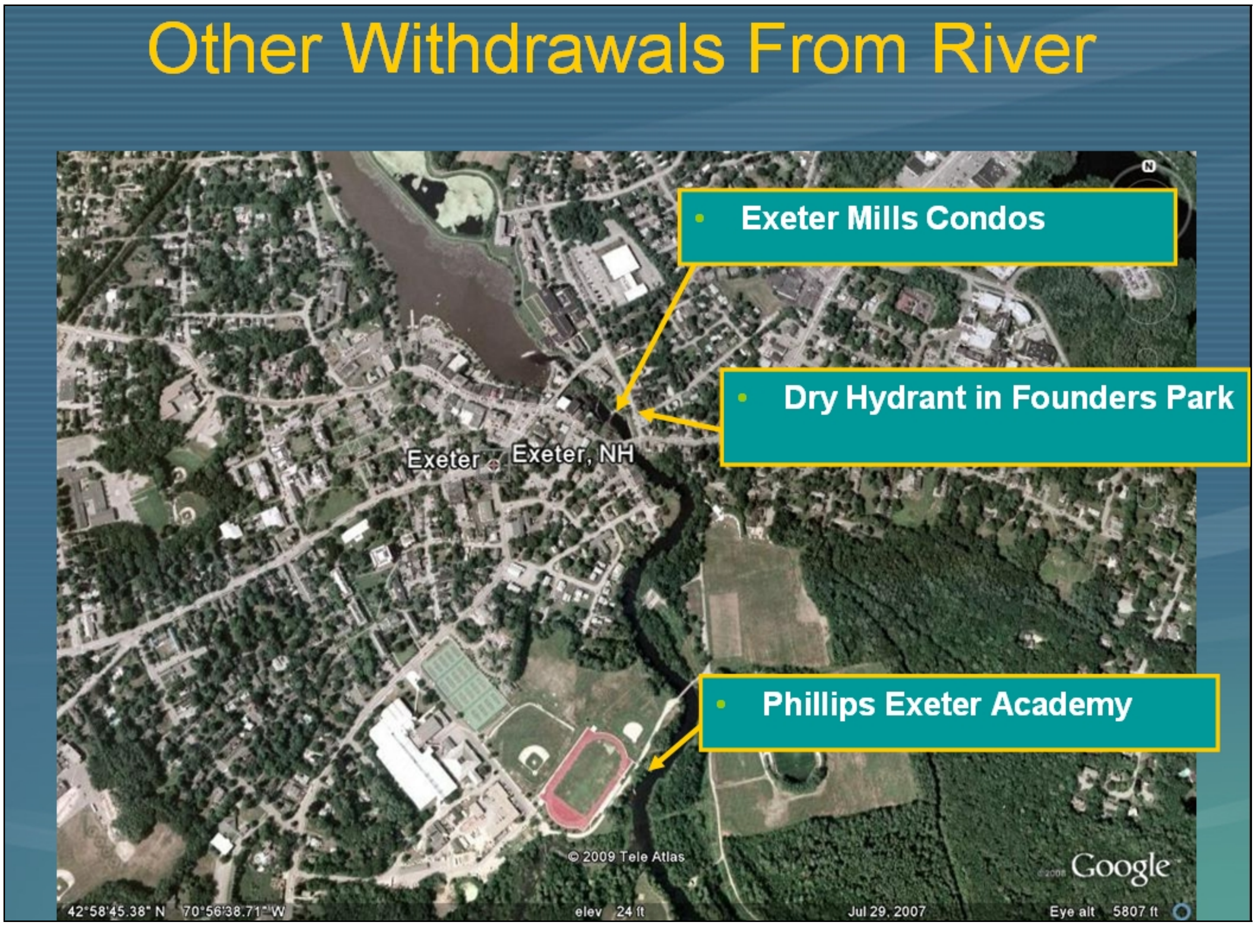




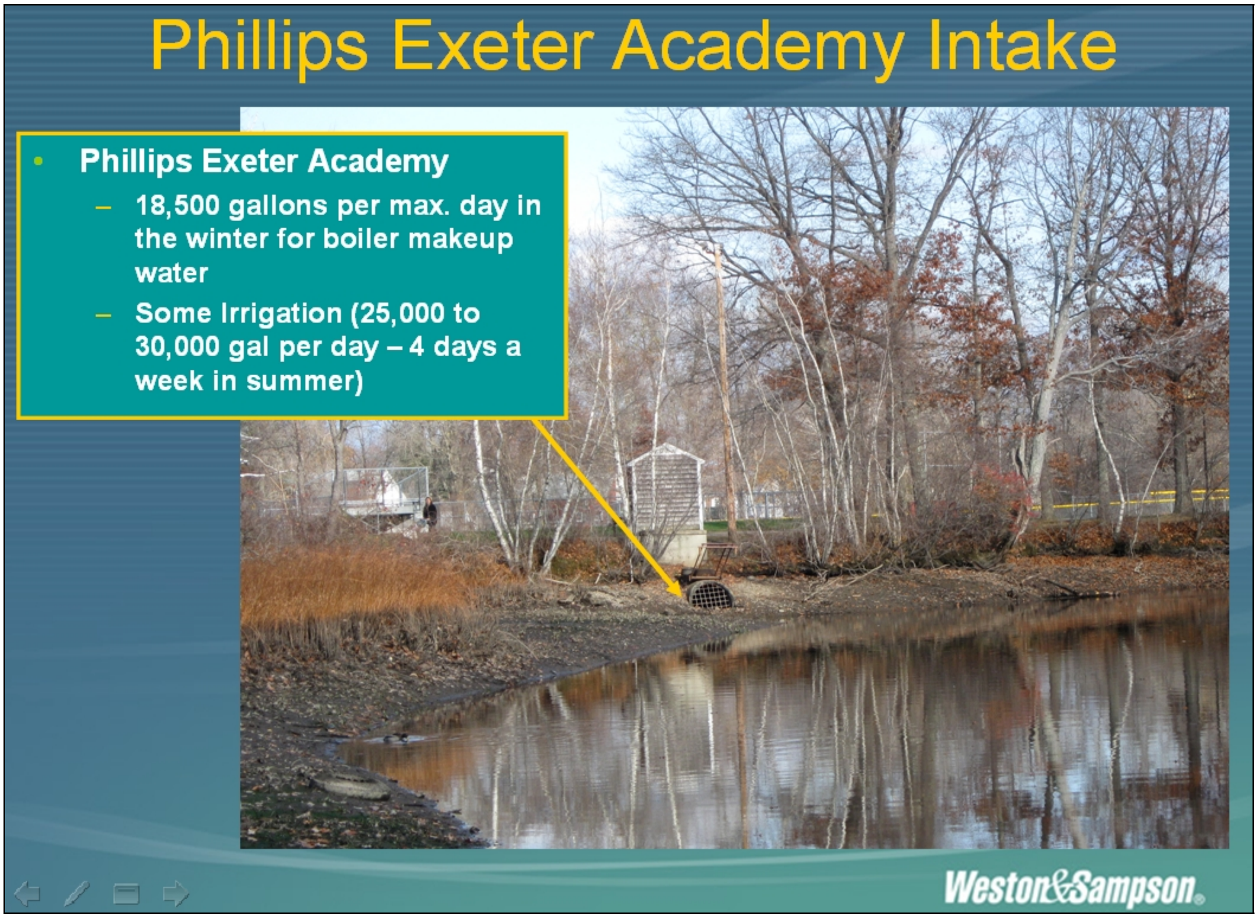
Lastly, the Drawdown provided insight into the potential impact of dam removal on groundwater levels in the aquifer that are accessed by Exeter's groundwater wells. Water level data was recorded from several observation wells accessing that aquifer during the Drawdown. That data is currently being analyzed and will be amended to this report via a letter.

3.8 Other Surface Water Withdrawals from the Impoundment

Another focus of this study was to research and determine the number and volume of other withdrawals that obtain water behind the Great Dam impoundment. The following graphic shows the three other withdrawals, besides the Town's river pumping station, that may be effected by dam removal:



3.8.1 Phillips Exeter Academy



According to correspondence with Mark Leighton, Phillips Exeter Academy's Associate Director of Facilities Management, the Academy's makeup water intake for the central heating plant is located adjacent to Lovshin Track, where there's a shallow well that is approximately 10.5 feet deep. It's also the same source to irrigate the soccer, baseball, and softball fields. River water is also used to irrigate the athletic fields adjacent to Phelps Stadium located on the East side of Exeter River. The source is also a shallow well located on the East side. During the months of June, July and August; approximately 25,000 – 30,000 gallons of river water is used per day for approximately 4 days per week for irrigation. The Central Heating Plant on average will use approximately 12,000 gallons per day of river water for the operation of the heating plant.

3.8.2 Exeter Mills Apartments

Weston & Sampson personnel conducted a site visit at the Exeter Mills on July 22, 2009. We spoke with Tracy Montgomery, Property Manager and Bill Hally, Property Maintenance Supervisor. They provided detail regarding their facilities and use of water from both the public water system and the river.

Exeter Mills Condominiums

The Exeter Mills complex is now almost entirely residential. The former Exeter Manufacturing Company facilities were converted into housing in the mid 1980's. Since that time, additional buildings have been converted and a few new ones added. Currently, there are 13 different buildings on the site, 12 of them are housing units that range from one bedroom apartments to townhouses. There is also a former warehouse located across the street from the main Mills buildings. According to the Mills, this facility is mostly vacant and may be demolished in the future to make room for additional housing. All 13 buildings get their domestic water from the Town's municipal water system. A total of 152 different housing units make up this use. Usage ranges from 309 gallons per day for the townhouses to 99 gallons per day for the one bedroom apartments. Overall, the average water use for the Mills is 120 gallons per day per unit.

The Mills still obtain water from the river via the penstock at the dam. This water is used for the cooling system that cools four of their main buildings. According to Bill Hally, the system is a heat exchanger that "can get up to 99 degrees in the summer." He also added that the state is "looking into having us cool it back down to 68 degrees before we return it to the river." Currently, the return flow from the exchanger goes directly into the tidal area of the river below the dam. He mentioned that they have looked into converting their system over to cooling towers rather than continuing use of the heat exchangers, however, at the time of this report there is no timeframe or decision to that effect. The other buildings are cooled by units that do not rely on river water.

At the time of our site visit the Mills had installed a new metering system on this water line though it was not in operation. However, during follow-up conversations with the Mills, they relayed data from the meter after it went on line and also referred to pump data for the system. According to this information, it is estimated that the Mills use 50,000 to 150,000 gallons per day from the river during the summer months for cooling.

The Mills can also use the river water for their irrigation system. At the time of our site visit they were also in the process of installing a meter on this system. However, as of the writing of this report the system had not been up and running.

According to Bill Hally, the Mills utilize the river for some of their fire suppression needs. During our site visit he explained that the larger buildings rely on a dry system that can obtain water from both the Town system and via booster pumps that derive water from the river. He also mentioned that some of the hydrants on site were also connected to the Town's system, however he did not know exactly which ones. We suggest that the Town follow-up and pressure test these hydrants and check for the presence of chlorine to determine exactly which ones are on the Town system. Finally, the warehouse no longer utilizes large fire pumps for their fire suppression system.

3.8.3 Dry Fire Hydrant in Founders Park

According the Town's Fire Department, there is a fire hydrant in Founders Park, adjacent to the Great Dam, which is piped into the river impoundment. This hydrant can be accessed by the fire department and hooked to a fire truck equipped with a pump and used as a supplemental source of fire fighting water for fires that may occur in the downtown vicinity.

3.8.4 Others

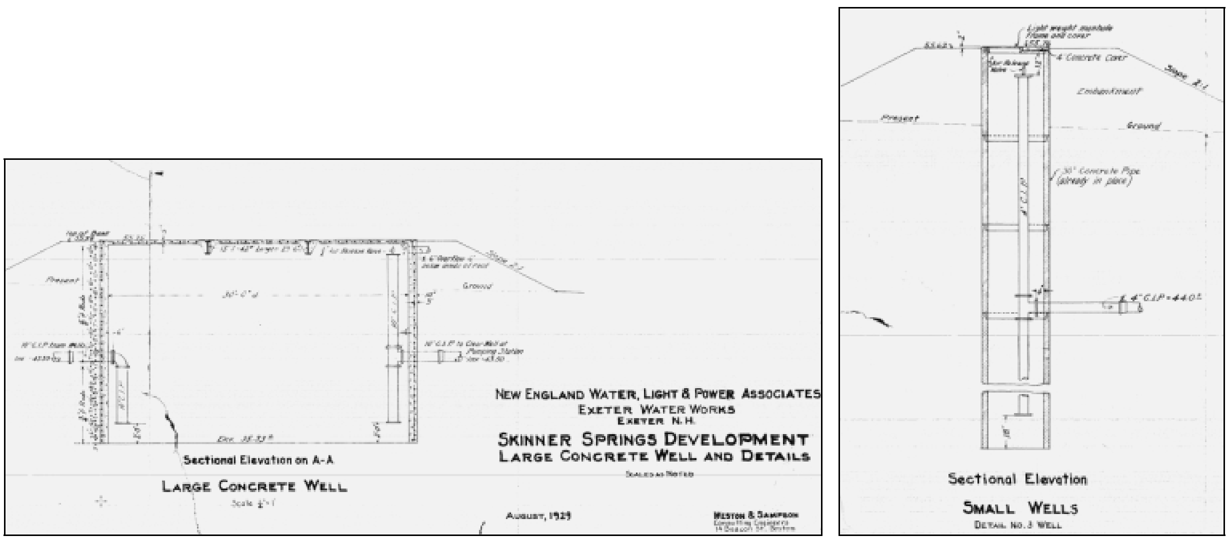
Weston & Sampson performed a query with DES and others regarding any other potential major withdrawals that take water directly from the Exeter River below the Pickpocket Dam that might be effected by dam removal and no others were found as of the writing of this report.

4.0 SKINNER SPRINGS AND EXETER RESERVOIR YIELD ANALYSIS

4.1 Skinner Springs

4.1.1 Overview and Inspection

The Skinner Springs have been utilized by the Town of Exeter as a public drinking water source since 1929. The system consists of six shallow wells manifolded into one collector well. All of the sources are fed by gravity into a 10-inch water line that sends water to the Town's surface water treatment plant located adjacent to the Exeter Reservoir.



Skinner Springs – Original Design Documents from 1929

The Skinner Springs collection system generally takes advantage of the "siphon" effect to withdraw groundwater from multiple locations. These multiple locations are "siphoned" to one central collection well allowing a single pumping location. This system, while capital intensive, often results in lower operating costs. In cases where additional drawdown is available, higher maximum yields may be available to optimize a source potential. A more specific description is provided below.

4.1.2 Well Construction

The center of the Skinner Springs source consists of a large diameter caisson well. This cement caisson is approximately 30 feet in diameter and 21.85 feet deep. The caisson walls appear to be well over 1 foot thick. It is not clear whether the side walls have any openings or "ports" near the bottom of the caisson, although this was a common design practice for that period. Additionally, the bottom of the caisson may be simply coarse gravel and sand allowing groundwater to pass upwards into the caisson. In this case, groundwater levels within the caisson reflect the piezometric head of the spring source.

Where a spring or set of springs is evident along the base of a large sloping hillside, yields were often maximized by installing multiple withdrawal points. In order to avoid multiple pumps, the central caisson or pumping location was tied to the other wells via drop pipes set in each collection point.


Skinner Springs – Inspection of Large Collector Well and Satellite Well

At Skinner Springs, up to three satellite wells were located in the field during a site visit performed by Weston & Sampson. These wells appear to be 32 inches in diameter and constructed of 2-3 inch thick cement caissons. These caissons were undoubtedly "sunk" into the ground by excavating natural formation/soils from inside of the casing. By slightly over excavating the internal material, the weight of the caisson alone would advance the well into the ground. Gravel fill material is shown on the construction diagrams allowing smooth laminar flow up into these "mini caissons". The internal piping is still evident within each mini caisson. The wells are filled with 4 inch drop pipes extending well below the static water level and below the effective limits of suction (approximately 28 feet). These drop pipes are fitted with air release valves and an alternate valve. Drop pipes at each well are then connected to a main trunk line which feeds back to the 30 foot caisson. It is not clear how this line was primed prior to operation; however, once filled with water, lowering the main caisson level would cause water to be drawn from each mini-caisson towards the main well.

As each mini-caisson is deeper than 28 feet (the effective lift for water), additional yield may be available from each withdrawal point. To test this, the minor amounts of soft silt and sediment accumulated in each caisson should be removed and a step rate pumping test conducted at each well. Measurements of interference should be made and a total yield estimate for the springs can be obtained.

4.1.3 Watershed Area

The watershed supporting the spring and the surficial aquifer is approximately 37 Acres in size. Recharge derived from infiltration into the subsurface from precipitation falling on the watershed is estimated to be approximately 21 inches/year (Flynn and Tasker, 2004).

4.1.4 Estimated Safe Yield

Using a mass balance approach, the six shallow wells at Skinner Springs are able to capture approximately 57,747 gpd (40 gpm). This estimate does not account for the possibility of leakage from bedrock into the surficial aquifer and subsequent capture by the shallow well system.

Previous reports have cited estimated yields of 125,000 gpd (Weston & Sampson, 1968) and 50-100,000 gpd (CDM, 2002). Anecdotally, Paul Roy, Water Treatment Plant Operator cites that the water quality seems to be optimized when the Skinner Springs valve is left open at a rate of approximately 75 gpm (108,000 gpd).

4.1.5 Water Quality

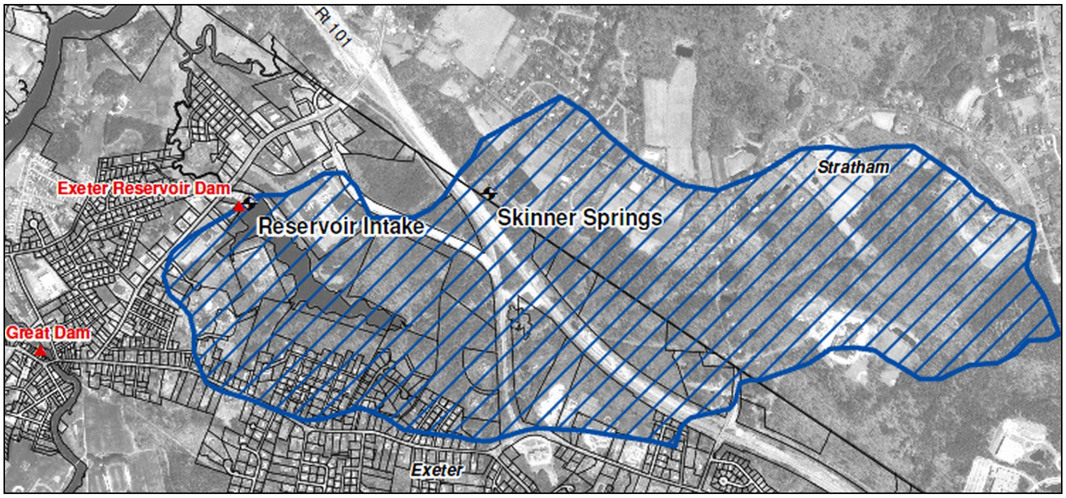
In general, the water quality of the springs is very good. There have been some concerns about the presence of bacteria in the well, but this is mostly an issue with the fact that the springs are listed as a groundwater source of supply in the DES database. In reality, they are piped to the water treatment plant and combined with the settled surface water at the filters, so the spring water is treated as surface water, with chlorination and filtration.

According to the water treatment operations staff, there are occasions when the springs cause red water due to iron and manganese. This happens when the transmission line, which is unlined cast iron, has been turned off for a period of time and then turned back on. Most likely, the colored water is coming from deposits on the pipe. This would most likely be improved if the line were cleaned and relined.

4.2 Exeter Reservoir

4.2.1 Watershed Description

As described in Section 2, the Exeter Reservoir was constructed in 1886 and is located in the Dearborn Brook Watershed. The watershed area upgradient of the impoundment is approximately 1.5 mi^2 in size. Since 1886, the dam has been raised at least four times increasing the impounding reservoir to an estimated storage capacity of 57,000,000 (Weston & Sampson, 1968). The active storage capacity however is estimated to be approximately 10-25 MG.



Exeter Reservoir Watershed Area

The Town of Exeter worked with the Rockingham Planning Commission and Piscataqua Region Estuaries Partnership to develop the "2003 Dearborn Brook Watershed Management and Protection Plan, Stratham and Exeter, NH." This plan provides summaries of the watershed and groundwater flow. They are as follows:

> The water resource value in this watershed is high. Groundwater flow in shallow unconsolidated sediments in this area roughly follows the slope of the land. The Dearborn Brook represents a local flow system. Since this watershed is small and topographically isolated, groundwater flows from hilltop to valley and exits the system via wetlands, seeps, springs and the brook. Groundwater flow from Rollins Hill, Stratham Heights and the High Street uplands towards the wetland area and Dearborn Brook and then flows beneath the wetland or brook towards the Exeter Reservoir. In the area east of Rollins Farm Road, the divide between groundwater flowing towards Dearborn Brook as opposed to the Winnicut River system is not precisely known. There may be times of the year when flow is reversed towards the Dearborn Brook area. In the area surrounding Skinner Springs, groundwater is forced upward as it flows from the high permeability kame terrace to the much lower permeability marine sediments.

4.2.2 Safe Yield

Generalized watershed yield curves developed by the New England Water Works Association (NEWWA) were used in an evaluation completed by CDM in 2002. These curves are based on analysis of several drainage basins in New England, and include the effects of the mid-1960's drought. The curves express the safe yield of a watershed as a function of drainage area, reservoir storage volume and water surface area. Using the data described in the preceding section, CDM's estimate of the Exeter Reservoir's Safe Yield is 0.2 – 0.25 MGD.

5.0 GROUNDWATER RESOURCE OPTIONS

5.1 Current Water Supply Options

As described in Section 3, the existing water supply sources for the Town consist of two surface water sources, one well and one relatively low yielding spring. Based upon three years (2006 – 2008) of monthly withdrawal data, the following table summarizes the average withdrawals from each source. Note that the Lary Lane Well was only used sporadically due to arsenic concentrations. As previous analysis in this report has shown, this well has contributed up to 20% of the Town's water supply needs in some years.

Table 5-1: Current Average Withdrawal Percentages

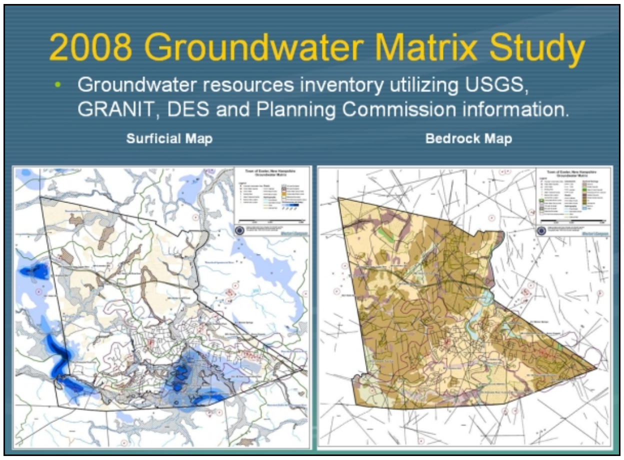
Type	Source	% of Total Withdrawal
Surface Water		
	River Intake	56%
	Reservoir	33%
Groundwater		
	Skinner Springs	5%
	Lary Lane Well	6%

Clearly, the majority (~89%) of the water is currently derived from the surface water sources with lesser contributions (~11%) from the two groundwater sources. As pointed out in other sections of this report, the use of groundwater has historically played a larger role than it currently does. Recognizing this fact, the Town has been proactive in its approach to diversify and contracted Weston & Sampson to conduct a desktop analysis of potential groundwater sources in Town.

5.2 Previous Work (Groundwater Matrix)

5.2.1 Purpose

The Town embarked on developing a Groundwater Matrix with Weston & Sampson and the former Water and Sewer Advisory Committee. This study was undertaken in 2007-2008 and was presented to the Town's Board of Selectmen in July 2008.



This work was to identify available groundwater development opportunities and develop a cost effective plan to better diversify the Town's sources of supply. With a more diverse supply, an integrated management plan could be developed and implemented. This plan would facilitate the optimum management of integrated surface water and ground water resources, and sustain a balance between water uses and water supplies so that the economic viability, social and environmental health, safety and welfare of the river basin can be achieved and maintained for both near and long term.

5.2.2 Considerations

Groundwater sources can (1) reduce expenses related to development, operations, maintenance and treatment of water supply, (2) be better protected from potential contamination sources, and (3) are less susceptible to regulatory limitations on withdrawal rates. For these reasons, a town wide search for both favorable surficial deposits and bedrock fracture systems was compiled. In an effort to utilize all existing information, this work also involved the creation of an electronic database of all studies, data, and research for easy reference, the updated version of which accommodates greater than 130 electronic documents. The referenced documents include 1) previous studies on file with the Town; 2) annual Town Reports on file at the library; 3) New Hampshire DES file search data; 4) USGS Reports; and 5) field reconnaissance and meetings with Town Public Works and Water System staff. This database is currently on file with the Town of Exeter.

All of this information was compiled and reviewed in the development of a ranking system that considered three major criteria dubbed water source, direct issues, and indirect issues. Fifty percent of the ranking was attributed to water source issues including:

- Potential Yield
- Water Quality Concerns
- Reliability of Data

The direct issues were given a weighting factor of 30% and included the following:

- Land ownership
- Capital costs
- Operations and Maintenance
- Ownership or easement for sanitary protective radius
- Distance from distribution system
- Pipeline capital costs
- Regulatory concerns (new source permitting)
- Site construction complexity

Indirect issues weighted the remaining 20% and included the following:

- Potential for public support/opposition
- Current land use in 4,000-ft radius (potential contaminant sources)
- Wetland issues
- Floodplain issues
- Impact on other water supplies
- Local approval considerations
- Wellhead protection area considerations

A total of four existing water supplies (Gilman, Stadium, Skinner Springs, and Lary Lane), seven potential new surficial sources, and ten potential bedrock sources were evaluated and ranked based on the aforementioned parameters as well as a spatial analysis utilizing GIS-based datasets derived from the USGS, DES, and UNH databases. The spatial analysis focused on the regulatory and hydrogeologic conditions favorable for the development of municipal groundwater supplies such as artificial recharge capabilities, formation characteristics, piezometric mapping, boundary conditions, induced infiltration, fracture trace analysis (bedrock), and an evaluation of adverse impacts from pumping.

5.2.3 Results & Recommendations

The results of the ranking provided quantitative support to the following recommendations:

1) Treat the Lary Lane Well (for Arsenic)
2) Reactivate the Gilman and Stadium Wells
3) Investigate Skinner Springs Optimization
4) Investigate potential for new groundwater source within the same aquifer the Gilman and Stadium wells are located within, but in the southeastern part of Town.

5.3 Recent Work Completed

5.3.1 Summary

Pursuant to the recommendations developed from the aforementioned Groundwater Matrix analysis, the Town moved forward with authorizing the first three recommendations in the later part of 2008. The following tasks were completed at this time:

- Preparation and submittal of the Preliminary Report (Env-Dw 302.12) in support of reactivation of Gilman and Stadium Wells.
- Conduct pumping test(s) on Gilman and Stadium wells pursuant to the approved Preliminary Report.
- Conduct pilot testing of the Lary Lane, Gilman and Stadium well source water to compare the efficacy of three iron and manganese removal processes.
- Prepare report to Town describing results of pumping and pilot tests completed with estimated yield and treatment needs.

5.3.2 Gilman Well

Upon further inspection of the Gilman Well and pump house it was determined that the well screen had collapsed at the junction of the screen and the casing. Prior to conducting a pumping test on the Gilman Well it was recommended that the well be rehabilitated and the concrete sanitary seal be reinforced to prevent the migration of surface waters into the lower aquifer and ultimately into the pumped water. The design of the liner screen was completed based on existing well construction diagram, television inspection of the well, caliper log, and analysis of existing gravel pack material. The result was to slip line the existing (collapsed) 18-inch shutter screen with a 5-ft long, 120-slot stainless steel 12-inch diameter well screen installed with a 12-inch x 18-inch K-packer assembly. This diameter screen was chosen to pass through the buckle in the existing well screen and allow for the 1/8 x ¼ -inch gravel pack to be emplaced within the new annulus. Once the well was slip-lined, the well was chlorinated and developed until the well was sand free and there was no appreciable increase in specific capacity. Additional concrete sanitary seal was also emplaced between the 24-inch x 18-inch annulus from 7 to 16 feet below ground surface.

Preparing for Pumping Test Observations (July 2009) and Gilman Pump Discharge Line

Upon completion of well rehabilitation efforts, a five-day pumping test and water treatment pilot study was conducted in conjunction with testing of the Stadium Well from June 26th to July 17th, 2009. The well was pumped at a rate of 230 gpm for five days. Results of this work are summarized in Section 5.4 below.

5.3.3 Stadium Well

Demolition of the Stadium Well Pumphouse

Stadium Well Restoration

Inspection of the Stadium well resulted in the recommendation to demolish the existing pump house and provide additional reinforcement of the concrete sanitary seal. Once this work was completed, a five-day pumping test and water treatment pilot study was conducted in conjunction with testing of the Gilman Well from June 26th to July 17th, 2009. The well was pumped at a rate of 500 gpm for five days. Results of this work are summarized in Section 5.4 below.

5.3.4 Lary Lane Well

At the completion of the Gilman and Stadium Well pumping test and water treatment pilot study, a water treatment pilot study was conducted on the Lary Lane Well while being pumped into the distribution system. Results of this work are summarized in Section 5.4 below.

5.4 Results of Work Completed

5.4.1 Gilman Well

The full analysis and evaluation of the safe yield and delineation of the wellhead protection area from the pumping tests conducted at Gilman and Stadium is provided in a report prepared for the Town and will be submitted to the Town under separate cover. The results suggest that the Gilman Well is capable of pumping at a rate of 580 gpm (0.84 MGD) when pumping individually and 330 gpm (0.47 MGD) when pumping with the Stadium Well pumping at 491 gpm.

5.4.2 Stadium Well

The full analysis and evaluation of the safe yield and delineation of the wellhead protection area from the pumping tests conducted at Gilman and Stadium is provided in a report prepared for the Town and submitted together with the analysis of the Gilman Well testing. The results suggest that the Stadium Well is capable of pumping at a rate of 838 gpm (1.21 MGD) when pumping individually and 491 gpm (0.71 MGD) when pumping with the Gilman Well pumping at 330 gpm.

5.4.3 Lary Lane Well

Piloting a Groundwater Pressure Filtration System at the Lary Lane Well

The Lary Lane Well was also considered as a viable source for this study. The work during the summer of 2009 included a pilot for groundwater treatment during the Gilman and

Stadium pumping tests. It also included additional piloting at the Lary Lane site to determine if arsenic removal was viable through pressure filtration. The study concluded that this is an option for the Town.

The yield of this well was discussed in Section 2 of this report. A detailed pumping test was not performed as part of this study, however, there is enough historical and empirical data to safely estimate that this well is capable of a yield that is approximately 0.25 million gallons per day. Therefore, we utilized this volume for planning purposes.

5.5 Summary of Groundwater Source Potential

5.5.1 Overview

As a result of the aforementioned work completed, a summary of the groundwater source potential is provided in Table 5-2 below.

Table 5-2: Proposed Average Withdrawal Percentages

Status	*Location*	*Estimated Safe Yield (MGD)*	*Cumulative Total (MGD)*
Existing			
	Lary Lane Well	0.25	0.25
	Skinner Springs	0.1	0.35
Proposed (Tested)			
	Gilman & Stadium	1.18	1.53
Proposed (Untested)			
	Southeast Aquifer	0.5	2.03
	Additional Sites	Unknown but > 0	

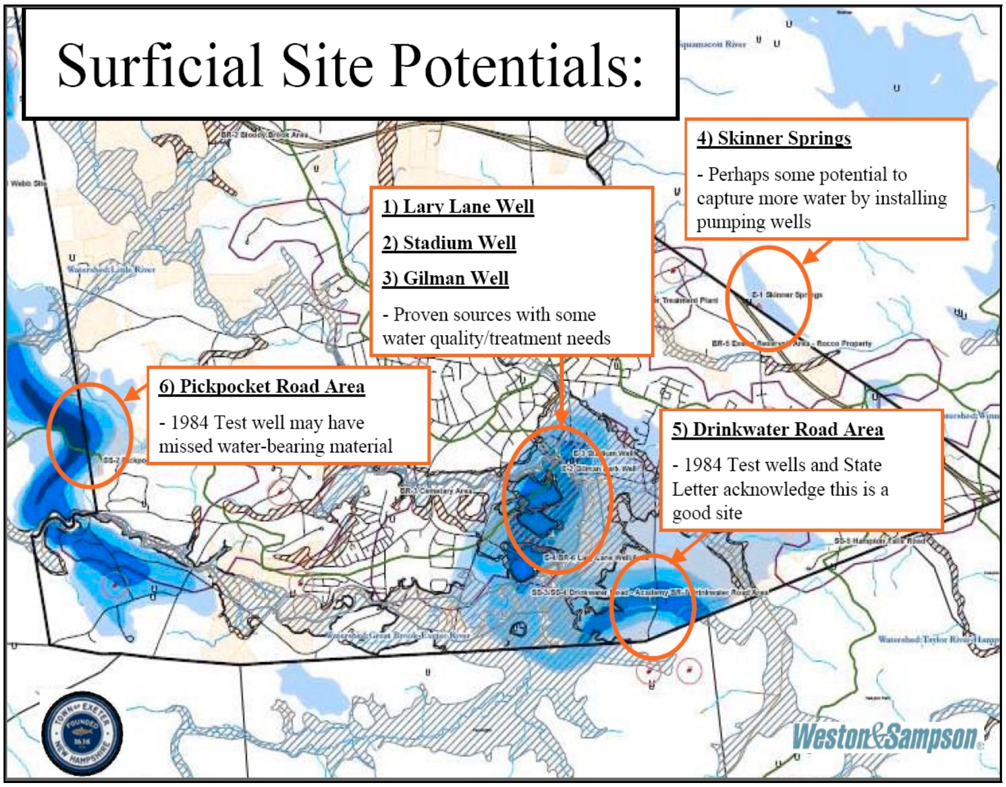
5.5.2 Southeast Aquifer

Several locations in the southeast aquifer were tested in mid 1980's for potential public water supply development. Two of those locations were determined to be favorable for yield and water quality. In 1984, a six-day pumping test was conducted on an eight inch test well at a rate of 360 gpm (518,400 gpd) on the Collishaw property. Data derived from the pumping well, observation wells and water quality analysis suggests that the aquifer properties are indicative of a confined aquifer. A realistic radius of influence was not determined and it is not known at this time whether there is indeed a connection to the aquifer near the Stadium and Gilman wells, but it is speculated to be the same aquifer. Rough estimates of aquifer safe yield coupled with previous testing completed at this location indicate that this area is 1) relatively undeveloped, 2) well protected from potential contamination sources due to the relatively impervious clay overlying the aquifer formation, and 3) estimated to be capable of producing approximately 350 gpm (0.5 MGD).

5.5.3 Other Sites

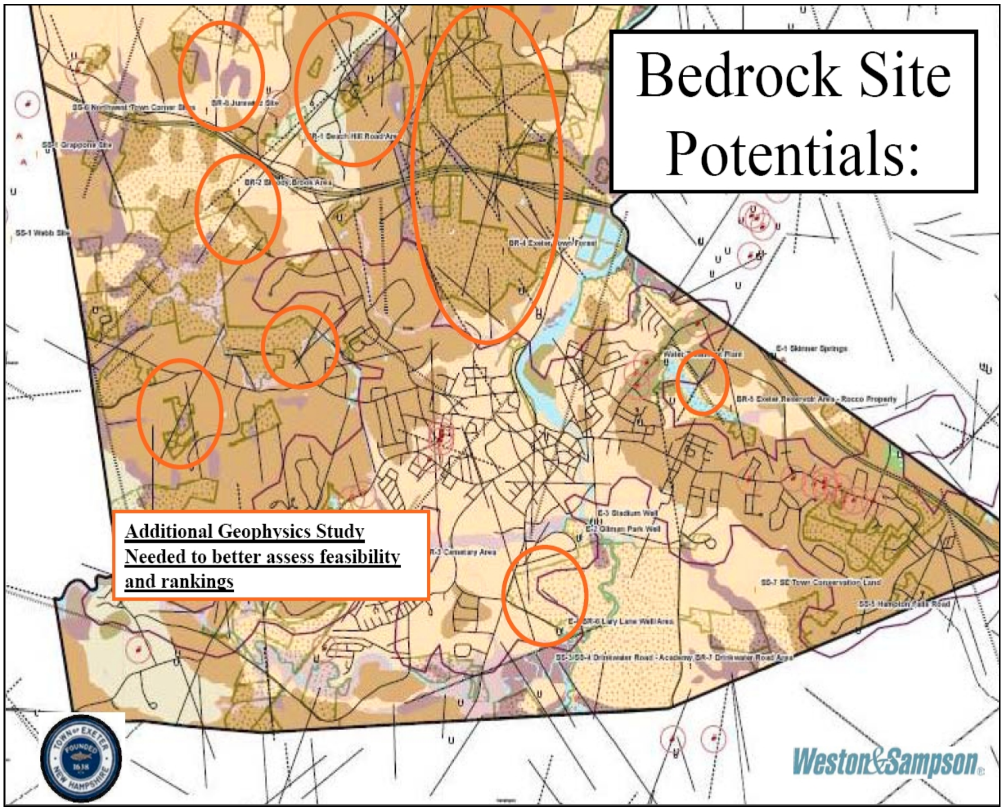
5.5.3.1 Overview

The following figures show the breakdown of possible groundwater sources of supply as presented by Weston & Sampson to the Exeter Board of Selectmen in July 2008.



5.5.3.2 Surficial Deposits

Additionally, an surficial well site was explored in 1984 in the Pickpocket Road area as part of the D.L. Maher study. A test well did not yield sufficient water at that time. However, the well site may have been just to the southeast of the water bearing material. We propose additional reconnaissance and geophysics at this site to examine the favorability of the site for water supply.



5.5.3.3 Bedrock Deposits

The Groundwater Matrix study revealed a number of additional sites worthy of further study. These included the potential for bedrock sources in the northern part of Town. In order to assess the viability of these sites we recommend site reconnaissance and geophysics to narrow down the possible areas of source exploration. Once these areas are more defined, test well drilling would be recommended.

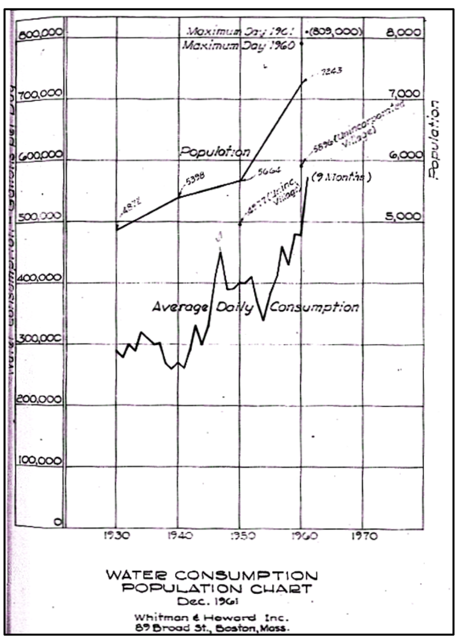
6.0 WATER SYSTEM DEMANDS, GROWTH AND DEMAND MANAGEMENT

6.1 Overview

A primary component of any public water system management plan is to include water system demand management into daily operations. This section of the report provides background data and studies regarding Exeter's water system demands, both projected and actual. This information provides an important perspective for future planning of water system needs.

This study also includes a detailed Water Conservation Plan for the Town's water system. A draft of this plan was developed by Weston & Sampson in conjunction with the Preliminary Report submittal for the Gilman and Stadium Wells (submitted to NHDES in November 2008). A copy of that document is provided under separate cover.

6.2 Water System Demand Studies



A number of studies commissioned over the years by the Town and others have projected future water use for the Town's water system. The graphic on the left is excerpted from a 1962 Whitman & Howard, Inc. report. It shows the Town's water system consumption trends from 1930 to 1960 and reveals an ever-increasing average daily use, nearly doubling from 300,000 gallons per day to 600,000 gallons per day. On review of this data it can be assumed that this increase of consumption could primarily be attributed to the Town expanding its water system service territory. This trend was similar to water use trends in the region and across the country at the time. Communities were experience steady growth in population and development, along with water system expansion, followed this pattern.

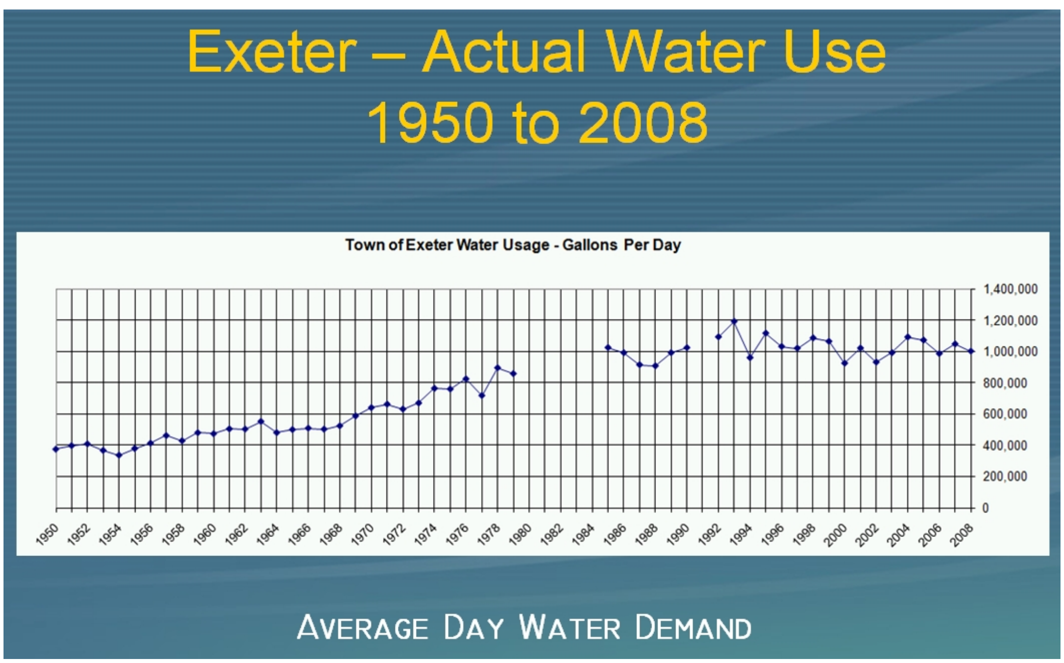
Subsequent water system studies projected increases of use similar to what the Town had experienced from 1930 to 1960. These studies were performed either for the Town of Exeter or as part of regional studies performed by others. Most of these studies projected water use for a 25 to 30 year timeframe. The following table lists the year these studies were performed and their projected demands for either the year 2000 or 2010.

Table 6-1: Water System Demand Studies

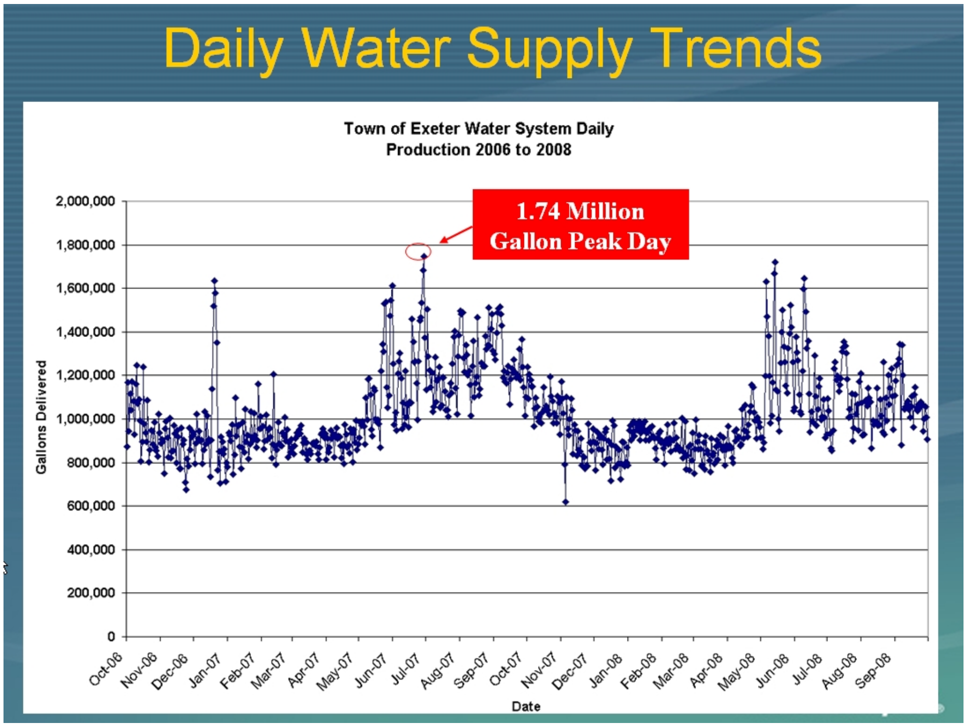
Study Year	Study	2000 Projected MGD	2010 Projected MGD
1968	Exeter Water Supply Study - Weston & Sampson	1.80	
1982	Southeastern Regional Water Study – Army Corps of Engineers	1.60	
1986	Water Supply Study - Whitman & Howard		2.19
1988	Route 108 Regional Study - Army Corps of Engineers		2.10
2002	Exeter Water System Evaluation – Camp, Dresser & McKee, Inc.		1.46
2007	Exeter Water & Sewer Advisory Committee Memo on Future Water Demand Projections		1.25 (2025)

6.3 Actual Water System Demand History

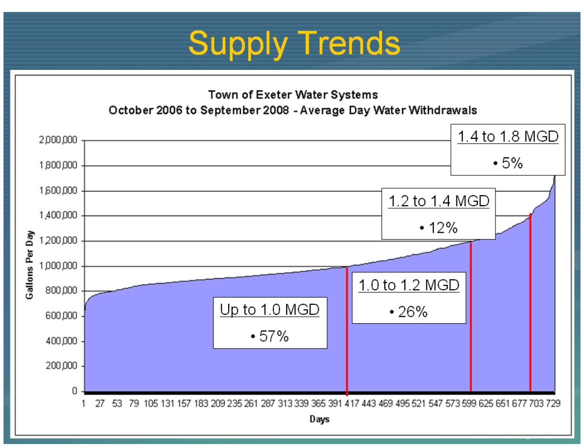
The following graphic shows the actual water use data for the Town of Exeter's public water system from 1950 to 2008. This data was obtained from previous engineering studies, Annual Town Reports and operational data. A few gaps occur due to the lack of available data however, a fairly clear picture of water supply demands for this 58 year period is evident. As it shows, water demands have leveled off in the last 10 years, holding steady at an average of approximately 1 million gallons per day.



Daily water system production for a two year period (October 2006 to September 2008) reveals the following demand pattern in the Exeter water system:



This data shows the seasonal nature of Exeter's water demand. This is a fairly typical pattern for most water systems in New Hampshire with summer demands being higher than winter demands. This can be attributed to the use of town water for irrigation, the filling of swimming pools and other outside water use. This data also shows a peak system production of 1.74 million gallons. The following graphic and table summarize the demand data over this same period of time:



Water Demand (MGD)	Number of Days	Percentage of Days
Up to 1.0	417	57%
1.0 to 1.2	190	26%
1.2 to 1.4	88	12%
1.4 to 1.8	37	5%

Source: Water Treatment Facility Operating Records - Based on 731 days of data (October 2006 to September 2008)

As this data shows, most of the water system demands are below 1.2 MGD (83%) and only 5% of the demands are above 1.4 MGD. From the perspective of planning for future water supply needs it is useful to see that Exeter's demands are not growing at a considerable rate, nor are their peak days excessive. The following section investigates this further.

6.4 Current Water System Demand Projections Based on Service Territory

The following figures show the Town's existing water system together with other water supply providers and land use patterns within the Town of Exeter's borders. Figure 6-1 shows the developed area of town, or the Town Center, which is served by the Exeter's municipal water system. Currently, this system serves approximately 3,300 customers.

Figure 6-2 shows Other Community Water Systems. These are water systems that have their own water source, pipelines and pumping facilities. The two largest systems include the Exeter River Landing system which serves 259 customers and the Exeter Mobile Home Park which serves 392 customers. Five other systems serve a total of approximately 130 customers.

Figure 6-1: Town Water System

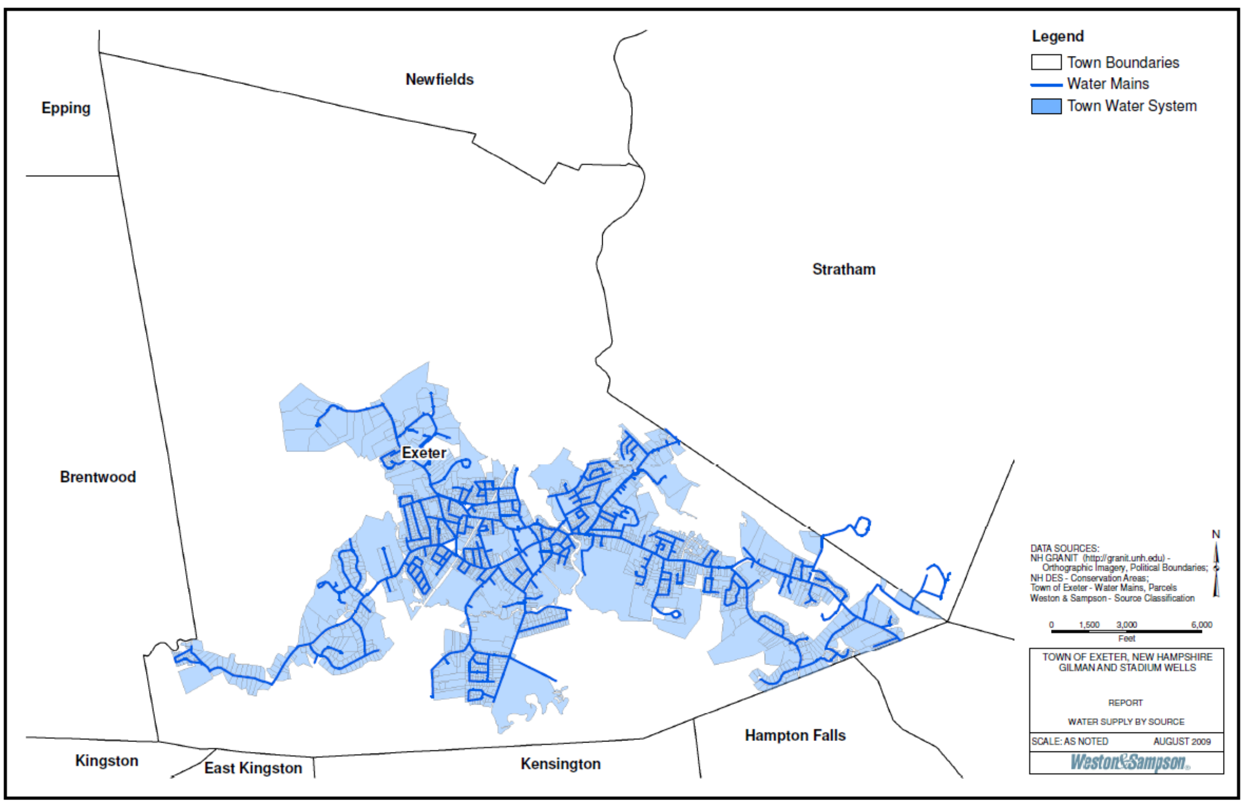
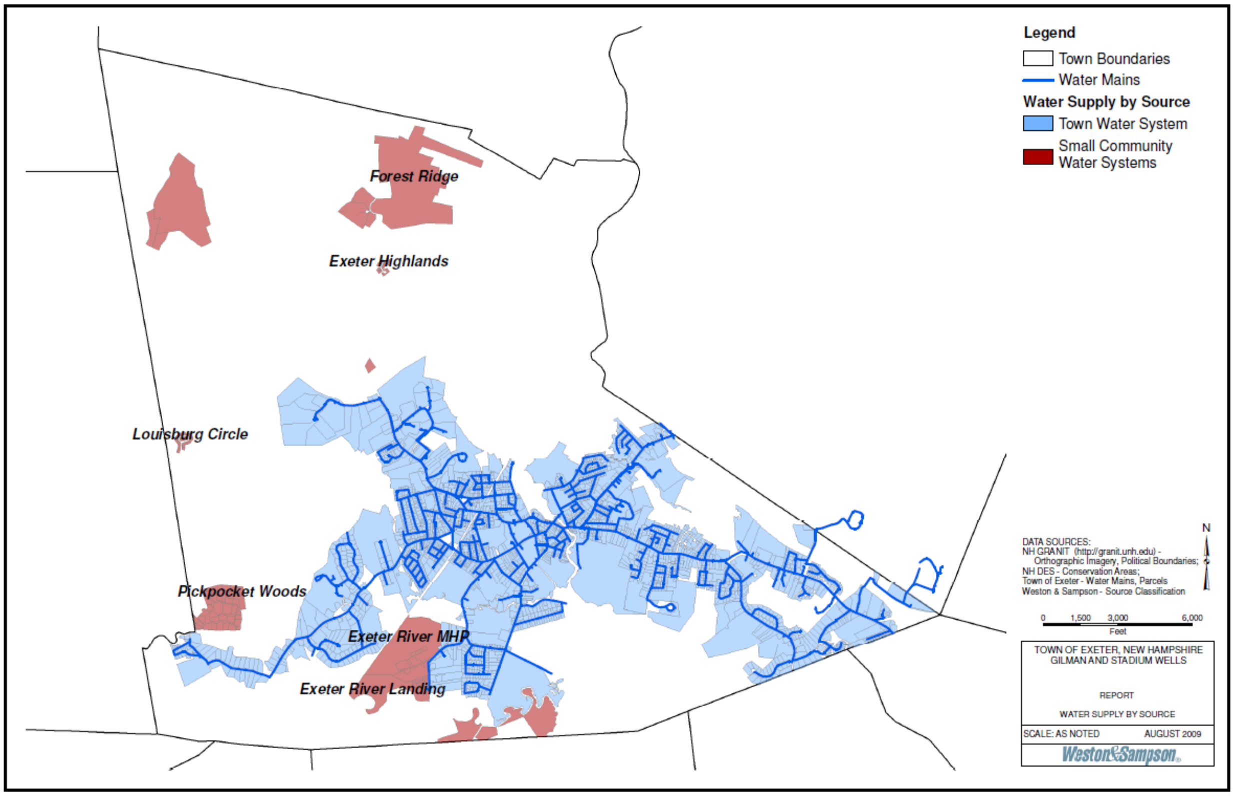


Figure 6-2: Other Community Water Systems



According to Granit GIS and town data, there are approximately 659 parcels in town that are not served by either the municipal water system or a separate community water system. These properties are mostly single family homes with their own water supply source, presumed to be an individual well. These properties are shown in pink in Figure 6-3.

There are 115 parcels totaling approximately 3,378 acres in the Town of Exeter either owned by the Town as conservation land or held by others as conservation. Figure 6-4 shows these properties in green.

Figure 6-3: Residential Wells

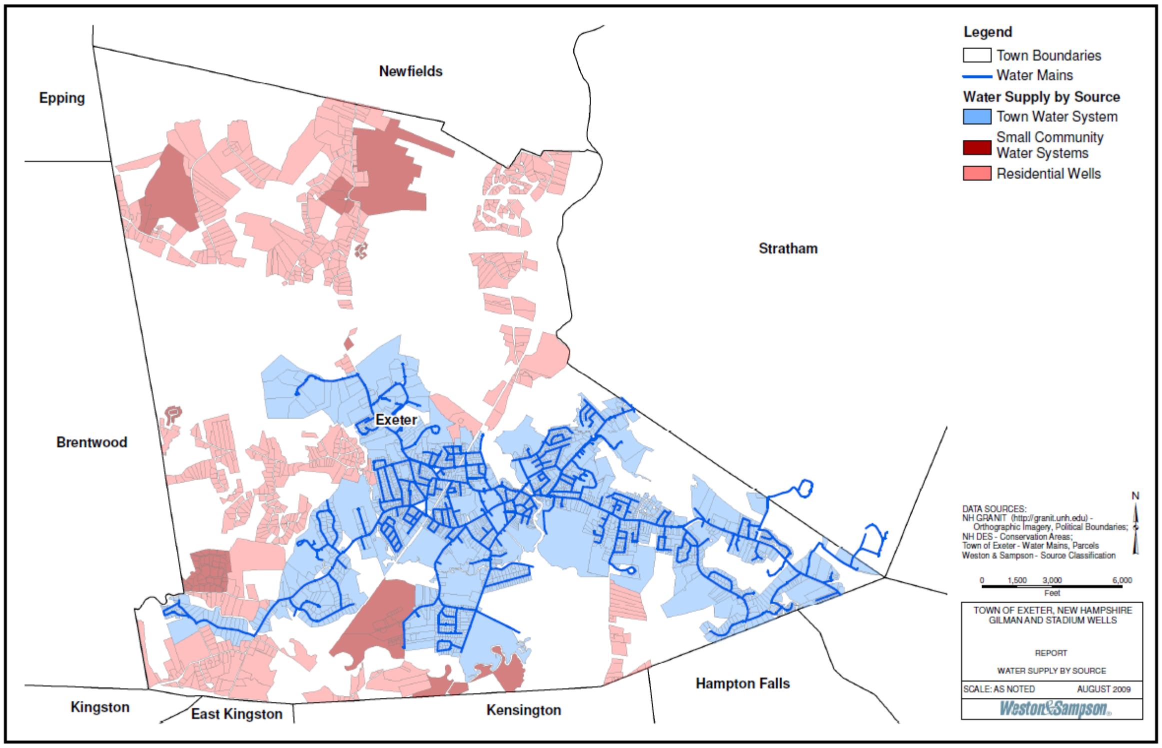
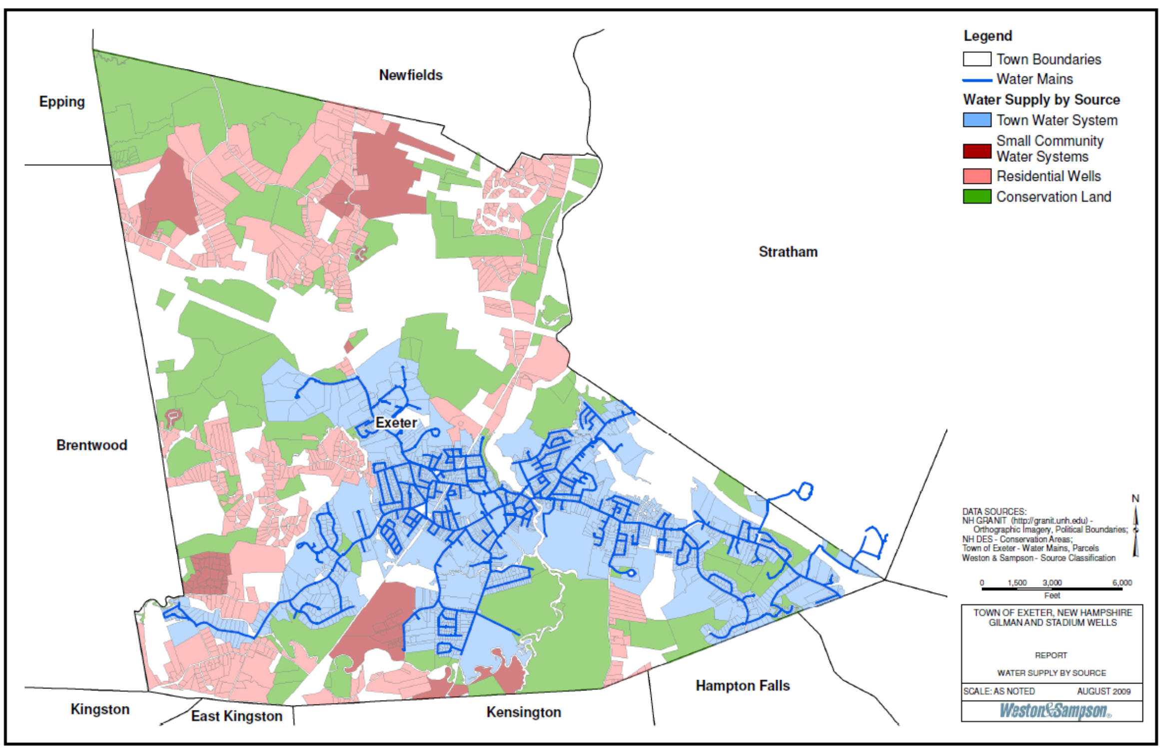
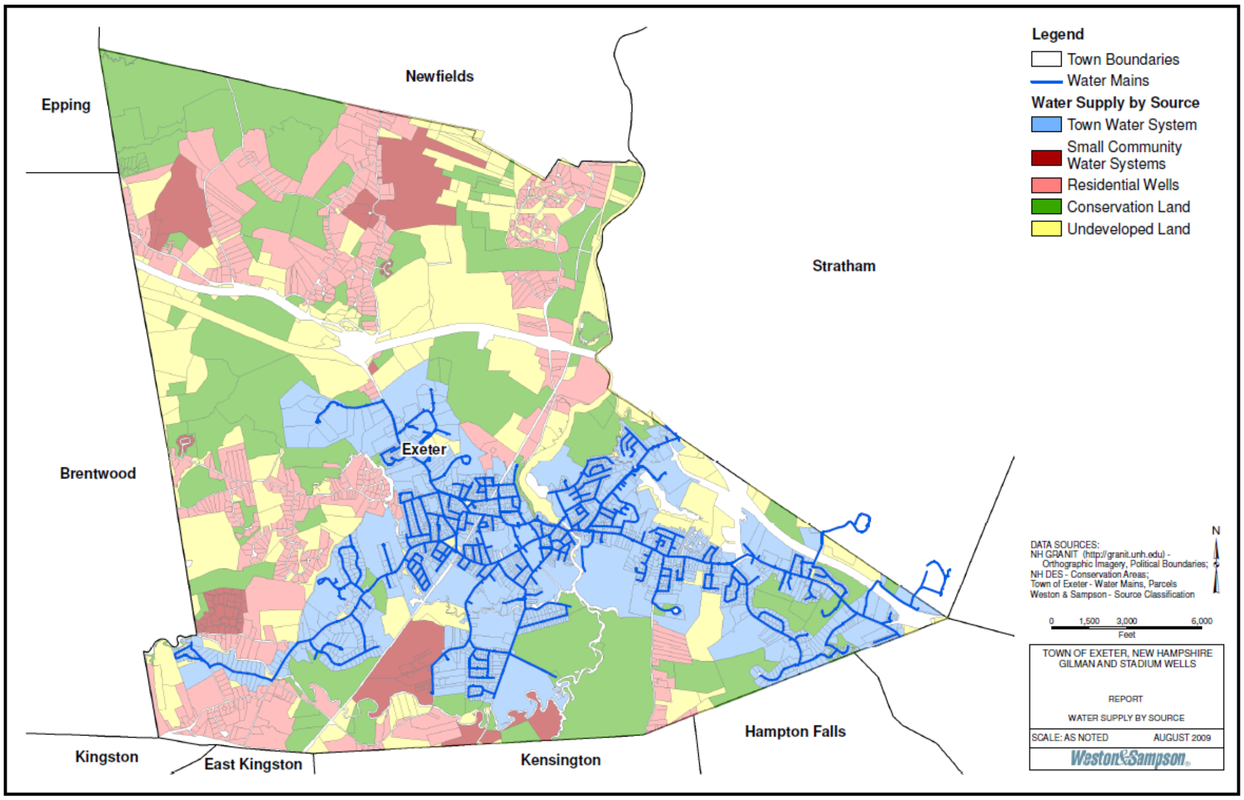


Figure 6-4: Conservation Land



Finally, as shown in Figure 6-5, there are approximately 238 parcels of land in town totaling 2,406 acres that is still undeveloped. Some of these properties are adjacent to the Town's municipal water system, most notably, the area north on Epping Road at the junction of Route 101. Currently, there are no major developments or new large water users anticipated for Exeter. If a large development were to be proposed, or a commercial user in need of a large amount of water were to be proposed, then it is most likely that the Town would require adequate additional source of supply be developed by anyone proposing such a development prior to approval.

Figure 6-5: Undeveloped Land



6.5 Water Use Demographics

The Town of Exeter currently serves 3,330 customers via their municipal water system. Weston & Sampson met with the Town of Exeter's water and sewer billing department and obtained two years worth of water user data from the Town's billing database. After reviewing the data it was agreed that utilizing one year of data for the period of October 2007 through September 2008 would be appropriate to determine water usage patterns. In review of that data we determined that some of the accounts had data that did not transfer correctly into the Excel format. By sorting these out and then doing follow-up with Town staff we were able to correct that data. This process was complicated be several factors: 1) water bills are issued quarterly, 2) water bills are staggered – approximately one third of users receive a bill each month, and 3) water meters are not always read on the first of a month. In order to fairly compare water usage rates among users, water usage records were transformed through a series of steps to account for these complicating factors. The following table reveals the following breakdown of water usage patterns for the Town of Exeter by customer accounts:

Table 6-2: Water Use Demographics

Water Use Range (GPD)	Number of Accounts	Sub Total	Percent of Accts
Over 20,000	2		
10,000 to 20,000	5		
5,000 to 10,000	10	17	0.5%
2,500 to 5,000	18		
2,000 to 2,500	16		
1,500 to 2,000	16		
1,100 to 1,500	44	94	2.9%
500 to 1,000	108		
250 to 500	449	557	16.9%
150 to 250	876		
100 to 150	693	1569	47.7%
50 to 100	663		
25 to 50	266	929	28.2%
5 to 25	123	123	3.7%
	3289		

As shown by this table, approximately 80% of the water users on the Town of Exeter's municipal water system average between 5 to 250 gallons per day. There are many ways one might interpret this data in respect to normal water usage. To gain some perspective we referred to the May 6, 2008 press release from the United States Geologic Service (USGS) regarding their recently published study "Methods for and Estimates of 2003 and Projected Water Use in the Seacoast Region, Southeastern New Hampshire" summarized their findings for water use in the region. It stated that:

> "Water demand for homes accounts for more than 70 percent of all water use in the region, whether those homes have private wells or are part of community water supply systems," said USGS hydrologist, Marilee Horn, lead author of the study. "We also found that each person in the region used about 75 gallons per day, although this value was highly variable from town to town," said Horn. "This amount increased to 92 gallons per day in the summer due to lawn and garden watering, car washing and other outdoor uses." Horn added that "the type of housing development significantly affected the amount of water use. For example, homes in less urbanized areas with extensive lawns consumed a much greater volume of water than homes in areas with a higher population density and limited needs for outdoor watering."

By utilizing the USGS's study findings and then referring back to the Town of Exeter's water usage records reveals that the Town's customers are fairly efficient with their water use. The median customer in Exeter uses approximately 140 gallons per day. It is most likely that this demographic of customer is a single family residential unit, as most of Exeter's customers are. If this is the case and we use the average household size 2.5 persons per household, then the average usage per person would equal 56 gallons per day, 25% below the average identified in the USGS study.

6.6 Top 25 Water Users

Weston & Sampson then investigated the water usage records for the top 25 water users on the Town of Exeter's municipal system. By knowing the usage demographics of these larger customers, the Town could hope to reduce its overall water demand by working with them to improve efficiencies.

Through our review of account information in order to identify the high water users in the system, we realized that we needed to combine a number of accounts into one customer. For example, the Phillips Exeter Academy (PEA) is the Town's largest water user, averaging 63,335 gallons per day of usage. However, they own a lot of property. These separately metered accounts range from large halls in the center of campus to student dormitories, to houses and condos that house teaching staff. Combined, they have 80 different accounts that include big users such as:

- Jeremiah Smith Hall – 16,998 GPD
- Main Street Hall – 2,907 GPD
- PEA Gym – 2,501 GPD

They also have 15 accounts that average between 1,000 to 2,000 GPD and many other accounts that range between 100 to 1,000 GPD, including:

- Boat House – 364 GPD
- Sleeper House – 212 GPD
- Kerr House – 113 GPD

Overall, these 80 PEA facilities use a combined average of 792 GPD. According the PEA website, the school has an enrollment of approximately 1,000 students and their employee community includes more than 650 people which include "hundreds of employees who support [PEA] in offices, dining services, facilities and other areas of the campus." Combined, this totals 1,650 people associated with PEA. Breaking their water use down on a per-person basis would equal a usage of 38 gallons per person per day on average. It must be noted however that the number goes up and down on a daily basis depending on when school is in session and that many of these people may only be on campus a portion of the time.

Similar multiple account users were identified and combined for this analysis. They include the Exeter Hospital and Exeter Health Care, Riverwoods, the Mills (condos, apartments and townhouses), and the Exeter School District. Additionally, there are a number of accounts that are served by one master meter that have multiple users. These include:

- Altid Enterprises, which is the business park located in Stratham that includes Timberland and the Lindt candy factory,
- Exeter Hampton Co-op, Sherwood Forest and Deep Meadows Mobile Home parks,
- Sterling Hill, Exeter West Condos, Exeter Housing Authority, 27 Ernest Avenue Condos,

The following table provides further detail of the Top 25 water users in Exeter:

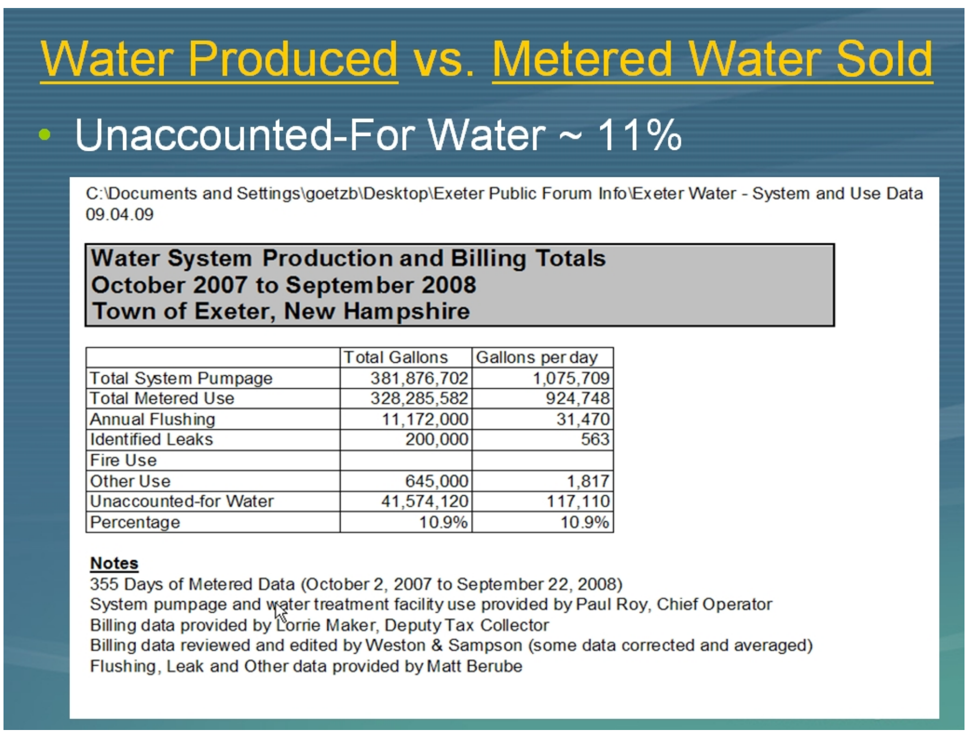
Table 6-3: Top 25 Water Users

Town of Exeter, NH - Top 25 Water Users Based on One Year of Water Use Data (Oct '07 to Sept '08)						
Rank	Primary Account #	Number of Accounts	Total Usage (gallons)	Usage/Day (gallons)	Usage/Day per Acct	Account Name
1	343465900	80	23,180,444	63,335	792	Phillips Exeter Academy
2	121241900	15	14,664,422	40,149	2,677	EXETER HOSPITAL
3	131374550	1	10,677,130	29,172	29,172	ALTID ENTERPRISES
4	212105901	16	6,359,323	17,375	1,086	RIVERWOODS CONDO
5	131379000	2	5,335,184	14,607	7,304	SUNBRIDGE HEALTH& REHAB
6	121237230	5	4,459,517	12,184	2,437	OSRAM SYLVANIA
7	131374650	1	3,862,440	10,553	10,553	EXETER HAMPTON COOP
8	212127125	1	3,123,977	8,535	8,535	DEEPMEADOWS MHP
9	242474000	1	2,937,786	8,027	8,027	SHERWOOD FOREST
10	323216970	1	2,843,956	7,770	7,770	CONTINENTAL MICROWAVE
11	111108550	13	2,271,370	6,206	477	THE MILLS
12	131371650	2	1,923,370	5,663	2,832	BROOKS PROPERTIES
13	313105125	1	1,910,203	5,219	5,219	EXETER SCHOOL DISTRICT
14	212102929	1	1,483,168	4,052	4,052	BLUE RIBBON CLEANERS
15	121237222	1	1,479,804	4,043	4,043	EXETER WOODS/ CLARK PROPERTY MGMT CO.
16	212102398	1	1,446,567	3,952	3,952	THE RINKS AT EXETER INC.
17	212106210	1	1,431,868	3,912	3,912	INN OF EXETER LLC
18	323216681	1	1,125,567	3,075	3,075	SIGARMS
19	323216555	1	1,097,803	2,999	2,999	BURNHAM DRY CLEANERS
20	121229000	1	1,039,796	2,827	2,827	FLYNN'S CAR WASH
21	121238125	11	920,267	2,514	229	EXETER HEALTH CARE
22	131376135	1	875,859	2,393	2,393	STERLING HILL
23	212102400	1	868,893	2,374	2,374	EXETER WEST CONDO
24	212128200	1	864,450	2,362	2,362	EXETER HOUSING AUTHORITY
25	212102350	1	833,004	2,276	2,276	27 ERNEST AVENUE CONDOS

It was envisioned that by addressing inefficiencies in the water usage of these top water users, the Town could significantly reduce its daily water demand. These Top 25 water users represent approximately 25% of the Town's total daily demand; reducing the volume of water used by these accounts by only 8% would represent a 2% or 21,000 gallon reduction in daily water demand. However, a review of the top users has revealed that perhaps these top users are already relatively efficient in their water usage. According to our research, these users do not appear to be heavy users of irrigation during the summer. In fact a lot of them do not irrigate at all. Most of these accounts service residential facilities such as apartments, trailer parks, and condominiums or medical facilities, such as hospitals, dentists, and physical therapy centers. The remaining accounts are generally schools, Town facilities, or commercial in nature. While there are certainly opportunities to improve the efficiency of water usage among these top users, particularly the few Town facilities and commercial properties, these top users are perhaps less capable of reducing the Town's total demand than previously envisioned. Therefore, the next step in the process would be to make a follow-up contact with each to determine what type of retrofits and/or programs they would be willing to embark on toward reducing water consumption. The next section, along with the Water Conservation Plan, to be submitted under separate cover, explores this issue further.

6.7 Water System Unaccounted-for Water

We compared water system pumpage records with metered billing records for the Town over a period of one year. We also queried town staff regarding water that is used but not metered. This use includes water used for hydrant flushing and other purposes. The town performs hydrant flushing twice a year and logs the amount of water used to flush each hydrant. They also track known water leaks in the system and estimate the volume. The following table shows these totals for the period of October 2007 to September 2008:



Water System Production and Billing Totals
October 2007 to September 2008
Town of Exeter, New Hampshire

	Total Gallons	Gallons per day
Total System Pumpage	381,876,702	1,075,709
Total Metered Use	328,285,582	924,748
Annual Flushing	11,172,000	31,470
Identified Leaks	200,000	563
Fire Use		
Other Use	645,000	1,817
Unaccounted-for Water	41,574,120	117,110
Percentage	10.9%	10.9%

Notes
355 Days of Metered Data (October 2, 2007 to September 22, 2008)
System pumpage and water treatment facility use provided by Paul Roy, Chief Operator
Billing data provided by Lorrie Maker, Deputy Tax Collector
Billing data reviewed and edited by Weston & Sampson (some data corrected and averaged)
Flushing, Leak and Other data provided by Matt Berube

As the table shows, the town's current unaccounted-for water is approximately 11%. This is considered good by industry standards and is also good when you consider that the town has pipes in the system over 100 years old.

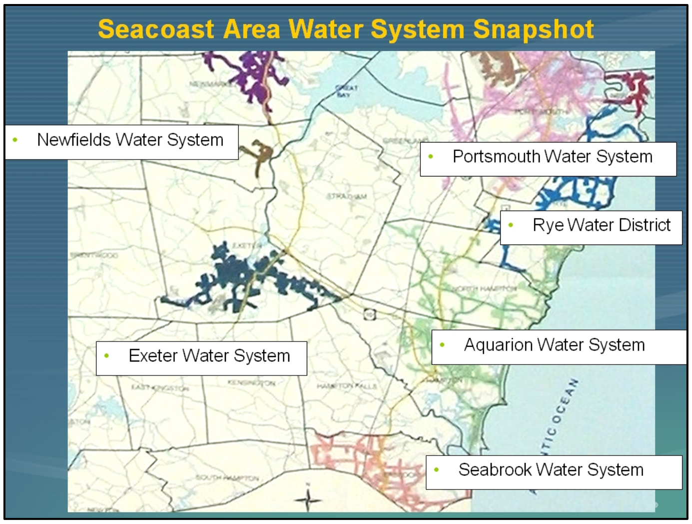
The town recently purchased advanced leak detection equipment to assist with locating hard to find leaks. And they were recently awarded a grant from the DES to have a comprehensive leak detection study performed on their entire system in the coming months. They are also in the process of replacing some of their larger meters to improve water accountability for those services. More discussion of these items is included in the Water Conservation Plan.

6.8 Customer Outreach and Conservation

The Town of Exeter has already implemented water conservation measures for customers on their system. These include:

1) Offering water conservation retrofit kits to their existing customers. These kits include low-flow showerheads and faucet aerators that replace existing higher flow units.
2) Developing public outreach packets regarding water conservation that have been distributed with water bills, the annual water supply report and on the Town's website.
3) Implementing an inclining block rate for customers. This rate increases as users use more metered water per billing cycle and has been proven by other water systems to be an effective means of reducing water consumption, especially irrigation in the summer.
4) The Town recently joined the EPA's WaterSense program. WaterSense is a voluntary program that provides member utilities with free water saving outreach information and assistance with developing comprehensive water conservation programs.

6.9 Regionalization Potential

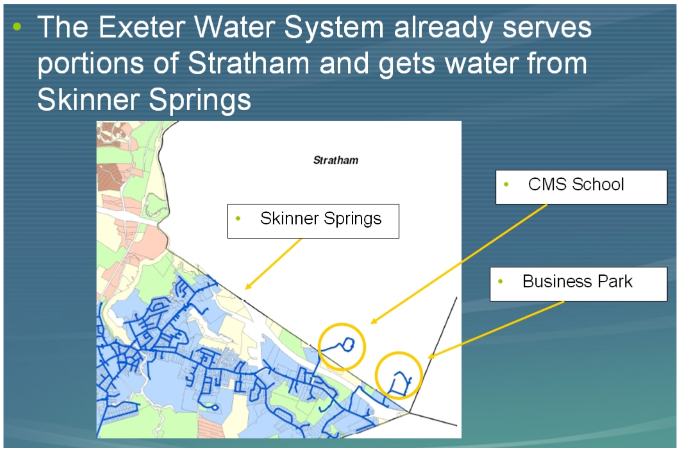


This graphic shows the surrounding public water systems in the Seacoast region. As can be seen, the Town of Exeter's water system is not directly adjacent to any of these systems. The closest potential interconnection is along Hampton Road with the Hampton water system served by the Aquarion Water Company of New Hampshire, approximately two miles from Exeter's water system. The next closest large public water system would be the Newfield's system, which is approximately 2.75 miles north of Exeter's.

Exeter is not alone when it comes to water system infrastructure needs. Surveying these surrounding water systems reveals that they too are studying and implementing improvements, including:

- Seabrook just approved a $12 million groundwater treatment facility
- The Aquarion Water Company spent $7 million dollars upgrading their system from 2001 to 2006.
- The Rye Water District has installed a new bedrock groundwater source.
- The Portsmouth Water Division has a six year capital plan that includes approximately $38 million of investment, including the replacement of their 50-year-old water treatment plant which is underway.
- Newmarket is exploring both groundwater and surface water options.
- Newfields has undertaken substantial efforts to rehabilitate their groundwater sources.
- Stratham is creating a fire service district to improve service along Portsmouth Avenue.

The State has been encouraging interconnection of public water system's in recent years for a number of reasons. Legislation in 1995 authorized the formation of the Seacoast Water District, comprising of voluntary participation by communities in southeastern New Hampshire to address "intersectional distribution, source location, and other issues related to water resources" (Chapter 42, laws of 1995). The legislation, introduced as House Bill 197, stated that, "the members of the district may include but not be limited to Hampton, Portsmouth, Newington, Seabrook, Exeter, Rye, North Hampton and Stratham. Other communities in southeastern New Hampshire may be affiliated, if they vote to do so." It also stated that, "The district shall address intersectional distribution, source location and any other issues related to water resources." The District has not convened to date, and the scope of the District was not defined further. However, one key recommendation not implemented was to develop "an overall planning process to meet the potential water supply deficits in a logical manner through the use of regional water supply plans compiled by Water Utility Coordinating Committees." The Task Force recommended that these committees be created by statute to operate in close conjunction with Regional Planning Agencies to develop and help implement regional water supply solutions.



Exeter's water system can already be considered a regional water system due to the fact that it serves areas in Stratham. Water mains extend into Stratham to serve the Altid Enterprises Business Park that includes Timberland and Lindt candy. They also extend into Stratham to serve the Consolidated Middle School. According to Town billing records, these accounts, along with a few others near the Rte 101 Rte 101 junction, combine to use approximately 35,000 gallons per day. The Skinner Springs water source is located just over the border of Exeter in Stratham.

A meeting with Stratham's Town Administrator, Paul Deschaine, and Public Works Advisory Committee Chair, John Boisvert was held on July 7, 2009. Brian Goetz and Ted Diers attended on behalf of the study team to discuss their water supply issues. Stratham had recently undertaken a planning level project to identify needs along the Route 108 business corridor. Two priority areas of need that arose from that plan were in regards to public water and sewer systems. The areas fire suppression system is currently a mix of individual systems served by fire ponds, pumps and tanks. Each of the properties also has its own water source, some that are listed on the state's community water system database. And each property has a separate septic system.

Through this meeting it was revealed that Stratham is embarking on a water supply study that will look at combining the fire service systems in the area into one fire service district. The study will also look into the potential that this system could eventually be turned into a full fledged public water supply system, which would require a new source of supply. Such a source would also have to provide redundancy, either from a second source of supply or via an interconnection with a backup source. The possibility of Stratham acquiring additional water from Exeter via an interconnection was mentioned. The pros and cons of this arrangement are listed in the following table:

Pros	Cons
1) Capital cost sharing	1) Less independent
2) Operational cost sharing	2) Who is "lead" agency?
3) Shared infrastructure such as supply and storage	3) Difficulty in assessing a fair rate for new customers to pay as a "buy in" fee
4) Larger service area with ability to obtain farther reaching water sources	4) How would water be allocated during droughts or emergencies?

Other regional water systems exist and operate effectively in New Hampshire and the Seacoast. The most prominent system of this kind in the area is the Portsmouth Water Division. This water system not only serves the City of Portsmouth, but also the communities of Newington, Greenland, New Castle and some customers in Dover, Madbury and Rye. Their water supply comes from a variety of water supply sources that include the Bellamy Reservoir and some wells in Madbury, wells in Portsmouth and a well in Greenland.

7.0 INTEGRATED MANAGEMENT

7.1 Sustainable Water Management

According to the American Water Works Association Research Foundation. "Minutes of Workshop on Total Water Management." Seattle, WA and Denver, CO: American Water Works Association, August 1996:

> Total Water Management is the exercise of stewardship of water resources for the greatest good of society and the environment. A basic principle of Total Water Management is that the supply is renewable, but limited, and should be managed on a sustainable-use basis. Taking into consideration local and regional variations, Total Water Management:
>
> - Encourages planning and management on a natural water systems basis through a dynamic process that adapts to changing conditions;
> - Balances competing uses of water through efficient allocation that addresses social values, cost effectiveness, and environmental benefits and costs;
> - Requires the participation of all units of government and stakeholders in decision-making through a process of coordination and conflict resolution;
> - Promotes water conservation, reuse, source protection, and supply development to enhance water quality and quantity; and
> - Fosters public health, safety, and community goodwill.

This definition focuses on the broad aspects of water supply. Examples can be given for other situations, including water-quality management planning, water allocation, and flood control.

The goal of developing an Integrated Management Plan for the Town of Exeter's municipal water system would be to address the needs outlined in the AWWA's guidance. An integrated management plan would further identify these resources and their capability and determine an operational scheme that would maximize their withdrawals while taking into account water quality and regional impacts. The concept of having many water supply sources creates flexibility for high supply demands, system maintenance down time, source contamination and drought conditions. This section of the report reviews how the Town of Exeter has managed their multiple water supply sources in the past and how that management scheme may be improved in the future.

7.2 Historical Supply Management

As noted in Section 2 of this report, the Town of Exeter's municipal water system has relied on four primary sources of water since the water treatment facility upgrades in 1972: 1) the

Exeter Reservoir, 2) Skinner Springs, 3) Lary Lane Well and, 4) the Exeter River. Historically, these sources have been used to varying degrees depending on the season. The following table of withdrawal rates provides a general overview of the seasonal operational nature of these sources:

Table 7-1: Historical Water Supply by Source

		Withdrawals - 2002 and 2006 Average (million gallons)				
Month	Days	River Intake	Reservoir and Spring	Lary Lane Well	Total	Total (GPD)
Jan	31	0	25,614,500	6,644,943	32,259,443	1,040,627
Feb	28	0	22,982,000	5,864,826	28,846,826	1,030,244
March	31	0	24,242,000	6,788,891	31,030,891	1,000,996
April	30	0	26,857,000	6,727,990	33,584,990	1,119,500
May	31	15,156,000	15,243,500	9,000,559	39,400,059	1,270,970
Jun	30	28,474,000	1,468,500	9,435,357	39,377,857	1,312,595
Jul	31	38,768,000	0	8,800,735	47,568,735	1,534,475
Aug	31	38,383,000	0	9,022,428	47,405,428	1,529,207
Sep	30	30,805,500	0	7,932,332	38,737,832	1,291,261
Oct	31	22,115,500	8,742,500	7,163,300	38,021,300	1,226,494
Nov	30	6,045,500	20,539,000	6,898,157	33,482,657	1,116,089
Dec	31	0	27,902,500	7,287,561	35,190,061	1,135,163
Total	365	179,747,500	173,591,500	91,567,075	444,906,075	1,218,921
Percentage		40.4%	39.0%	20.6%		

Source: Town of Exeter "Great Dam and Water Supply" memo dated May 23, 2007.

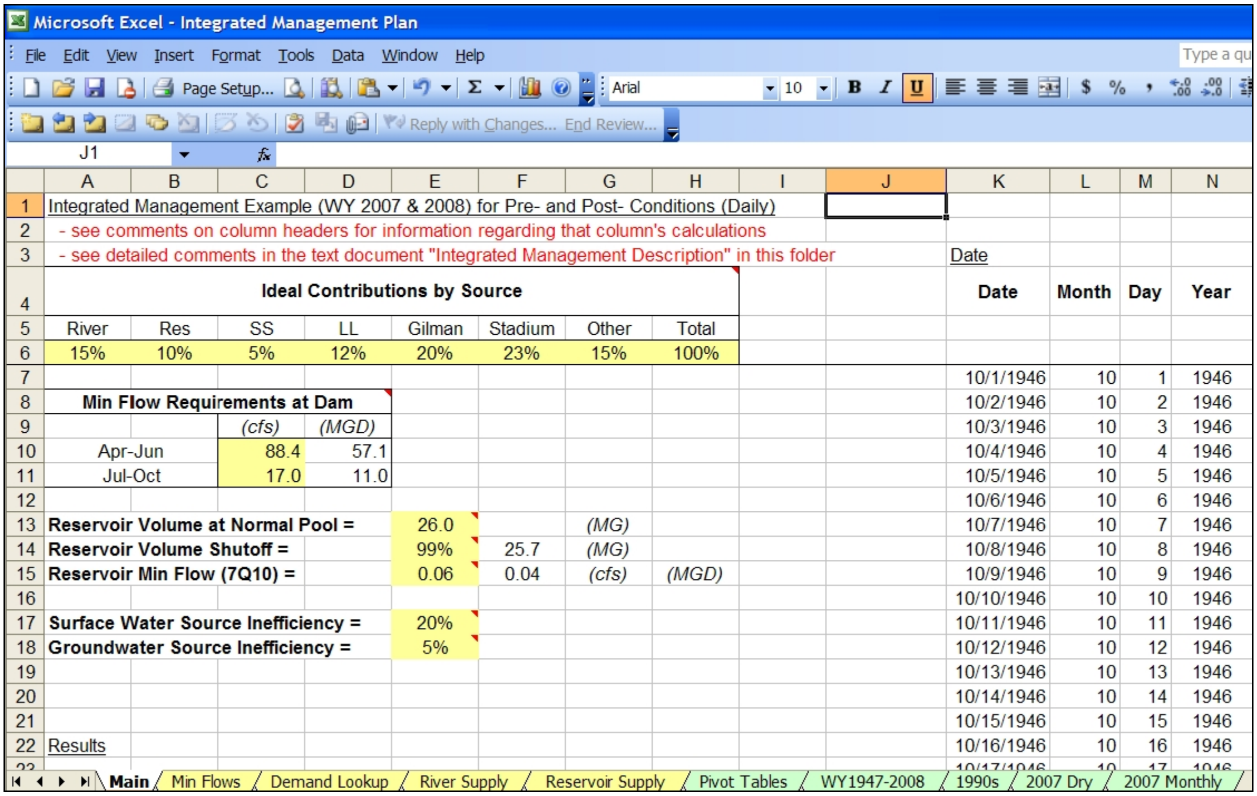
As shown in Table 7-1, the Town's water supply operation plan relied primarily on the Reservoir during the winter and spring. The River provided the primary supply during the summer and fall. One of the goals of our study was to envision how this reliance could be distributed through many sources over the entire year rather than a very few sources in a seasonal pattern.

7.3 Future Water Supply Management Scenario with an Integrated Management Plan

7.3.1 Integrated Management Plan Spreadsheet

In order to envision how an Integrated Management Plan might work for the Town of Exeter's municipal water systems, an Integrated Management Plan Spreadsheet (IM Plan) was developed for the Exeter River Study Water Supply Alternatives Analysis project. The IM Plan was developed to create graphics of potential future water management scenarios for the Town of Exeter and also as the foundation of an automated management application.

The IM Plan functions by simulating demand-driven water withdrawals from the various public water supply sources at rates (as a percent of total supply) specified by the user. The IM Plan also factors in user input regarding reservoir volumes, surface and groundwater treatment inefficiencies, and variable minimum flow requirements in the Exeter River and outlet of the Reservoir. These input cells are shaded yellow in the "Main" tab. The following graphic provides an overview of the spreadsheet's layout.



There are several tabs in the IM Plan Spreadsheet that are responsible for various functions.

- The "Main" tab, shaded orange, is the primary user interface; all user inputs are entered on this tab and all of the withdrawal calculations are performed on this tab. The "Main" tab references the other input tabs, shaded yellow.
- The "Min Flows" tab shows the process used to calculate the min flow requirements based on the 2006 Dam Management Plan for Great Dam.
- The "Demand Lookup" tab is the source of the daily demand data that drives the IM withdrawal calculations. Currently, the two years of demand data from 10/01/2006 – 09/30/2008 is continuously looped for the entire time scale of the IM Plan, 10/01/1946 – 09/30/2008.
- The "River Supply" tab contains the Exeter River daily hydrograph as it was extended by the Parker River gage record. The "River Supply" tab contains the extended river hydrograph at the Haigh gage and river intake locations as well as a maximum river withdrawal data series calculated by subtracting minimum flow requirements from the river intake hydrograph.
- Lastly, the "Reservoir Supply" simply contains an area-weighted daily inflow hydrograph for the Exeter Reservoir as scaled down from the Exeter River hydrograph. It is assumed that all evapotranspiration occurring within the Reservoir watershed is accounted for in

the inflow hydrograph. Note that modifying the Exeter River hydrograph will modify the Reservoir hydrograph as well.

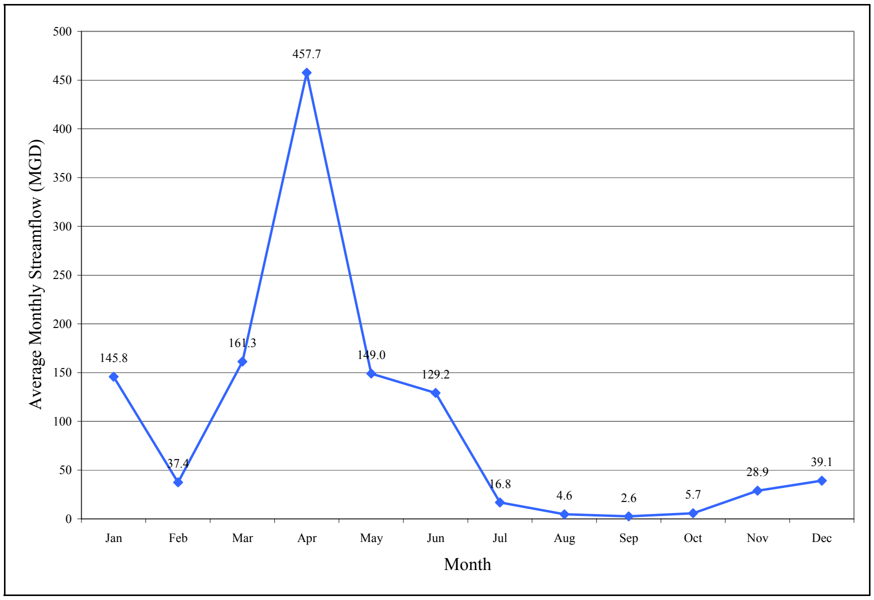
The calculations that run the IM Plan begin with the daily demand record. The daily demand is split up among the various sources based on user-defined percentages. Inefficiencies are then considered, yielding a daily withdrawal target for each source. The River supply is limited by the minimum flow requirements considered in the "River Supply" tab. If the maximum river supply is below the daily river withdrawal target, the Reservoir is then tasked with supplying the difference (when possible). Reservoir withdrawals are limited by a user-specified minimum impoundment volume. If the Reservoir volume falls below this limit, all withdrawals from the Reservoir cease as well, and the withdrawal burden is spread among the groundwater sources based on their user-specified relative contributions. To minimize periods when the Reservoir falls below its minimum impoundment, it is "topped off" with water from the River whenever the River has a surplus of flow following its own withdrawals. The Reservoir is essentially treated as a storage tank in this version of the IM Plan.

7.3.2 An Integrated Management Example

To evaluate the potential of the IM Plan, Weston & Sampson compared water withdrawals by source for 2007, under both the Town's historical operational scheme and the integrated management scheme modeled by the IM Plan. The year 2007 was chosen for two reasons: 1) despite the intense spring flooding, it was a relatively typical year with regard to streamflow and precipitation, and 2) comprehensive water withdrawal records were available for all sources.

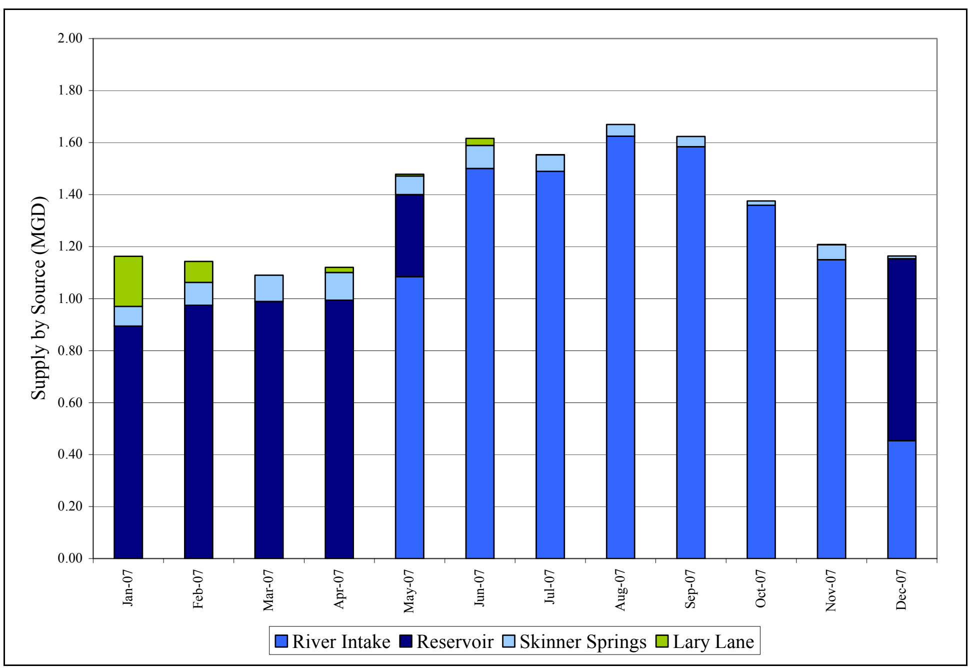
In 2007, the Exeter River exhibited behavior typical of New England. Relatively steady runoff from groundwater baseflow was supplemented with relatively low rates of snow melt during the warmest hours of sunny winter days to yield relatively consistent and moderate flows, ranging from approximately 30 to 150 million gallons per day. The coming of spring and the associated snowmelt coupled with intense rainstorms largely incapable of infiltrating the snow-covered soil brought on high streamflows ranging from 150 to 2,500 MGD. The end of the snowmelt season and the coming of dry, hot, summer days, however, dried out the soil, allowing it to absorb much of the infrequent summer. The river level dropped accordingly, maintained by groundwater baseflow at a level between 2 to 30 MGD.

Figure 7-1: Average Monthly Streamflows for 2007



Withdrawals from the Town's various water supply sources in 2007 were also relatively typical of the Town's historical supply management scheme discussed in Section 7.2. Figure 7-2 reflects that fact, showing the average monthly withdrawals by source for 2007.

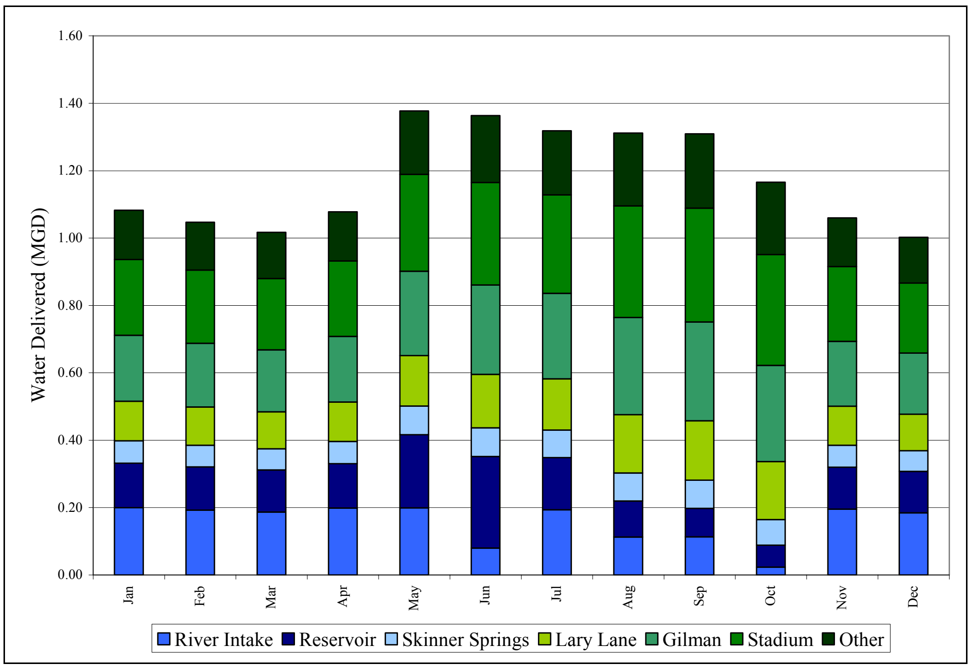
Figure 7-2: Historical Withdrawals by Source for 2007



During the late fall, winter, and early spring, the Town relied primarily upon the Exeter Reservoir to satisfy water needs. With the annual spring turnover of the Reservoir, brought on by increasingly warm days (discussed in more detail in the "Reservoir Aeration Upgrades" section of Chapter 8) and a corresponding increase in water treatment costs, the Town turned to the Exeter River to supply water during the late spring, summer, and early fall. While a significant majority of the Town's water demand was met by withdrawals from the Reservoir or River, those sources were supplemented by a very consistent supply from Skinner Springs as well as groundwater withdrawals from Lary Lane. Withdrawals from Lary Lane typically represent a more significant portion of the Town's water supply as shown in Table 7-1 but were limited at times during 2007 due to water quality issues. However, the Town's water supply operations during 2007 highlight the key components of Town's historical water supply management scheme, namely: 1) rely heavily on the Reservoir during the winter, 2) rely heavily upon the River during the summer, and 3) supplement the two primary sources with small groundwater withdrawals.

The hypothetical integrated management scenario simulated by the IM Plan, described in Section 7.3.1, provides one alternative management scheme that includes additional water supply sources and distributes water withdrawals more evenly between sources. Figure 7-3 shows the average monthly withdrawals by source for a typical year like 2007 under such a management scheme.

Figure 7-3: Hypothetical Water Supply by Source for 2007



Under this hypothetical management scenario, water withdrawals are distributed among seven sources, no single source responsible for more than 25% of total withdrawals. This scenario draws more heavily upon surface water sources during the relatively wetter months of late fall, winter, and spring. However, during the drier months of summer and late fall, a greater emphasis is placed upon groundwater sources. It should be noted that the total withdrawals shown in Figure 7-3 are less than the total withdrawals of Figure 7-2; this is due to the greater efficiencies of treating groundwater than surface water.

It is important to note that this spreadsheet has been developed to foresee potential scenarios for the Town with what was known at the time it was developed. It also foresees the Town having a more diverse water supply with a larger percentage of supply coming from reactivated and new groundwater sources. As such, it is only a preliminary Integrated Management Plan. A final version to be used by Town operators would require significant work, specifically fine-tuning the day-to-day controls, freezing cells so they could not be adjusted, and factoring in groundwater limits, among many other improvements.

7.4 Demand Management and Public Outreach

7.4.1 Water Supply Update

An effective way to manage water system demand is to provide customers with up-to-date information regarding sources of supply and water system capability. This information can then be distributed to them in a variety of ways, including:

1. Information provided on water bills
2. Additional flyers inserted in water bills
3. Daily, weekly, monthly or quarterly updates distributed via:
    a. Press releases to local news outlets
    b. Memorandums to Town Boards
    c. Town website
    d. Pre-recorded voice message through Town's telephone system
4. Water Supply status signs posted at Town facilities (Public Works Department on Newfields Road, Water Treatment Plant on Portsmouth Avenue, other)
5. Other outlets

This update would include the following information:

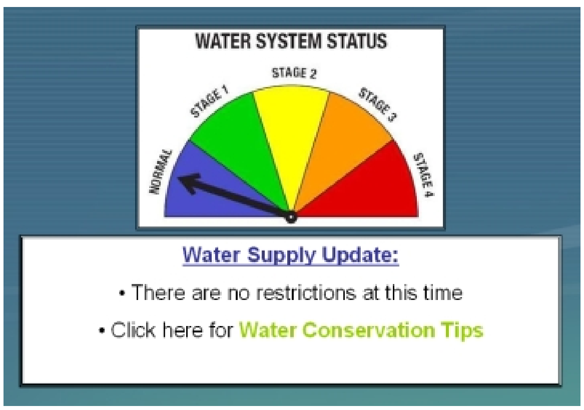
1. Current weather information because the source of supply capability is most dependent on weather patterns. Suggested information could include:
    a. Recent precipitation (monthly or quarterly)
    b. 12-month rolling average precipitation (to show trends)
    c. Comparison with normal precipitation patterns
2. Projected weather patterns and precipitation forecasts are available from the online resource Drought Monitor (http://drought.unl.edu/dm/monitor.html), a drought assessment website hosted by the Climate Prediction Center and the National Oceanic and Atmospheric Administration.
3. Status of sources of supply in system:
    a. Surface water capability
    b. Springs capability
    c. Groundwater capability
4. Status of treatment capability and/or issues with water quality
5. Current water system demand

6. Projected water system demand based on weather patterns and water use demographics
7. Status of Supply versus Demand
8. Other water system projects such as flushing, ongoing capital improvement projects, meter changeouts, links to conservation tips, etc.

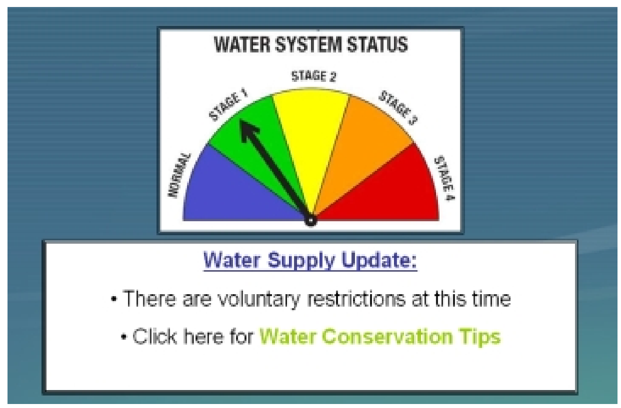
7.4.2 Water Supply Status Sign

To develop a simple method for public outreach it is suggested that the Town consider developing a matrix for determining various levels of water supply status and then utilize this matrix to inform customers on the system how things are going. This method would enable customers a simple snapshot of how the system is doing. This information could then link to additional information, such as the detailed Water Supply Update memorandum.

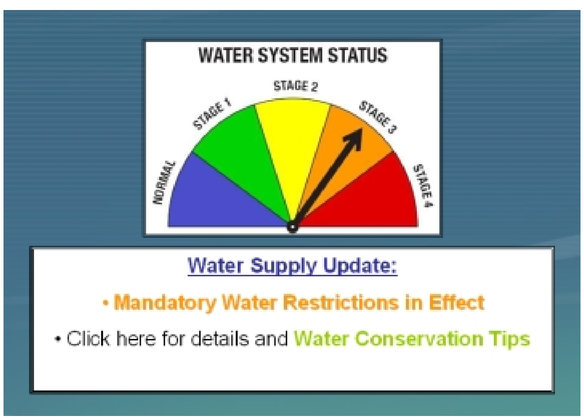
The following graphics show examples of the levels that Exeter might use for public outreach regarding the Water Supply Status:



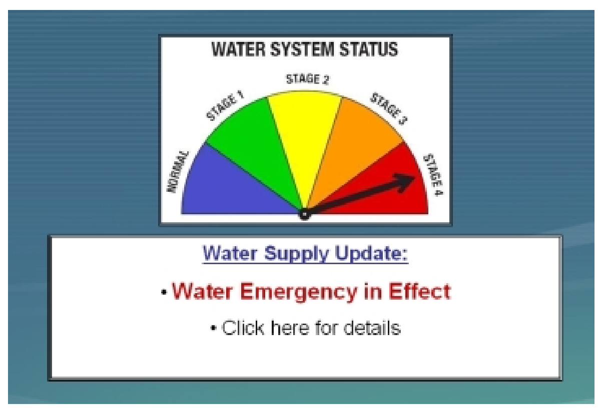
Normal Stage – No Restrictions



Stage 1 – Voluntary Water Conservation



Stage 3 – Mandatory Restrictions



Stage 4 – Water Emergency

7.4.3 Drought and/or Emergency Situations

According to Vogel, et. al, “In general, drought management is shown to be an effective management strategy for reducing both human and instream flow water uses.” The American Water Works Association’s Water Resources Planning Manual M50 contains a detailed section entitled “Short-term Demand Reduction (Drought Contingency” Planning.” In it, they note that “drought differs from other adverse meteorological events such as storms in several ways. Storm events develop in a matter of minutes for tornadoes or days for hurricanes. By contrast, the first sign of drought is often a number of beautiful, sunny days. Droughts take months to develop and last for months and even years.” This section goes on to add that “drought and emergency management plans all contain specific mandatory and enforceable requirements and penalties that become effective when certain conditions are met.” Therefore, they recommend the following plan elements be developed:

1. Declaration of purpose
2. Public education and outreach
3. Trigger conditions. These conditions are important because “they provide specific written criteria that give the utility authority to impose specified legal restrictions once a trigger condition has been met and also provide the set points of reference for the utility to watch for to determine when they are approaching drought conditions.”
4. Response measures and actions
5. Implementation procedures

The intent of such a plan is to have something written and defensible as a guide for the Town to implement during a drought or an emergency. As of the writing of this report, we do not know of any such ordinance or other legal means that the Town of Exeter has in place should they need to implement restrictions during a drought or other emergency. We suggest that the Town develop a plan.

7.5 Integrated Management Summary

A few key findings came to the forefront during this study with respect to the implementation of an Integrated Management approach for the Town’s municipal water system:

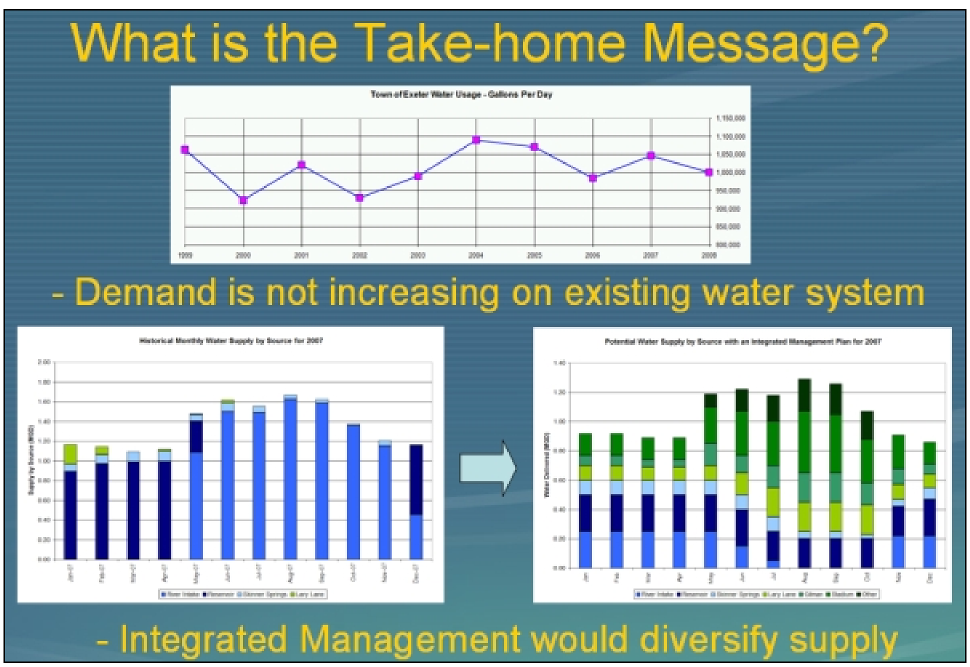
1. The reservoir source should be able to provide more of the surface water supply if it had better aeration to improve water quality.
2. The Town’s capability of withdrawing from the Exeter River is more dependent on the river flows and the Town’s Dam Management Plan than the impoundment’s storage.
3. Groundwater resources are developable and may be able to offset the loss of surface water supplies during dry periods.
4. Water system demand has leveled off, holding steady at approximately 1 million gallons per day average for the period of record from 1998 to 2008.
5. Instream flow requirements are likely to be refined over time.

Table 7-2 summarizes the hypothetical scenario for the overall integrated management of the Town of Exeter's water supply sources with the integration of more groundwater and management of surface water sources to optimize their withdrawals:

Table 7-2: Hypothetical Integrated Management of Water Supply Sources

Hydrologic Trend	River	Reser-voir	Wells	Demand Mgmt	Notes
Very High					Surface water quality may be compromised or flooding may be occurring
High					Utilize surface water, rest wells to allow for optimum recharge
Above Normal					Utilize surface water, rest wells to allow for optimum recharge
Normal					Utilize all sources
Below Normal					Pump from river to reservoir to keep reservoir full, voluntary restrictions
Low					Switch back to reservoir, start implementing restrictions
Extremely Low Flow					Utilize wells and implement mandatory water restrictions
Emergency					Emergency conditions (utilize all available sources and notify public)

The take-home message regarding the potential for integrated management of Exeter's Water System:

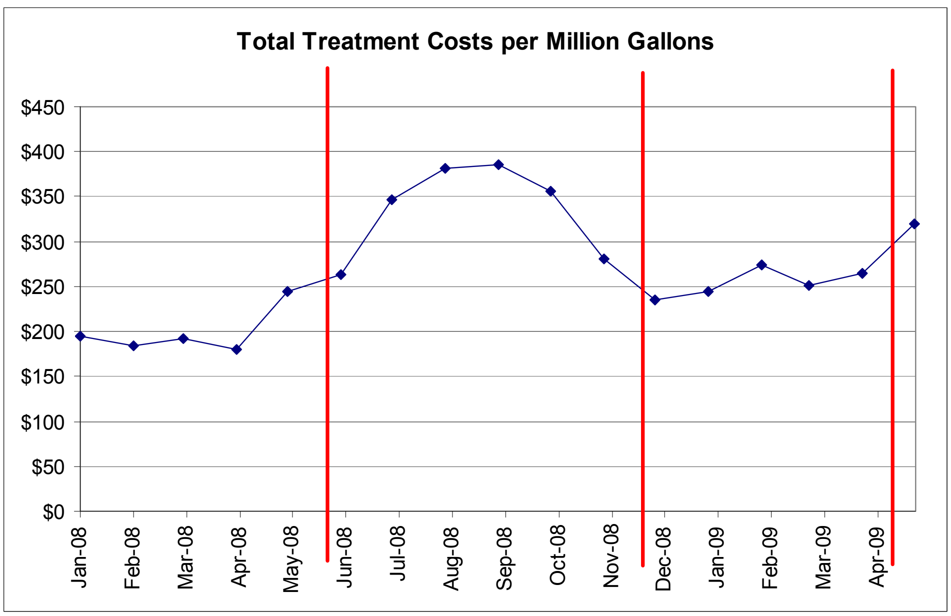


8.0 INFRASTRUCTURE OPTIONS AND COST ESTIMATES

8.1 Water Treatment Cost Analysis

As part of this study we performed an analysis of Exeter's current water supply treatment costs. Information was gathered from the Chief Treatment Facility Operator, Paul Roy, and calculated to determine a "cost per million gallons" from the surface water treatment facility. We also broke down the seasonal cost of treating water from the reservoir versus the river. Overall, as the following graphic shows, the reservoir source is less expensive to treat than the river water:

Figure 8-1: Total Treatment Costs per Million Gallons



Note: These costs are strictly for power for pumping, WTP processes and treatment chemicals

When pumping costs are added to the equation, utilizing river water as a source of supply to the water treatment facility is even more expensive. The overall average cost of utilizing the reservoir source is $313 per million gallons while utilizing the river is $560 per million gallons. The following table summarizes that analysis:

Table 8-1: Average Total Treatment Costs by Source

Exeter Water System - Pumpage and Treatment Costs

	Source	Million Gallons	Chem Cost	Electric KWH per MG	Electric Cost Per MG	Total Cost per MG	Total Monthly Cost
Jan	Reservoir	37.6	$214.57	871	$91.64	$306.22	$11,504
Feb	Reservoir	32.1	$214.36	871	$91.64	$306.01	$9,823
Mar	Reservoir	29.4	$222.00	871	$91.64	$313.64	$9,235
Apr	Reservoir	36.2	$222.22	871	$91.64	$313.87	$11,358
May	River	44.6	$281.88	2118	$232.14	$514.02	$22,915
Jun	River	42.5	$263.01	2118	$232.14	$495.15	$21,050
Jul	River	42.4	$347.03	2118	$232.14	$579.18	$24,576
Aug	River	43.4	$381.42	2118	$232.14	$613.56	$26,600
Sep	River	43.2	$384.97	2118	$232.14	$617.12	$26,639
Oct	River	43.1	$356.39	2118	$232.14	$588.54	$25,388
Nov	River	34.7	$280.94	2118	$232.14	$513.08	$17,808
Dec	Reservoir	36.8	$234.82	871	$91.64	$326.46	$12,015
							$218,910
Month Ave	Reservoir	34.4	$221.60	871.0	$91.64	$313.24	$10,786.83
Month Ave	River	42.0	$327.95	2118.0	$232.14	$560.09	$23,567.98

*Note that Million Gallons is source water. The treatment facility has to waste approximately 20% of this water through backwashes.

Another aspect of the water treatment facility's cost is the inefficiency of its operations. Currently, due to more stringent water quality regulations, the facility must waste approximately 20 to 30 percent of the water going through the process in order to meet those parameters. This means that when water demand is 1 million gallons a day the facility must take in anywhere from 1.2 to 1.3 million gallons – 200,000 to 300,000 is sent to lagoons and the Town's wastewater treatment system. Not only is this inefficient for the water system, it adds additional loads to the wastewater system. Water treatment operators have made strides in recent years to reduce the wasted water but getting below the 20% threshold may be very difficult with the inefficient surface water treatment system that is in place.

8.2 Reservoir Aeration Upgrades

As shown by the cost analysis, the Town would benefit from being able to utilize the reservoir for their surface water supply more often. However, as pointed out in previous sections of this report, the reservoir can "turnover" on summer days when it heats up. This causes dramatic changes in water quality coming into the surface water treatment facility which in turn causes upsets to the treatment process. Previous studies have pointed out that better aeration might solve this problem. The reservoir currently has a small bubbling system at the intake, but it does not alleviate the turnover problem due to its size, position, and other design considerations.

Weston & Sampson examined the possibility of upgrading the aeration facilities at the Exeter Reservoir. Improved aeration would improve the Town's water supply system regardless of the potential removal of Great Dam. Specifically, improved aeration of the Reservoir would likely prevent the annual spring turnover that causes a sharp decrease in the Reservoir's water quality. This spring turnover occurs as increasingly warm days heat up the top layers of water in the Reservoir. These warmer, denser waters sink to the bottom of the Reservoir, forcing the bottom water upwards. The bottom water is generally laden with nutrients acquired over the many winter months from either the silt bottom or organic waste settling down from above. The low-oxygen environment of the Reservoir bottom prohibits the natural uptake of these nutrients by bacteria, macroinvertebrates, and other small organisms. This nutrient-laden water is difficult to treat, and in the case of the Exeter Reservoir, elevated levels of manganese, in particular, have been cost-prohibitive for many years.

The impact of spring turnover can often be mitigated through various aeration techniques. Aerating the bottom water year round would provide two benefits: 1) physically mix the bottom water with the rest of the Reservoir and 2) increase the oxygen content of the bottom water, promoting the natural uptake of nutrients. While the Reservoir is currently aerated to some degree, based on a water quality assessment of the Reservoir, it appears that the aeration is not sufficient.

Weston & Sampson contacted a vendor that specializes in the design and installation of aeration equipment in public drinking reservoirs. Based on water quality results provided by the vendor and phone conversations with three of the vendor's previous clients, it appears that the installation of a new, modestly priced, aeration system in the Exeter Reservoir would significantly improve the Reservoir's water quality and potentially allow for its year-round use as a water supply source. A preliminary proposal from the vendor indicated an initial cost of approximately $10,000 to purchase and install the aeration equipment, not including an electrical connection to the existing Water Treatment Plant. Previous clients suggested an annual maintenance cost of approximately $1,000 to $2,000. Based on this review of the costs and benefits of such an aeration system, it appears that aerating the Exeter Reservoir would reduce the cost of treating Reservoir water and increase the Reservoir's availability regardless of any potential removal of Great Dam.

8.3 River Pump Station and Intake Modifications

As mentioned in Section 3.6, if the dam were to be removed, the river pump station would require modifications. This next part of the report highlights our investigation of the options.

8.3.1 Natural Riverbank Infiltration

Natural riverbank infiltration does not appear to be an effective replacement option for the existing river intake due to the nature of the soils in the area (mostly marine clays). However, a modified man-made riverbank infiltration system may be feasible through excavation of the river bank and installation of a horizontal screened collector conduit. The excavated river bank area would be backfilled with highly pervious material and bank stabilization material to allow for infiltration of river water into the buried intake system. Placement of the system at an elevation similar to or below the low flow river elevation would ensure a constant water supply. Similar to a well system, the collector screen would need to be cleaned annually. Additional engineering would be required to determine the size, depth, capacity and hydrogeologic yield of such a river bank replacement and infiltration collection system.

8.3.2 Vacuum Collection System

Another option to consider in conjunction with or as an alternate to the river bank infiltration system is a vacuum collection system using a single intake or multiple horizontal intakes. The vacuum system would allow the water from the river to be drawn up into a can and pump system. This would alleviate the need for a lower river intake elevation and raw water wet well floor, saving costs associated with deep excavation, river bank support, and dewatering.

8.3.3 Modifications to Existing Pumping System

With the removal of the dam, modifications to the existing river intake and pumping station would be required in order to continue use of this system as a surface water supply. Estimates of associated costs are included in Section 8.9 while more general observations with respect to these impacts are as follows:

1. The reduction in impoundment area and depth would require revisions to the safe yield and pumping rates at this site.
2. The intake pipe would be exposed during periods of low flow. Depending upon safe yield determination and allowable pumping during periods of low river flow, the intake may need to be lowered. The intake could be lowered by up to one foot and replaced with an intake system sized for the revised safe yield.
3. A passive intake screen at the intake end of the pipe would improve screening of materials getting into the intake. Passive intake screens are cleaned by bursting air through the screen periodically to remove organic debris.
4. To obtain greater water supply, the river intake pumping station wet well would need to ensure adequate water supply during low river flow periods. This would require significant construction dewatering and excavation support. Depth of excavation would exceed twenty feet and proximity to the river would require substantial excavation support methods to support the adjacent river bank.

Regardless of the effect of the dam removal on the raw water source quantity and quality, modifications to the river intake pump station should incorporate protection from flooding. Recent flood events cause inundation of the wet well and first floor of the pump station. While the mechanical equipment in the wet well is not damaged by immersion, the electrical and mechanical equipment in the pump house first floor is not designed for total immersion. Options for flood protection include:

1. Build a sealed water-tight bermed area around the first floor with sump pumps. Steps and ramps to allow access up and over the berm are necessary. Water-tightness would be required between the first floor and the wet well.
2. Raise the first floor level or build a second story for installation of mechanical and electrical equipment. Complete demolition above the first floor slab would be required. Ramp access to the new raised floor would be required.
3. Build a secondary structure adjacent to the existing building. The secondary structure would house the electrical and mechanical equipment at an elevation above the 100-year flood elevation. A submersible motor or immersion rated motor would be installed at the river intake pump.

8.4 Gilman Park, Stadium Well Reactivation, and Treatment System

The Gilman Park and Stadium Well work performed by Weston & Sampson from 2007 to 2009 revealed that these wells are very good candidates for reactivation. The inspection, rehabilitation, pumping tests and piloting that were performed in the summer of 2009 confirmed this assessment. The following discussion describes the potential next steps to reactivate these wells.

8.4.1 Reactivation of Wells and Connection to Lary Lane

The reactivation of the Gilman Park and Stadium wells will require the following additional work:

- Submit and obtain final approval from DES to reactivate the wells
- Obtain approval and/or easements from PEA to complete infrastructure improvements at the Stadium well. It is anticipated that the well would be equipped with a submersible pump with a pitless adapter. It is also anticipated that the electronics and controls could be housed in the river pumping station. Provisions would need to be made to bring the top of the well above the floodplain of the river.
- Develop an infrastructure plan for equipping the Gilman Park Well. This could either be via improvements to the existing structure, a new structure, or incorporating the structure into a new combined groundwater treatment facility adjacent to the well.
- Prepare preliminary design plans for connecting the Gilman Park, Stadium and Lary Lane wells together. It is assumed that the existing pipeline from the Stadium to the Gilman Park well that runs under the river would most likely be a candidate for sliplining with new pipe or a replacement line.

The connection of the Lary Lane well could either be accomplished by:

1. Obtaining an easement through Academy property and connecting to the Gilman/Stadium wells. The approximate distance through this property is 3,000 feet. Considering the fact that there are a number of wetlands in the area, permitting and construction may be timely and expensive. With that in mind we have not prepared a cost estimate for this option.

2. Running new parallel pipe from the end of Lary Lane up Court Street and over to the Gilman/Stadium wells via Crawford Avenue. The existing pipeline from Lary Lane to Court Street would be converted to a transmission main and re-used. The approximate distance is 4,000 feet. Therefore, at an installation cost of $150 per foot the piping cost would total investment approximately $600,000.

The following table highlights the probable capital cost estimate for this work:

Table 8-2: Well Reactivation and Connection Cost Estimate

	Size		Cost
Stadium Well			
pump/motor/VFD equipment	75 hp	$	175,000
piping	8-inch	$	40,000
electrical and controls	LS	$	50,000
building rehab	NA		
Design (20%)		$	53,000
TOTAL		**$**	**318,000**
Gilman Well			
pump/motor/VFD equipment	40 hp	$	125,000
piping	8-inch	$	40,000
electrical and controls	LS	$	50,000
building rehab	?	$	200,000
Design (20%)		$	83,000
TOTAL		**$**	**498,000**
Lary Lane			
pump/motor/VFD equipment	40 hp	$	125,000
piping	8-inch	$	40,000
electrical and controls	LS	$	50,000
building rehab	NA		
Design (20%)		$	43,000
TOTAL		**$**	**258,000**

- Total cost estimate for well infrastructure - $1,074,000
- Cost estimate for connecting Lary Lane Well to groundwater treatment - $600,000
- Contingency of 20% - $335,000
- **Total Cost Estimate - $1.67 to $2.00 million**

8.4.2 Groundwater Treatment System

Treatment of the Gilman and Stadium Wells was piloted in July 2009 to determine current water quality and to test the effectiveness of various iron, manganese, and arsenic treatment filter media. The water quality test results revealed that that groundwater is of very good quality. The results of the pilot show that all of the three media tested perform satisfactorily with regards to iron, manganese and arsenic removal for all three source waters. The Gilman and Stadium wells required only chlorination to oxidize the iron and arsenic, with absorption of manganese occurring during the filtering process. The Lary Lane Well required the addition of Ferric Chloride since its source water was low in natural iron. It is our opinion that combining the higher iron Gilman/Stadium well water with the Lary Lane well and blending them prior to treatment would negate the need for the addition of ferric. Blueleaf, Inc. ran the pilot and performed jar tests to simulate this blending; however, their benchtop results were inconclusive.

The pilot results are submitted with the Gilman/Stadium pumping test report, but the conceptual design parameters are summarized below:

Media:	Greensand Plus, Layne Ox, Pureflow
Design Surface Loading Rate:	7.5 gpm/sf
Oxidation Chemical:	Sodium hypochlorite (NaOCl)
NaOCl Dosage:	3 mg/L

The treatment facility would be designed to treat the Gilman, Stadium, and Lary Lane Wells and sized for future expansion to incorporate additional well supplies.

It is our recommendation to the Town to:

- Pursue the reactivation of the Gilman and Stadium wells (with a combined yield of approximately 1.0 MGD)
- Manifold these wells together with the Lary Lane well (yield of approx. 0.25 MGD)
- Design and construct an iron-manganese pressure filtration system capable of treating 1.5 MGD with the ability to expand if other groundwater sources are added at a later date.

A capital cost estimate was performed to determine cost projections for construction of filter systems utilizing either Greensand Plus filter media (Option #1) or Option #2, which would be either Pureflow or LayneOx media. These estimates are included in the following tables:

Table 8-3: Groundwater Treatment Options Cost Estimate

Option #1				
1 - Treatment of Gilman, Stadium, and Lary Lane				
Building - Assume 7.5 gpm/sf, then 4 8-ft filters with room for fifth				
A - Greensand - no clearwell	QTY	Unit	Unit Price	Price
Building for filters, elec, mech, chemical	2500	sf	$200	$500,000
Foundation (no tank, residuals to sewer)	150	cy	$800	$120,000
Filters with media, piping, valves, controls	4	ea	$500,000	$2,000,000
Electrical/Mechanical	1	ls	$300,000	$300,000
Site work/excavation	850	cy	$40	$34,000
Yard Piping	200	lf	$150	$30,000
Backwash - assume from dist system	0			
Total				**$2,984,000**
Plus Design Engineering (10%)				$298,400
Plus Construction Administration (10%)				$298,400
Plus Contingency (15%)				$447,600
Add Backwash tank - concrete	350	CY	$800	$280,000
excavation	2500	cy	$15	$37,500
backfill	1500	cy	$25	$37,500
Equipment, piping, controls	1	LS	$200,000	$200,000
				$3,539,000
Plus Design Engineering (10%)				$353,900
Plus Construction Administration (10%)				$353,900
Plus Contingency (15%)				$530,850
TOTAL A - without residuals handling				**$4,028,400**
TOTAL A - with residuals handling				**$4,777,650**

B - Layne Ox or Pureflow (with clearwell/pumps)				
Building for filters, elec, mech, chemical	3600	sf	$200	$720,000
Foundation (no tank, residuals to sewer)	225	cy	$800	$180,000
Filters with media, piping, valves, controls	4	ea	$500,000	$2,000,000
Electrical/Mechanical	1	ls	$400,000	$400,000
Site work/excavation	4500	cy	$50	$225,000
Yard Piping	200	lf	$150	$30,000
Backwash - assume to sewer	0			$0
Clearwell	200	cy	$800	$160,000
Backwash pump/finished water pumps	1	ls	$175,000	$175,000
Total				**$3,555,000**
Plus Design Engineering (10%)				$355,500
Plus Construction Administration (10%)				$355,500
Plus Contingency (15%)				$533,250
Add Backwash tank - concrete	350	CY	$800	$280,000
excavation	2500	cy	$15	$37,500
backfill	1500	cy	$25	$37,500
Equipment, piping, controls	1	LS	$200,000	$200,000
				$4,110,000
Plus Design Engineering (10%)				$411,000
Plus Construction Administration (10%)				$411,000
Plus Contingency (15%)				$616,500
TOTAL B without Residuals handling				**$4,799,250**
TOTAL B with Residuals settling				**$5,548,500**

These tables provide a general overview of the groundwater treatment components and capital cost estimates. Further discussion of the treatment process and components is included under separate cover in the Gilman and Stadium Well Pumping Test and Pilot Reports.

8.5 Operation Cost Estimate for Groundwater Sources and Treatment

Operating costs related to chemical usage and electrical consumption were investigated for the groundwater treatment option listed above. The following assumptions were made regarding demand, operating rates, chemical dosages and electrical use:

- Flow rates are assumed from pump test results.
- Total dynamic head for the pumps assume a well pumping depth of 30 feet, system pressure of 85 psi, head loss of up to 15 psi through the filter plant.
- Chemical feed rates were taken from the pilot study and reflect the high end of the estimated range. For Stadium and Gilman Wells a sodium hypochlorite dosage of 8 mg/l was used. For the Lary Lane Well a sodium hypochlorite dosage of 4 mg/l was used and dosage of 2.9 mg/l of ferric chloride was assumed.

Table 8-4: Groundwater Treatment Operating Cost Estimate:

	Flow rate (gpm)	TDH (ft)	BHP	KWH/MG	Elec Cost per MG	Chemical Cost Per MG	Total Cost Per MG
Gilman	250	300	28.41	361.79	$39.80	$10.01	$49.81
Stadium	500	300	63.13	803.98	$88.44	$22.23	$110.67
Lary Lane	225	300	31.57	401.99	$44.21	$11.12	$55.33
Total	975			1567.76	$172.45	$43.36	$215.81

We calculated groundwater pumping and treatment cost for the actual volumes treated by existing methods for the months in 2008. The following table can be compared to the table above. As you can see, the groundwater treatment operating cost estimate is less than half the current annual operating costs to the Exeter water system. The electrical usage for groundwater treatment is higher than reservoir treatment but lower than the river pumping treatment. To determine brake horsepower, an assumed combined motor and pump efficiency of 0.6 was assumed. This is very conservative for vertical turbine pumps if premium efficiency motors are used. The real cost savings would be in the significant reduction in chemicals required for treatment with a groundwater system.

Cost Comparisons

The following table summarizes the cost comparison scenarios on a per million gallon basis utilizing information gathered from this report. It also presents a hypothetical cost if each source were the sole source for the Town's municipal water supply for a year:

Table 8-5: Cost Comparison by Source

Source of Supply	Cost per Million Gallons	System Demand (million gallons per year)	Gallons treated vs. gallons produced	Total Gallons treated per year	Hypothetical Cost per Year (365 million gallons)
Reservoir	$313	365	1.20	438	$137,094
River	$560	365	1.20	438	$245,280
Groundwater	$216	365	1.05	372	$80,416

New River Intake and Treatment Systems Located adjacent to the Lary Lane Well

As mentioned in section 2 of this study, a conceptual site plan was developed for the construction of a new 2 mgd surface water treatment facility to be located adjacent to the Lary Lane Well. This recommendation was not implemented; however, it does have some intriguing components when looked at in the context of this study and Exeter's water system needs. They are as follows:

1. The site is still undeveloped and possibly available for the construction of a facility.
2. Since a groundwater treatment system is also recommended, construction of two separate systems, one for groundwater, one for surface water, would have an economy of scale. The two systems could share some common infrastructure like electrical services, operational areas, SCADA controls, chemical delivery and storage areas, clearwell and high lift pumps, etc.
3. The Exeter River has a deep spot in that area, deeper than the existing pumping station, which could be utilized for a river intake.
4. Building an entirely new surface water treatment facility on high ground could create opportunities for a much smaller and efficient surface water system being constructed at the Exeter Reservoir.

We have not performed any cost estimates for such a facility due to the scope of this study. It has simply been mentioned at this point as something that might warrant further analysis.

8.6 New Southeast (Drinkwater Road) Well Site

A memorandum was prepared and sent on September 30, 2008 by Weston & Sampson and sent to Jennifer Perry and Russ Dean regarding the potential groundwater source on

Drinkwater Road. As mentioned in Section 4 of this report, this area was studied and tested extensively in 1984. Test wells at that time revealed that the quantity and quality of water in the area is good. Yields for a production well are anticipated to be approximately 500,000 gallons per day.

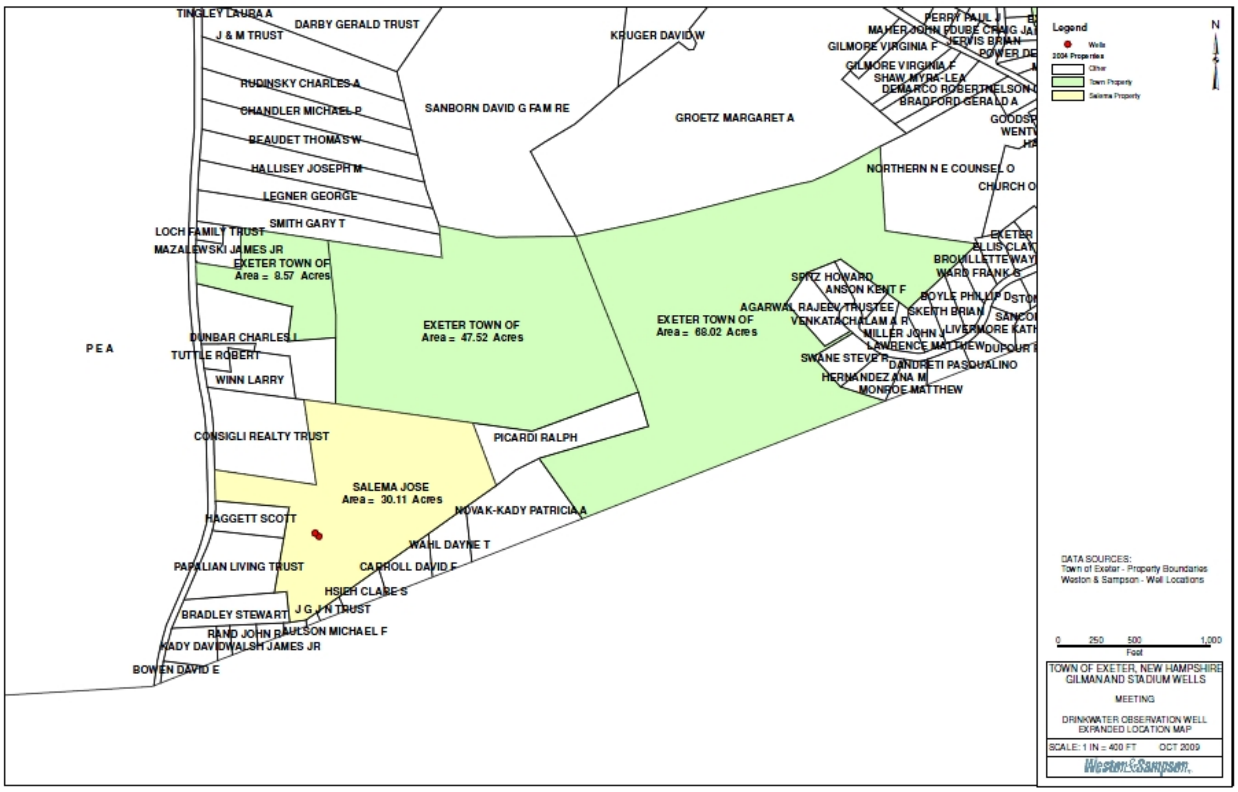
During the 2009 Gilman and Stadium rehabilitation and pumping test study we utilized two of the test wells in the Drinkwater area as monitoring points. The information gathered from this monitoring revealed that the wells did not appear to be impacted by the pumping of Gilman/Stadium wells even though they are in the same aquifer. Longer-term data may be necessary regarding any influence the pumping of these two wells might have at this site; however, this preliminary assessment is good news in regards to future development of a groundwater source in this area.

A Large Groundwater Withdrawal permit would have to be submitted for a new site on Drinkwater Road, as this would be an entirely new withdrawal. Our experience is that this process would take approximately 18 to 24 months to complete as there are a number of steps that would have to be taken prior to completion and approval. The site is deep and would require a number of deep monitoring wells, which would increase costs. Access and wetlands for monitoring may be an issue as well. The proximity of the site to the Towns of Kensington and Hampton Falls would also require their potential review and involvement per DES requirements. Finally, residential well owners in the area would have to be noticed and allowed an opportunity to have their wells inspected and possibly, monitored during a pumping test.

We are recommending that the Town pursue the purchase and/or easement from the property owner to move forward with the process of permitting a new groundwater source at this site. In addition to being a good potential source of groundwater, this site would add to the Town's protected land in the area, as they already own two parcels totaling 115.5 acres in the area.

If purchase, and/or acquisition of this site (via lease or easement) for groundwater development does not prove out for the Town, the we recommend that the Town might re-visit the test well program to identify if a good source of groundwater is available on the Town's parcels. There were test wells drilled in the 1984 study, however, a site closer to the successful test well may be feasible. Finally, the PEA property across the road from the Drinkwater test wells also showed some potential during the 1984 study. The Town may chose to pursue some type of agreement with the Academy for use of this property. Figure 8-2 details this area:

Figure 8-2: Drinkwater Road Test Well Area



Once a site has been developed, the long-term viability and treatment needs would then be assessed during a pumping test. Depending on water quality, the well would either be pumped directly into the Town's water system via a new transmission main up Drinkwater Road or connected to the Gilman/Stadium and Lary Lane groundwater treatment system. This would most likely be accomplished by running a transmission main through the utility easement that goes from Drinkwater Road to the Stadium well site. Capital cost estimates were derived for both options.

8.7 New Southeast (Drinkwater Road) Well Site

As previously mentioned in this study and also addressed during the Groundwater Matrix project, there have been other potential groundwater sites identified in the Town of Exeter. We recommend that the Town continue exploration of these sites to determine their viability. The scope of additional study would range from performing more site reconnaissance and desktop analysis to doing on-the-ground follow-up exploration like geophysics for bedrock sources or test wells for surficial sources.

8.8 Skinner Springs Well Redevelopment and Monitoring System

The inspection of the Skinner Springs well system during this study revealed that the wells may have lost some capacity over the years due to buildup of iron, manganese and other silts that have gathered at the bottom of the wells. We recommend that a scope of work be developed for the Town to bid for and hire a well drilling contractor to clean and rehabilitate the wells. We also recommend that an online water level monitoring system be installed to enable the water system operators to track water levels and long-term yeilds of the springs.

8.9 Total Capital Cost Estimate for Water System Alternatives

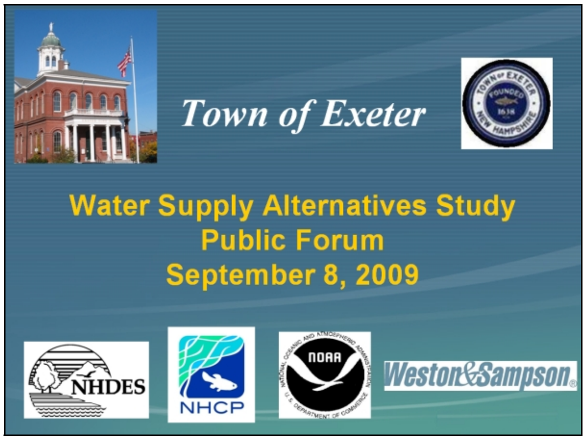
The following table summarizes our preliminary capital cost analysis for the design, permitting and construction of various facilities as discussed in this study. The items have been categorized according to their broad impact to the Town's water supply system. These recommendations follow a phased approach, to allow for study and analysis of the success of each step prior to proceeding with additional work in the next phases. Step 1 would diversify the Town's water sources and provide the opportunity to start implementing an integrated management plan as discussed in Chapter 7. Step 2 addresses the Town's long-term supply needs via additional groundwater sources while Step 3 focuses on modernizing the Town's water treatment facilities in support of their long-term supply needs. Additional discussion of this phased approach is included in the recommendations section of this report.

Table 8-6: Total Capital Cost Estimate

Capital Upgrade	Cost Estimate (2009 dollars)	
Reservoir Aeration Upgrade	$0.015 to $0.025 mil.	Step 1
Gilman, Stadium, Lary Lane Equipment and Piping Connection	$1.67 to $2.0 mil.	
Groundwater Treatment (1.5 MGD Facility)	$4.0 to $5.0 mil.	
Additional 0.5 MGD Groundwater Source in Southeast area of Town	$1.9 to $2.8 mil.	Step 2
Additional Hydrogeologic Study for Groundwater Supplies	$0.1 to $0.2 mil.	
Skinner Springs Well Cleaning, Redevelopment and Water Level Monitoring	$0.05 to $0.075 mil.	
River Intake and Station Upgrades	$0.75 to $1.0 mil.	Step 3
Upgrades to Existing Surface Water Treatment or New Facility altogether	$10.6 mil. *	

* The estimate for surface water treatment upgrades takes into account the fact that less water would need to be treated if groundwater development proves successful. This cost estimate is currently only a placemark at this point and is inserted for planning purposes. Further analysis would be necessary to determine the final scope and cost estimates for surface water treatment upgrades.

9.0 PUBLIC FORUM PRESENTATION AND DISCUSSION



Exeter Public Forum Presentation

Introduction by Russ Dean, Town Manager

A primary component of this study's scope was to investigate options regarding water supply alternatives for the Town of Exeter should the Great Dam be removed and then put that information into a format that the general public could understand. This was done via a public forum that was held on September 8, 2009 at the Exeter High School. This forum was noticed during Town of Exeter's Selectmen's meeting and also in the local newspaper. Over 70 residents attended the forum that evening and it was also carried on Exeter's local access television station, Channel 22.

In developing the presentation for this forum, the study's working group met in a workshop to brainstorm the topics so they could be broken down into a format that would provide both proper background and perspective of the issues regarding both the Town's water supply and those pertaining to the Great Dam and the Exeter River watershed. Several iterations of the presentation were then refined by the group prior to the forum. Speakers assigned based on those most familiar and appropriate for the topics. The following table summarizes how the topics were broken down and who did the presenting:

Topic	Presenter
Study Background and Water System History	Russell Dean, Exeter Town Manager
Supply History and Water Demands	Brian Goetz, Weston & Sampson
River Flows and Regulatory Implications	Ted Diers, New Hampshire Coastal Program
Groundwater Supply Options	Kevin MacKinnon, Weston & Sampson
Integrated Management Options	Andrew Walker, Weston & Sampson
Demand Management and Capital Costs	Brian Goetz, Weston & Sampson
Regional Component and Summary	Ted Diers, New Hampshire Coastal Program
Public Input	All

The presentation lasted approximately one hour. A copy of the accompanying PowerPoint slides is included the appendix of this report.

Public Comments, Questions and Discussion:

Following the presentation the forum was opened up for public comment. A summary of those questions, comments and the study team's responses follows. We have done our best to include the names of the speakers when they identified themselves.

- Q: Where is the recharge area for the Gilman/Stadium wells?
    - Mr. MacKinnon responded by pointing to the maps on the stage and gave a brief discussion of the hydrogeology of the area
- Q: The analysis presented looked at a lot of the historical supply and demands based on past climate information, however, did we look at any revised estimates with potential climate changes?
    - Mr. Goetz responded that it was not directly in the scope but that we would look to the climate experts for the prediction and the recent Northeast Climate Impact Assessment. That New England is expected to be a little bit warmer and wetter overall but that there will be more peaks in precipitation and more frequent, shorter periods of drought.
- Q: What will the riverbank look like with the river down and what about bank restoration?
    - Mr. Diers responded that we are going to undertake a lowering of the impoundment this fall and we hope to see what it will look like. He also said that the area will revegetate but that this would be looked at in further studies if we get to that point.
    - Mr. Diers added that this study is just one of many that would take place – that it is just the beginning of what would be a long process of discovery regarding issues surrounding potential dam removal besides water supply. However, water supply was the "show stopper," so we had to take a look at this first.
- Q: If you remove the dam what might happen to flows and the String Bridge?
    - Mr. Diers responded that this was looked at in the Wright-Pierce report and that study revealed that at certain points during high flow the Great Dam is simply a "bump in the river." The dam is inconsequential during high flows… it's the High Street Bridge that is the flow control. However, he added that looking at scour and other changes that might occur with the dam removal would also be part of the next step of further study.
- Q: Mike Lambert commented that this is a great meeting, but why do you keep going back to the Gilman/Stadium well option, why not Fort Rock Farm area or the Buxton Well?
    - Mr. Mackinnon responded that Gilman/Stadium are proven sources, have high yields, are close to the existing system and scored high in analysis when Weston & Sampson did the Groundwater Matrix Study.

- Mr. Goetz added that the Fort Rock Farm area has been noted as a good possibility for bedrock exploration.
- Mr. Goetz responded to the Buxton well question that it fell down the list because it is in a developed area in town and that source protection issues would make permitting difficult. It is on the list, but ranked lower than other sites.

➢ Q: At what point would the PUC have to get involved if Exeter starts expanding into other towns?

- Mr. Goetz responded that this study does not recommend that Exeter aggressively pursue expansion of its system. We are just pointing out the economies of scale and benefits that larger regional systems have.

➢ Q: What does Integrated Management look like if you don't have any water on the river?

- Mr. Walker responded that this is when Exeter would shift over to groundwater sources and that this is the whole point of developing a more diverse water system.

➢ Q: What would happen to the Mills?

- Mr. Goetz responded that there would have to be some type of mitigation to replace their cooling water system with a type that wouldn't depend on the river.

➢ Q: What about when the fire department has in the past had to pull water from the river?

- Mr. Goetz responded that this is one of the reasons the Town installed the new water tank on Epping Road; to get more fire storage and increase the water pressure. They also installed water main into the center of town. Perhaps the Town has done some follow-up regarding flows before vs. after the installation of this new infrastructure.

➢ Q: Representative Donna Schlacman asked if a new water treatment plant would be more efficient than the one they have?

- Mr. Goetz responded that the current facility is inefficient because they have such stringent regulations. The facility was upgraded 35 years ago to meet the standards at that time. Since then, regulations have become tougher for the facility to meet because it just wasn't designed that way. He added that the way they are operating right now they have to waste a lot of water in the process (20%) but that they are also probably doing as good a job as at any time during the facility's operating lifetime.

➢ Q: Does the Great Dam provide aeration for the fish?

- Mr. Diers answered that "no" the dam actually creates a situation that's bad for the fish – Increased temperatures behind the dam, increased organics and low dissolved oxygen.
- Mr. Diers added that if the Town keeps the dam, they will still have to address those water quality issues. These are separate from the water supply issue.

➢ Q: What about recreation on the river?

- Mr. Diers responded that "yes" recreation would change, but that, again, this would be looked at in a next phase of study.

- Q: If the Town invests in groundwater will they be able to get by without major fixes to the surface water treatment plant or be able to build a smaller, less expensive one?
  - Mr. Goetz responded that a "cheaper" system is probably not likely but that it would definitely be a smaller facility, which would reduce costs. He added that the point of diversifying the system would be to bring the groundwater into the mix and then after it is on line the Town would know how large a facility they would need for surface water treatment.
  - Mr. Dean added that this is the very question that Exeter is grappling with as a community, that Exeter's water system has higher rates than other systems in New Hampshire and a good part of that has to deal with economies of scale. The complexity issue also hits a small town hard.
  - Mr. Dean continued to point out that the Town is looking at $1.6 million in costs for dam modification and you have the dam removed, and it's someone else's cost, then you have good savings for the Town.
  - Mr. Dean added that this study is another step toward evaluating the options and the costs so that the Town can make educated decisions with respect to these issues. He made the point that the Town has been wondering for years about the viability of the Gilman/Stadium well option and that they now have that answer. So, now it's time to move forward with the decision process.
  - Mr. Dean concluded that that Mrs. Perry and the Public Works Dept. now has a comprehensive capital improvements plan for the water system that includes more than just the supply.
- Q: A resident near the Gilman Park Well asked about the noise level of a treatment plant at the Gilman Park area?
  - Mr. Goetz responded that the noise this summer was just temporary; due to drilling the monitoring wells and that this would not be the case with the treatment facility.
- Q: What about the wildlife?
  - Mr. Goetz mentioned that there would be some changeover, like with other dam removal. He added that there is a common misconception that when you remove a dam the water goes away. This is not the case. What you end up with is a much more diverse ecosystem.
  - Mr. Diers added that future studies would have to do more mapping and detail of the scenarios regarding what would happen to the surrounding area with dam removal.
- Q: What about shoreline cleanup?
  - Mr. Diers responded that there are examples of other communities doing cleanups after dam removal. Exeter could look to these.
- Comments from Brian Grisset:
  - Clarification that Gilman and Stadium were identified through work with the Water and Sewer Advisory Committee. More discussion of how these sources came up higher on the list.

- The new tank really adds to the ability to do Integrated Management. The rates were designed to take this into account so that there would be a reserve of money that would offset big rate increases.
- You could look to take the cost savings from not having to fix the dam and put that toward water system improvements. This may also be a situation that the Town could get some grant money to assist with the expense.
- Mr. Diers added that there is a lot that can be derived from the recent Winnicut Dam removal study and ongoing work there (the dam is currently being “deconstructed”).

➢ Q: What about the other dams up the river like the Pickpocket?

- Mr. Diers said that these dams have been looked at but that it was not within the scope of this study to go into any depth with researching them. Just looking at the issues surrounding the Great Dam was enough to bite off at this time.
- He added that using them to regulate water during low flows is not a very viable option because they are “run of the river” dams.

➢ Q: What is the process the Town would have to go through if they decide to have the dam removed?

- Mr. Diers responded that there is “a lot” that they would still have to do. Essentially it is a 106 NEPA process they’d have to go through.
- Mr. Diers added that there would have to look at an environmental assessment, historical, archeological, land use and landscape, and other issues

➢ Q: At what point are we in the process?

- Mr. Diers responded that after this study is presented to the Selectmen then it would be up to them to decide where next to go.

➢ Q: What about the condition of the dam?

- Mr. Diers responded that the letters of deficiency the Town has on the dam are not about the integrity of the structure, just about its inability to pass the 50-year flood flows.

➢ Q: Peter Olney (owns property downtown adjacent to the fish ladder): How much does the wall by Founders Park restrict the flows?

- Mr. Diers commented that this wasn’t a part of the study scope but that any future work regarding dam removal would include that. We don’t envision a big change from what is there right now but there would have to be more specific mapping.

➢ Q: They dredged when they did the fish ladder and it showed a lot of sediment. Also, what about the trees and other growth along the river? What effect would dam removal have on them?

- Mr. Diers commented that, again, this is something that would have to be looked at. Right now there are some eddies that occur around the fish ladder. Those would go away but we don’t know what would replace them. Fish scour analysis would look at that.

- Regarding the siltation issue, Mr. Diers responded that there was some look at this in the Wright-Pierce/Woodlot study and said that this report is available on the Town website.
- Mr. Diers then added how the soils that are currently saturated because of the water level with the impoundment from the dam might end up being less saturated. He said that this may actually improve low flows because this water would be stored and then released slowly during dry periods. It may also mitigate flooding.
- Mr. Diers summed up his response that these points are really good but they are the issues that would need to be addressed in subsequent phases of study.
- Mr. Goetz added that during the course of the study we reviewed some historical documents to gain some insight as to the history of the dam. The earliest records talk about "the Great Falls" where the Great Dam now resides. This is most likely due to the bedrock in the area.
- Mr. Diers then added that there is a lot of misconception about what dams do in regards of the downstream. They don't have much effect downstream, it's what's above them that they effect.

➢ Q: If you lower the water level what is going to happen to shallow dug wells in the area?

- Mr. Diers said that this would be something to look at in the next stages.

➢ Q: Did anybody look at the feasibility of using this for hydroelectricity?

- Mr. Diers gave perspective about hydroelectricity in New Hampshire and the impacts that small hydro may have on riverine environments. He added that you really need to look at this dam in the context of the whole river. This is one of the issues that'd we'd have to look at further.
- Mr. Diers didn't debate the fact that there are a lot of communities looking into small hydro projects but that it, in and of itself, is a very complicated permitting process.

➢ Comments from Don Clement (who has been involved with the Exeter River Advisory Committee for 12 years):

- The dam really causes a lot of water quality issues as noted. If we look at dam removal there are still a lot of questions to be answered but the Town needs to take into account the overall river environment.
- The Little River impounded area would see an improvement in quality. The impoundment creates a negative impact to wildlife.
- People need to see that changes to the river with dam removal would not be as dramatic as they think.
- The diversity of water supplies for the Town would be a great benefit.

Russ Dean then concluded the night by thanking everyone in attendance and that the Town will look forward to getting the study and then reviewing the options put forward.

10.0 SUMMARY AND RECOMMENDATIONS

10.1 Recommendations

The following section summarizes the recommendations of this study.

Gilman, Stadium and Lary Lane Wells

1. Finalize the reactivation process for the Gilman and Stadium Wells.
2. Develop preliminary design plans for:
   - Equipping the Gilman and Stadium Wells.
   - Piping and manifolding the Gilman, Stadium and Lary Lane wells.
   - Coordinating preliminary design with Phillips Exeter Academy regarding upgrades that will occur on their property.
3. Develop preliminary process and design plans of the groundwater treatment system.
4. Determine final site layout and location of groundwater treatment system.
5. Finalize cost estimates to present for budgets in the fall of 2010 for warrant articles to be voted on in March 2011 with potential final design and construction starting in the summer of 2011.
6. Submit projects for potential funding via the DES SRF and/or Federal Stimulus project.

Additional Groundwater Sources

1. Acquire, lease and/or obtain easement for property in southeastern portion of Exeter to develop a new source of approximately 0.5 MGD and then proceed to develop an application to DES for a new large groundwater withdrawal permit. (A memorandum from Weston & Sampson was provided to the Public Works Director, Jennifer Perry and Town Manager, Russ Dean, on September 30, 2009 with this recommendation)
2. Continue investigation of other potential surficial sites and/or bedrock groundwater sites as identified in the Groundwater Matrix Study.

Exeter Reservoir Upgrades and Operation

1. Design and install new aeration system in reservoir.
2. Refine the Integrated Management Plan to optimize pumping to reservoir from river in order to keep it full as dry periods approach.

Skinner Springs Redevelopment

1. Develop scope of work to clean and redevelop the six wells in the area.
2. Install water level monitoring devices at Springs to gain further insight regarding seasonal yields and status of water availability.

River Pump Station/Water Treatment Facility

1. Develop preliminary design plans if necessary to accommodate a deeper intake at the existing river pumping station.
2. Re-investigate the option of siting a new surface water treatment facility and intake adjacent to the Lary Lane well.

Demand Management

1. Finalize Water Conservation Plan
2. Develop public outreach and website presence for Water Supply Status Updates
3. Determine if further water conservation incentives are warranted:
   a. Toilet rebates
   b. Lawn retrofit rebates
4. Rate Changes
   a. Seasonal rates
   b. Irrigation rates
   c. Other

Regionalization

1. Continue to maintain dialog with Town of Stratham regarding mutually beneficial efforts for water system improvements.
2. Continue to track potential formation of the Seacoast Water District as laid out in Chapter 42, laws of 1995.

Dam Removal Option – Next Steps

If the removal of the Great Dam is to move forward, at a minimum, this study has revealed that the following items would have to be addressed:

- There are three other withdrawals identified in this study that would need to be mitigated if the Great Dam were removed:
  - The Exeter Mills Apartments would require changes to their cooling and fire systems for their larger building. These systems currently obtain source water from the river. The complex also has an irrigation system that would require an alternative source of water.
  - The Phillips Exeter Academy would require upgrades to their existing river intake to continue to supply irrigation water for their fields and makeup water for their heating system.
  - The fire hydrant in Founders Park that utilizes river water would have to be upgraded or replaced with another system if the Town still requires it as a source of supplemental water to fight fires in the downtown area.

- The river pumping station and river intake would require upgrades to enable withdrawal of water from a lower impoundment when flows on the river low.
- The Exeter Reservoir would need aeration and upgrades to enable its use as a surface water source during the summer.
- The Town would need alternative sources of reliable water, such as the Gilman, Stadium and Lary Lane Wells, to enable continued water supply during periods when the river withdrawals would be reduced and/or unavailable due to low flows and/or poor water quality.
- Work with the environmental regulators, legislatures and other interested parties to leverage resources such that the Town's capital infrastructure costs can be offset if dam removal becomes a reality.

The following table was presented to the Exeter River Local Advisory Committee during this study. It summarizes the items listed above and provides the capital cost estimate for each:

Table 10-1: Preliminary Cost Estimates to Mitigate Effects of Dam Removal

River Intake and Station Upgrades	$0.75 to $1.0 mil.
Reservoir Aeration Upgrade	$0.05 to $0.10 mil.
Replace Founders Park Dry Hydrant by installing secondary fire system upstream	$0.125 to $0.250 mil.
Lower Phillips Exeter Academy Intake and pump station	$0.10 to $0.25 mil.
Exeter Mills - Retrofit irrigation, fire suppression and cooling system *Fire system could be integrated with Founders Park System	$0.25 to $0.50 mil.
Gilman, Stadium, and Lary Lane Well – Equipment, Piping and Groundwater Treatment	$5.80 to $6.80 mil.
Total Estimate	**$7.08 to $8.90 mil.**

The following table was also presented in section 8 of this report but is included here in the recommendations section for easy reference. As also mentioned in that section, these recommendations follow a phased approach, to allow for study and analysis of the success of each step prior to proceeding with additional work in the next phases:

- Step 1 would diversify the Town's water sources and provide the opportunity to start implementing an integrated management plan as discussed in Chapter 7.
- Step 2 addresses the Town's long-term supply needs via additional groundwater sources.
- Step 3 focuses on modernizing the Town's water treatment facilities in support of their long-term supply needs.

Table 10-2: Total Capital Cost Estimate

Capital Upgrade	Cost Estimate (2009 dollars)	
Reservoir Aeration Upgrade	$0.015 to $0.025 mil.	Step 1
Gilman, Stadium, Lary Lane Equipment and Piping Connection	$1.67 to $2.0 mil.	
Groundwater Treatment (1.5 MGD Facility)	$4.0 to $5.0 mil.	
Additional 0.5 MGD Groundwater Source in Southeast area of Town	$1.9 to $2.8 mil.	Step 2
Additional Hydrogeologic Study for Groundwater Supplies	$0.1 to $0.2 mil.	
Skinner Springs Well Cleaning, Redevelopment and Water Level Monitoring	$0.05 to $0.075 mil.	
River Intake and Station Upgrades	$0.75 to $1.0 mil.	Step 3
Upgrades to Existing Surface Water Treatment or New Facility altogether	$10.6 mil. *	

* The estimate for surface water treatment upgrades takes into account the fact that less water would need to be treated if groundwater development proves successful. This cost estimate is currently only a placemark at this point and is inserted for planning purposes. Further analysis would be necessary to determine the final scope and cost estimates for surface water treatment upgrades.

10.2 Step 1 Recommendations Scope: Gilman, Stadium and Lary Lane Well Groundwater System

The 2009 analysis, pumping test and water treatment piloting recommendation to the Town:

- Pursue the reactivation of the Gilman and Stadium wells with a combined yield of approximately 1.0 million gallons per day (MGD).
- Manifold these wells together with the Lary Lane well (yield of approx. 0.25 MGD).
- Design and construct an iron-manganese pressure filtration system capable of treating the Gilman, Stadium and Lary Lane wells with the ability to expand if other groundwater sources are added at a later date.

This effort would include:

- Prepare and submit a final report to the Department of Environmental Services to complete the reactivation process for the Gilman and Stadium wells.
- Assist the Town with discussions with the Phillips Exeter Academy regarding upgrades to the Stadium well site.
- Develop conceptual design plans for reactivating the Gilman and Stadium wells:
    - Site improvements, including floodplain issues.
    - Preliminary sizing of pumping equipment, electrical loads and process control.
    - Determine pipe size and routes in order to manifold the Gilman, Stadium and Lary Lane wells together.
- Develop basis of groundwater treatment design plans, sizing and functional operation descriptions for submittal to DES for the groundwater treatment system:
- Sizing and selection of chemical feed systems
- Sizing and selection of process piping and valves
- Loading rates and preliminary filtration design
- Conceptual building layout and materials
- Concurrently with item 4, determine final site layout, footprint and location of groundwater treatment. The current sites under consideration include:
    - Former volleyball court in Gilman Park.
    - Basketball court in Gilman Park.
    - Lary Lane well site. (This site would require discussions with PEA)
- Finalize cost estimates to present for budgets in the fall of 2010 so that warrant articles can be voted on in March 2011 for final design, bidding and construction of facilities.
- Work with Town officials to develop a public outreach effort in order to gain support of the project.
    - Artist rendering of potential buildings and site improvements. The current thought is to incorporate park-like facility structures for the Gilman Park site and to minimize facilities at the Stadium site, possibly integrating them into the existing river pumping station.
    - Present recommendations and conceptual designs to the Board of Selectman.

- **Other recommendations for the Town's water system in 2010**

    - Work with Town officials to acquire and/or lease property in the southeastern portion of Exeter for a future groundwater source of supply. It has been determined through previous investigations and recent analysis that this area has a capability of at least 0.5 MGD of additional groundwater which could be incorporated into the groundwater system.
    - Continue development of the Town's Water Conservation and Demand Management Program to include additional public outreach measures and a drought management plan. This effort may include the development of public outreach and website presence for Water Supply Status Updates, additional rebate programs for water efficiency measures, and/or new rate changes to promote

water efficiency. The Demand Management Program would include the following components

- Declaration of purpose
- Public education and outreach
- Trigger conditions. These conditions are important because "they provide specific written criteria that give the utility authority to impose specified legal restrictions once a trigger condition has been met and also provide the set points of reference for the utility to watch for to determine when they are approaching drought conditions."
- Response measures and actions
- Implementation procedures

Proposed Project Timeline for 2010 Calendar Year

The following table provides a general overview of the project timeline as recommended in this study for the 2010 calendar year:

PROPOSED PROJECT TIMELINE

Town of Exeter Water Supply Upgrades
Groundwater System, Demand Management, and Public Outreach

Item No.	Task Description	2010 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Prepare and submit final report to DES for reactivation of Stadium and Gilman wells	■	■										
2	Assist Town with PEA discussions regarding Stadium well site		■	■	■								
3	Develop conceptual design plans for reactivation of Stadium and Gilman wells			■	■	■	■						
4	Develop conceptual design of groundwater treatment system and submit to DES			■	■	■	■	■	■				
5	Determine final site layout, location and footprint of groundwater treatment system			■	■	■	■	■	■	■			
6	Finalize cost estimates and scope for budgeting and presenting to Town in 2011							■	■	■	■		
7	Public outreach effort								■	■	■	■	■
8	Assistance with the acquisition or lease of future well site in Southeast portion of Town						■	■	■	■	■	■	■
9	Water Conservation and Demand Management Plan	■	■	■	■	■	■	■	■	■	■	■	■

Estimated Capital Improvement Plan

The following table provides a general overview of the estimated cost and timeline for the proposed capital improvement plan for the Town's water supply sources:

2010-2016 Town of Exeter Capital Improvement Plan										
Water System - Source of Supply Upgrade Schematic										
Weston & Sampson Comments										
18-Nov-09										
									Schedule	
Project	**Projected Million Gallons per Day**	**Year**	**Total Amount**	**FY10 Amount**	**Fund**	**Financing Method**	**Length of Issue**	**Rate**	**2010**	**2011**
WATER - DPW										
Groundwater System Prelim Design		2010	150,000	150,000	Water	Cash	10	2.50%	150,000	
Groundwater System Final Design		2011	350,000	-	Water	Bond/SRF	10	2.50%		350,000
Groundwater System Construction	1.25	2011	6,000,000	-	Water	Bond/SRF	10	2.50%		2,000,000
Additional Groundwater	0.50	2011	2,500,000	-	Water	Bond/SRF	10	2.50%		200,000
WTP Upgrade Design		2013	600,000	-	Water	Bond/SRF	10	2.50%		
WTP Upgrade Construction	1.50	2015	10,000,000	-	Water	Bond/SRF	10	2.50%		
Totals	**3.25**		**19,600,000**	**150,000**					**150,000**	**2,550,000**

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APPENDIX A

Public Forum and Exeter River Advisory Committee Presentations

Town of Exeter

ater Supply lternatives Study
Public orum
September

Weston&Sampson

Purpose of Study

- Exeter has been studying the Exeter River and fixes to the Great Dam for a number of years
- Exeter has also been studying water supply alternatives for many years
- The Town approved funding for Great Dam reconstruction design via a 2008 warrant
  - $377,000 for design
  - Estimate for construction is $1.1 to $1.4 million

Weston&Sampson

Purpose of Study

If the dam were to be removed, determine:

- Reduction of Yield from River Intake for Town's Water Supply
- How Could this reduction be Mitigated?
- What's the Cost to Mitigate?

Weston&Sampson

Pro ect Funding

- The project was funded by the National Oceanic Atmospheric Administration (NOAA) Coastal Restoration Center in conjunction with the New Hampshire Coastal Program at the New Hampshire Department of Environmental Services.

Weston&Sampson

Tonight's Speakers

- Russ Dean – Town Manager
- Ted Diers – NH Coastal Program
- Weston & Sampson
  - Brian Goetz – Project Manager
  - Kevin MacKinnon – Hydrogeologist
  - Andrew Walker – Hydrologist

Weston&Sampson

Overvie of this Public orum

- **ac ground (Russ)**
- Demand Trends (Brian)
- River Flows and Regulatory Implications (Ted)
- Groundwater Supply Options (Kevin)
- Results and Options (Andy)
- Demand Management and Costs (Brian)
- Regional Component and Summary (Ted)
- What's Next for the Town? (Russ)
- Public Feedback (All)

Weston&Sampson

Water System History

- "In Ch. 179 of the Laws of 1885, the Exeter Water Works was chartered to bring water into the Village of Exeter.
- Eight years later, in Chapter 220 of the Laws of 1893, the Legislature authorized the Town of Exeter to own and operate a water system, assuming the franchise and property of the former Exeter Water Works Corporation."

Reference: Pierce-Atwood Water Rights Report (2004)

Weston&Sampson

Exeter Water Works Pond and Pumping Station built in 1886

Reference: "Exeter New Hampshire – 1888-1988"

Weston&Sampson

Water System History

- Water system was privately owned and operated until it was purchased by the Town in 1951.
- The Town embarked on extensive water system upgrades after taking control of system:
  - New water mains
  - New Hampton Road Tank
  - Gilman Park, Lary Lane and Stadium Wells

Weston&Sampson

Water System History

- Recent upgrades:
  - New Water Tank on Epping Road
  - New water main from Epping Road Tank to center of town

Weston&Sampson

Water System History

- No Recent Major Upgrades on Sources of Supply:
  - $1.7 million appropriated for design of a new water treatment plant in 2003
  - 2004 vote for new facility did not pass
  - 2005 vote for $17.5 million facility upgrades did not pass

Weston&Sampson

Overvie of this Public orum

- Background (Russ)
- **Supply and Demand Trends (rian)**
- River Flows and Regulatory Implications (Ted)
- Groundwater Supply Options (Kevin)
- Results and Options (Andy)
- Demand Management and Costs (Brian)
- Regional Component and Summary (Ted)
- What's Next for the Town? (Russ)
- Public Feedback (All)

Weston&Sampson

Water System Background

- Special thanks to:
  - Town Hall
    - Russ Dean, Town Manager
    - Lorrie Maker, Water Billing Department
  - Public Works
    - Jennifer Perry, Public Works Director
    - Paul Vlasich, Town Engineer
    - Paul Roy, Chief Water Treatment Operator
    - Matt Berube, Engineering Technician
    - Steve Tucker, Foreman
  - New Hampshire DES and Wildlife
    - Ted Diers, Steve Roy, Brandon Kernen, Kevin Lucey, Sally Soule, Wayne Ives,Cheri Patterson and John MaGee

Weston&Sampson

Sources of Supply

- 1906 – Water Filtration Facility constructed adjacent to the Reservoir (Water Works Pond)

Skinner Springs

- 1929 – Six gravel packed wells are installed at Skinner Springs. Water is piped to the Treatment Facility.

Weston&Sampson

Reservoir and Skinner Springs Area

Weston&Sampson

Gilman Park Well

- 1951 – Town installs the Gilman Park Well
  - This well was utilized for seven years as the primary source of water supply for the Town.

Weston&Sampson

Lary Lane Well

- 1958 – Town installs the Lary Lane Well.
  - This well is still in service, however, recent changes to the arsenic concentration rules have limited its use.

Weston&Sampson

Stadium Well

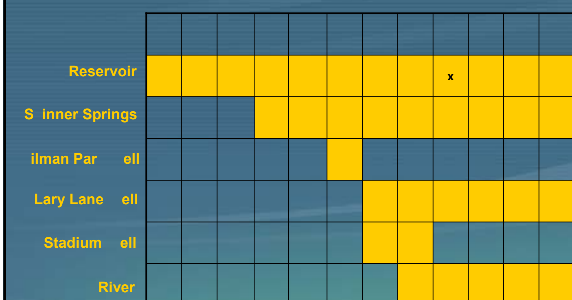
- 1963 – Town installs the Stadium Well.
  - This well was utilized with the Lary Lane Well until 1974.

River Pumping Station

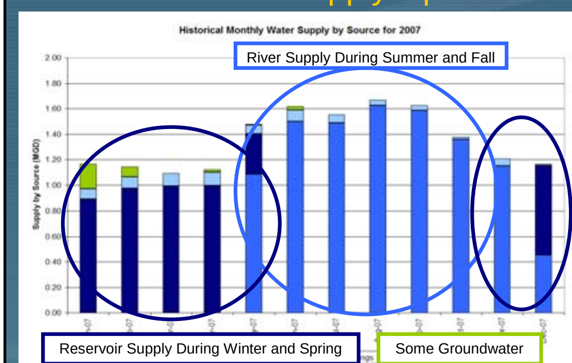
- 1970's – The Town acquires water rights from Exeter Manufacturing to utilize water from the Exeter River.
  - A river pumping station is constructed to supplement water from the Exeter Reservoir
  - The Water Treatment Facility is upgraded.



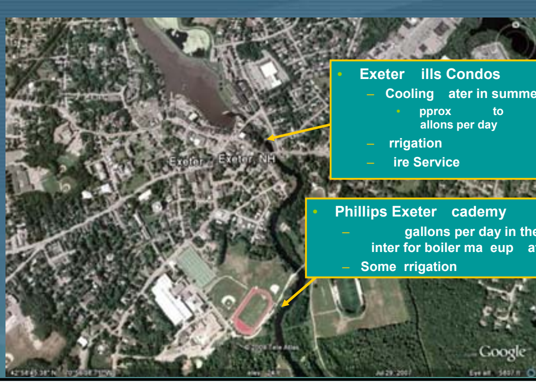
Source of Supply Timeline



Historical Water Supply Operations

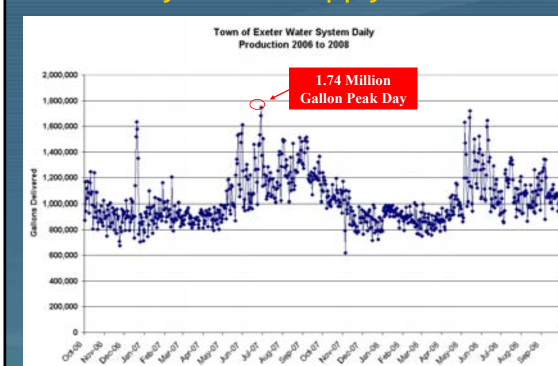


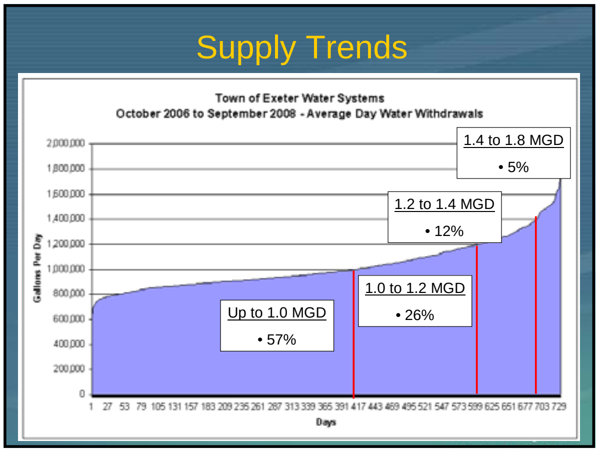
Other Withdrawals From River

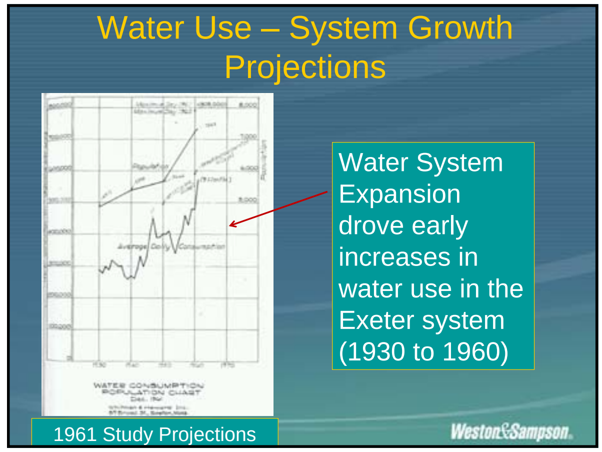


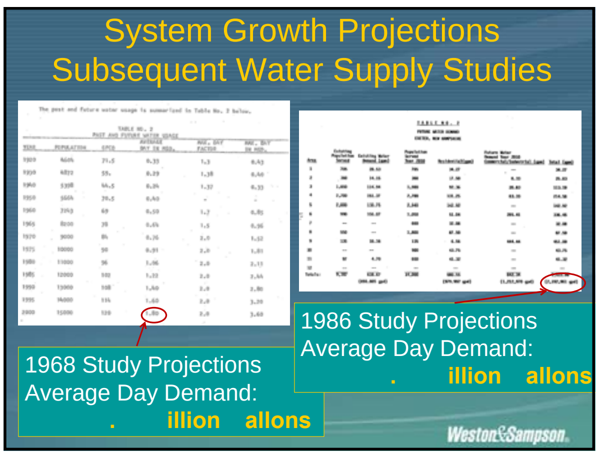
- Exeter ills Condos
  - Cooling ater in summer
    - pprox to allons per day
  - rrigation
  - ire Service
- Phillips Exeter cademy
  - gallons per day in the inter for boiler ma eup ater
  - Some rrigation

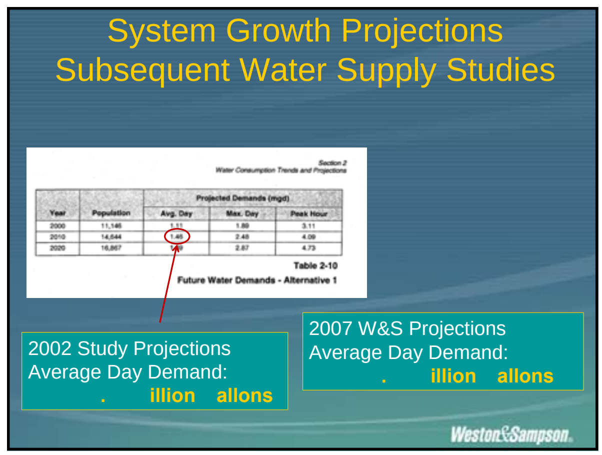
Daily Water Supply Trends

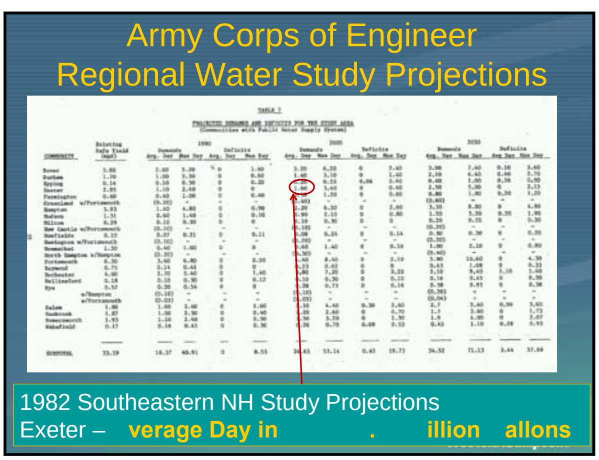


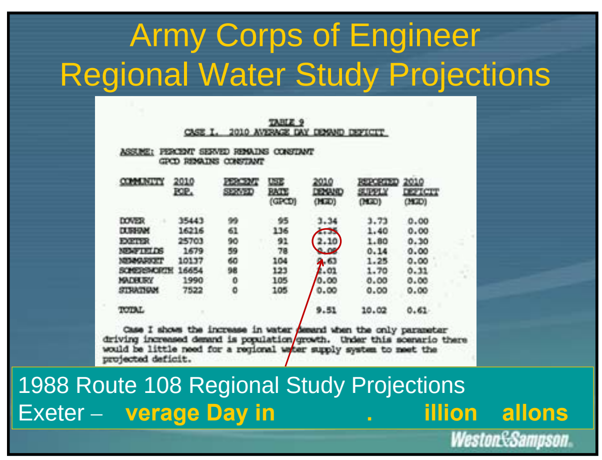

Supply Trends
Town of Exeter Water Systems
October 2006 to September 2008 - Average Day Water Withdrawals
1.4 to 1.8 MGD
• 5%
1.2 to 1.4 MGD
• 12%
1.0 to 1.2 MGD
• 26%
Up to 1.0 MGD
• 57%
Gallons Per Day
Days


Water Use – System Growth Projections
Water System Expansion drove early increases in water use in the Exeter system (1930 to 1960)
1961 Study Projections
Weston&Sampson


System Growth Projections
Subsequent Water Supply Studies
1968 Study Projections
Average Day Demand:
. illion allons
1986 Study Projections
Average Day Demand:
. illion allons
Weston&Sampson


System Growth Projections
Subsequent Water Supply Studies
Table 2-10
Future Water Demands - Alternative 1
2002 Study Projections
Average Day Demand:
. illion allons
2007 W&S Projections
Average Day Demand:
. illion allons
Weston&Sampson


Army Corps of Engineer
Regional Water Study Projections
1982 Southeastern NH Study Projections
Exeter – verage Day in . illion allons


Army Corps of Engineer
Regional Water Study Projections
TABLE 9
CASE I. 2010 AVERAGE DAY DEMAND DEFICIT
1988 Route 108 Regional Study Projections
Exeter – verage Day in . illion allons
Weston&Sampson

USGS Seacoast Water Use Study Regional Water Study Projections

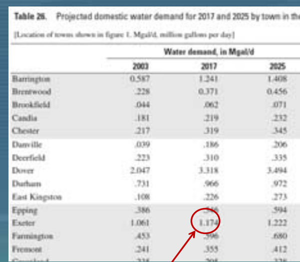


Table 26. Projected domestic water demand for 2017 and 2025 by town in the

[Location of towns shown in figure 1. Mgal/d, million gallons per day]

	Water demand, in Mgal/d		
	2003	2017	2025
Barrington	0.587	1.241	1.408
Brentwood	.228	0.371	0.456
Brookfield	.044	.062	.071
Candia	.181	.219	.232
Chester	.217	.319	.345
Danville	.039	.186	.206
Deerfield	.223	.310	.335
Dover	2.047	3.318	3.494
Durham	.731	.966	.972
East Kingston	.108	.226	.273
Epping	.386	[illegible]	.594
Exeter	1.061	1.174	1.222
Farmington	.453	.596	.680
Fremont	.241	.355	.412

2003 USGS Study Projections
Average Day Demand:
. illion allons (domestic use only ncludes private residential ells)

Summary of Study Projections

Study Year	2000 Projected MGD	2010 Projected MGD
1968	1.80	
1982	1.60	
1986		2.19
1988		2.10
2002		1.46
2007		*1.25

* Projected for 2025

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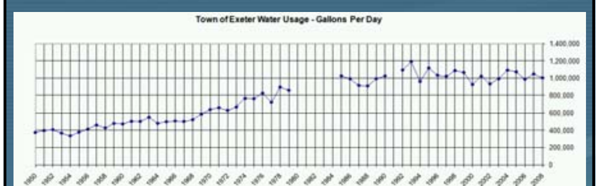
Exeter – Actual Water Use 1950 to 2008



AVERAGE DAY WATER DEMAND

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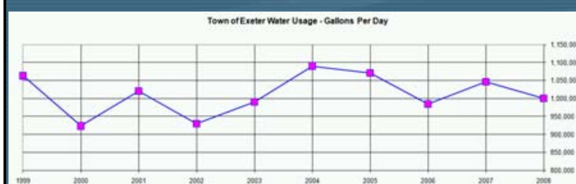
Weston&Sampson

Water System – The Last 10 Years



Average Day Water System Use

The existing water system is not experiencing an increase in water demands – Holding steady at approximately 1 million gallons a day

Weston&Sampson

Why has Water Supply Demand Leveled Off?

- **ater Conservation message is getting through**
- **ater Rates have gone up**
  - **ncreasing bloc rates**
  - **Se er fees are tied to ater use**
- **Lea Detection identifying lea s in system**
  - **Exeter has recently purchased ne lea detection e uipment**
  - **DES ust a arded the To n a grant to do a comprehensive lea detection study**
- **ater System is mostly built out**

Weston&Sampson

Water Conservation Kits

The Town has been offering these kits to residential customers so they can retrofit their existing plumbing.

vailable at Public or s

- Low flow showerhead
- Toilet dam to reduce volume
- Faucet aerators
- Leak detection tablets
- Water Conservation Tips

Water Produced vs. Metered Water Sold

- Unaccounted-For Water ~ 11%

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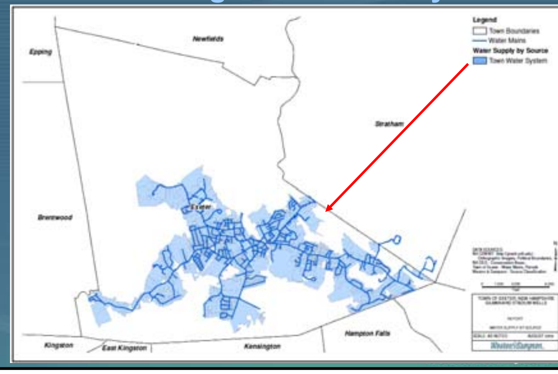
Water System Production and Billing Totals
October 2007 to September 2008
Town of Exeter, New Hampshire

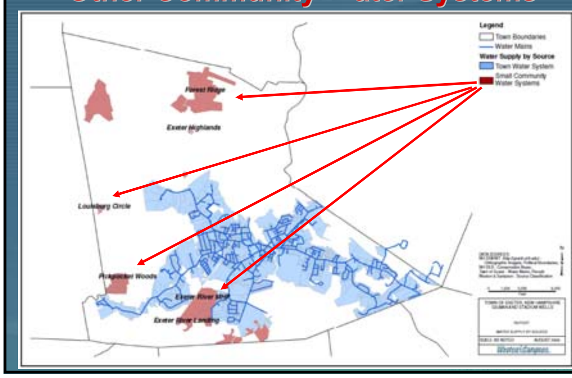
	Total Gallons	Gallons per day
Total System Pumpage	381,876,702	1,075,709
Total Metered Use	328,285,582	924,748
Annual Flushing	11,172,000	31,470
Identified Leaks	200,000	563
Fire Use		
Other Use	645,000	1,817
Unaccounted-for Water	41,574,120	117,110
Percentage	10.9%	10.9%

Notes
355 Days of Metered Data (October 2, 2007 to September 22, 2008)
System pumpage and water treatment facility use provided by Paul Roy, Chief Operator
Billing data provided by Lorrie Maker, Deputy Tax Collector
Billing data reviewed and edited by Weston & Sampson (some data corrected and averaged)
Flushing, Leak and Other data provided by Matt Berube

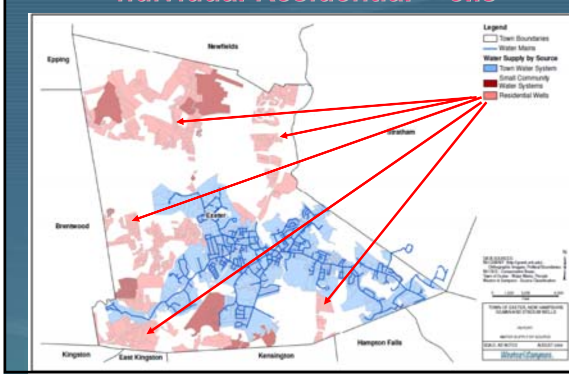
Water Use – Growth Potential?
The Existing To n ater System



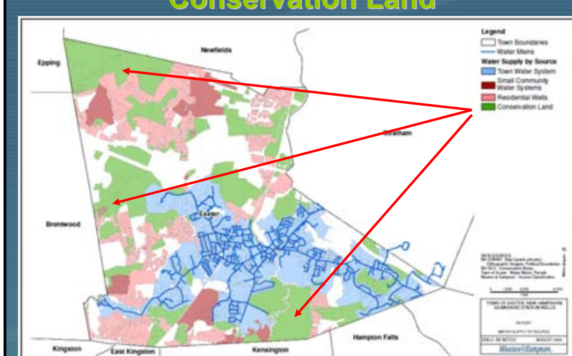
Water Use – Growth Potential?
Other Community ater Systems



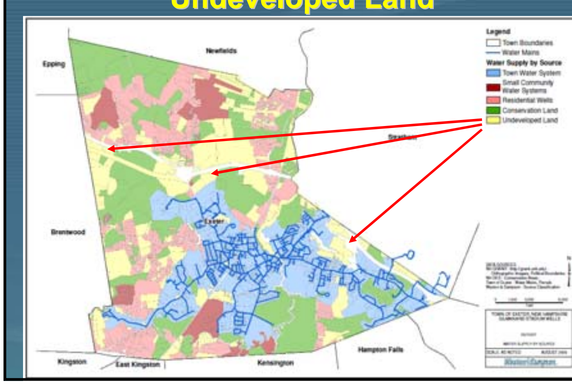
Water Use – Growth Potential?
ndividual Residential ells



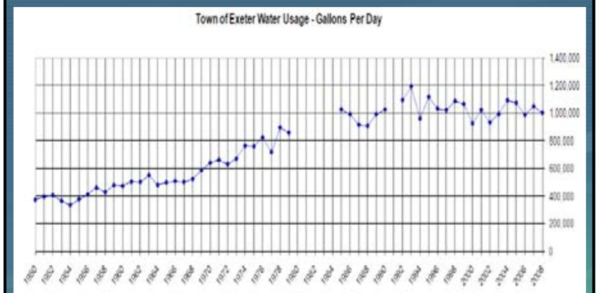
Water Use – Growth Potential?
Conservation Land



Water Use – Growth Potential?
Undeveloped Land



Water Use – Growth Potential? Existing System Demand Not Increasing



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Overvie of this Public orum

- Background (Russ)
- Supply and Demand Trends (Brian)
- **River lo s and Regulatory mplications (Ted)**
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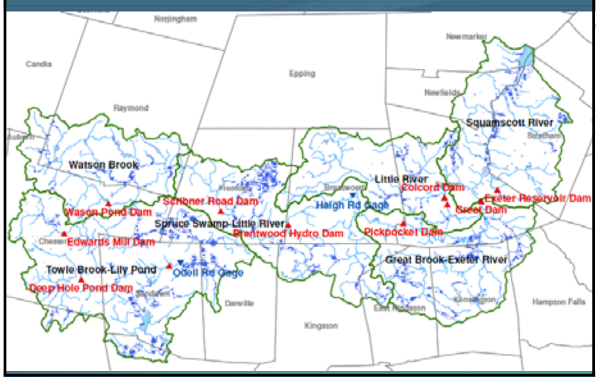
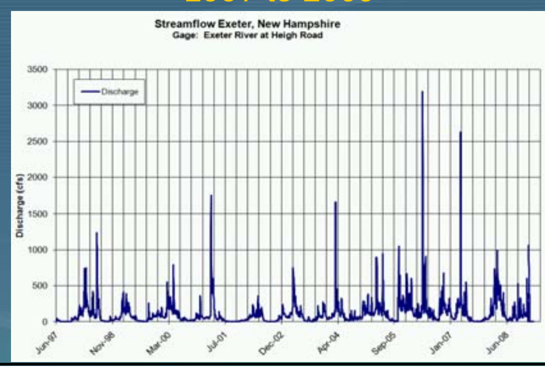
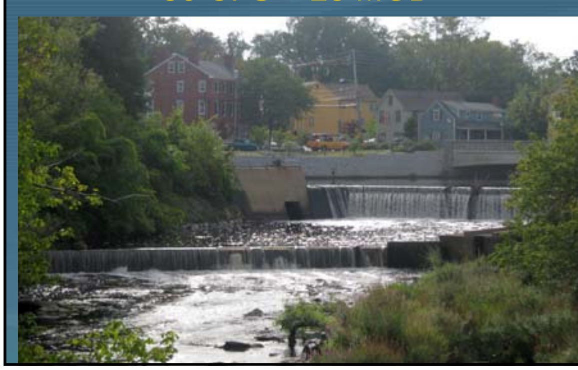
The Exeter River



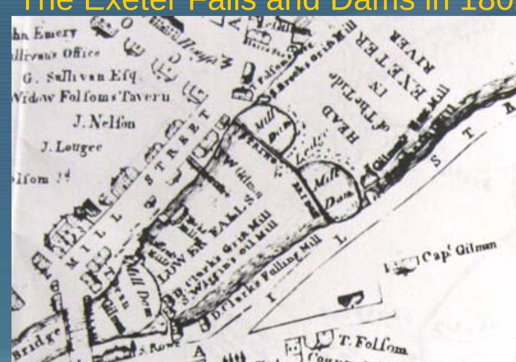
Flows on the Exeter River 1997 to 2009



Flow This Morning at Great Dam 36 CFS ~ 23 MGD



The Exeter Falls and Dams in 1802



Reference: "A Plan of the Compact Part of the Town of Exeter"

Weston&Sampson

The Exeter Falls and Great Dam Location

- Various Dams for mill operations constructed since the 1700's
- 1861 – Act of the legislature conveys all the water rights at the lower dam to the Exeter Manufacturing Company.
- 1914 - Current Great Dam built by Exeter Manufacturing Company.
- October 1981 - Town acquires the Great Dam. Exeter Mills retains some water withdrawal rights.

References: History of the Town of Exeter by Charles H. Bell (1888), Pierce-Atwood 2004 Report on Town of Exeter's Water Rights, and the New Hampshire Dam Bureau

The Great Dam – 2009

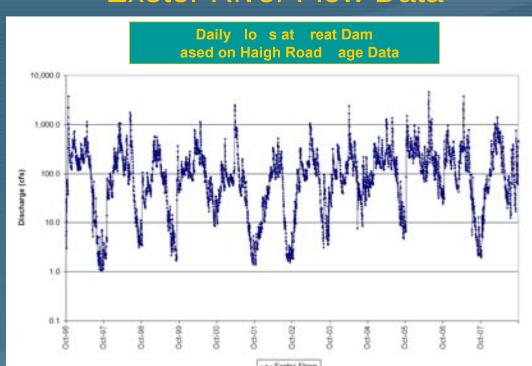
Water Availability During Low Flow * A New Issue for the Town ?

- Past studies of water supply have assumed that full use of impounded water would be available for withdrawal
- Water quality regulations in NH require downstream flow to occur
- The Town of Exeter's 2006 Dam Management Plan requires:
  - 6 inches of flow over the dam from April 1st to June 30th
    - C S or million gallons per day
  - 2 inches of flow over the dam from July 1st to Oct 30th
    - C S or million gallons per day

Water Availability During Low Flow

- Even with the Great Dam impoundment, Exeter will likely have to reduce withdrawals from the river for the water supply
  - This occurs during most years

Exeter River Flow Data



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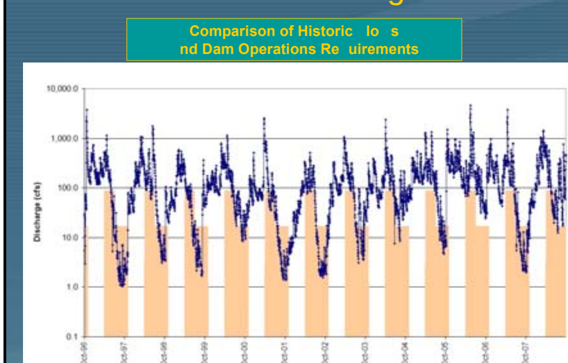
Water Withdrawal During Low Flow



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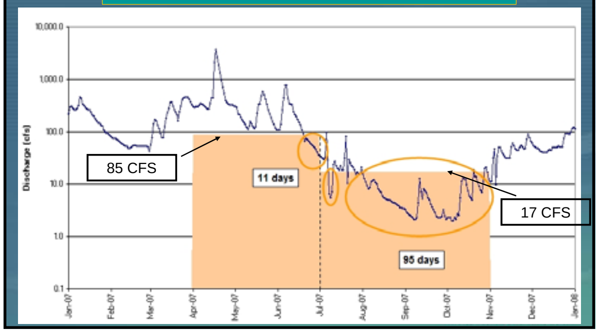
Water Withdrawal During Low Flow

Comparison of Historic lo s
nd Dam Operations Re uirements



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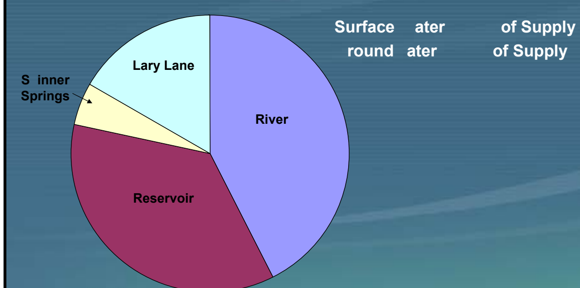
Current Sources



Diversify Sources

round ater vs. Surface ater

- Protection
- Water Quality
- Treatment Costs
- Yield
- Regulation

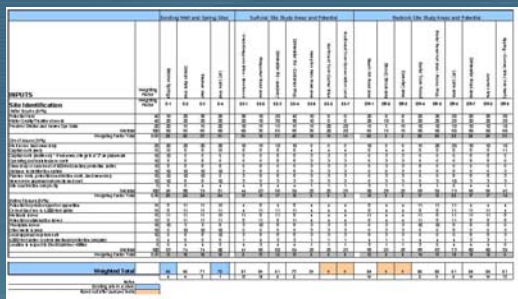
Groundwater Matrix

- Developed in 2007/2008
- Summarize Existing Studies / Information
- Identify All Groundwater Sources Available
- Rank Sites for Comparison

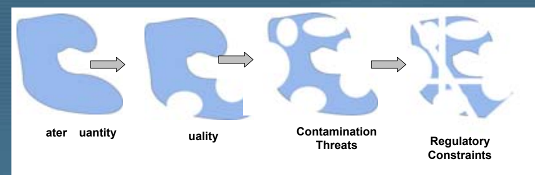
Groundwater Matrix Considerations

- Location
- Distribution System
- Funding
- Power
- Accessibility
- Yield
- Artificial Recharge
- Aquifer Management
- Formation Characteristics
- Piezometric Mapping
- Boundary Conditions
- Induced Infiltration
- Water Quality
- Wellhead Protection
- Adverse Impacts
- Fracture Trace Analysis

Rank Sites



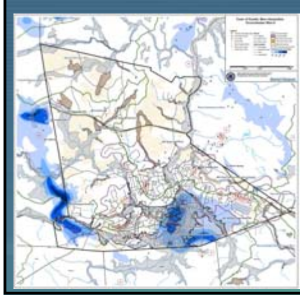
Spatial Analysis



Groundwater Matrix

- Groundwater resources inventory utilizing USGS, GRANIT, DES and Planning Commission information.

Surficial ap



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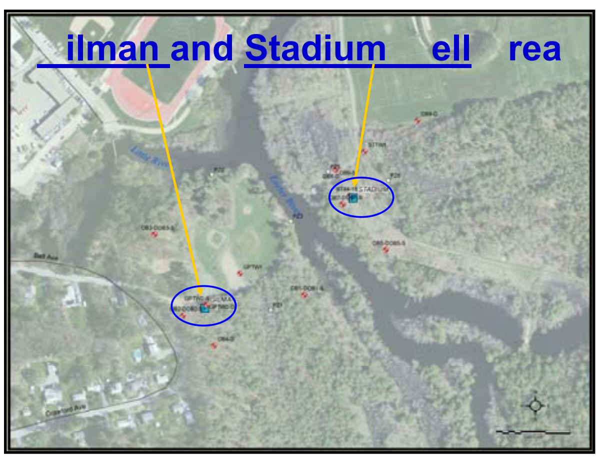
Matrix Recommendations

- Use What You Have!!
  1. Treat Lary Lane Well
  2. Reactivate Gilman and Stadium Wells
  3. Investigate Skinner Springs Optimization
- Continue Research of Additional Sites

July 2008 Implementation

- Gilman and Stadium Well Evaluation
  - Production Well Rehabilitation
  - Pumping Test and Pilot Treatment Study
  - Assess Construction Costs
    - Well Completion and Treatment System

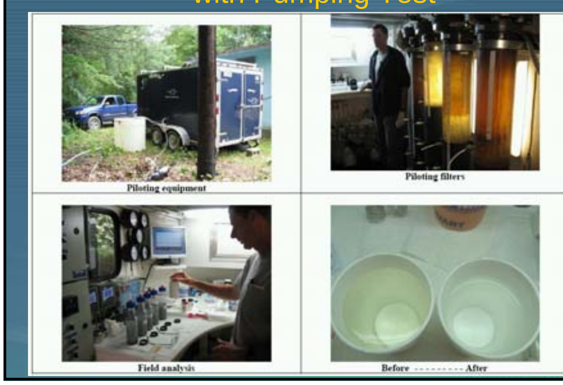


Gilman Park Well Rehabilitation

Stadium Well Rehabilitation

7-Day Pumping Test: July 2009

Water Treatment Piloting Coordinated with Pumping Test



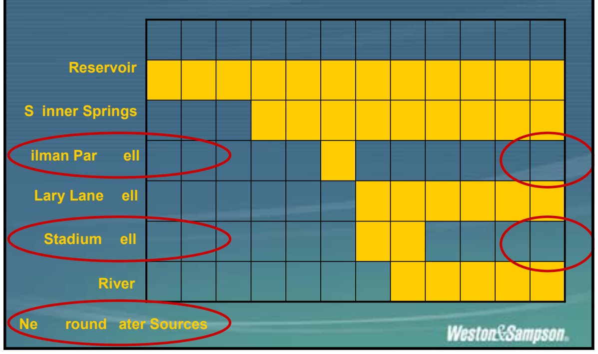
round ater Source Potential

- Existing Groundwater Sources
  - Lary Lane = 0.25 MGD
  - Skinner Springs = 0.1 MGD
- Additional Tested Groundwater Sources
  - Gilman & Stadium Safe Yield ~ 1 MGD
- Additional Untested Groundwater Sources
  - Additional Site(s) w/in Aquifer ~ 0.5 MGD
  - Additional Site(s) in Town ~ Unknown, but >0

TOT L POTENT L . D

Weston&Sampson

A More Diverse Source of Supply



Weston&Sampson

Overvie of this Public orum

- Background (Russ)
- Supply and Demand Trends (Brian)
- River Flows and Regulatory Implications (Ted)
- Groundwater Supply Options (Kevin)
- **Results and Options (ndy)**
- Demand Management and Costs (Brian)
- Regional Component and Summary (Ted)
- What's Next for the Town? (Russ)
- Public Feedback (All)

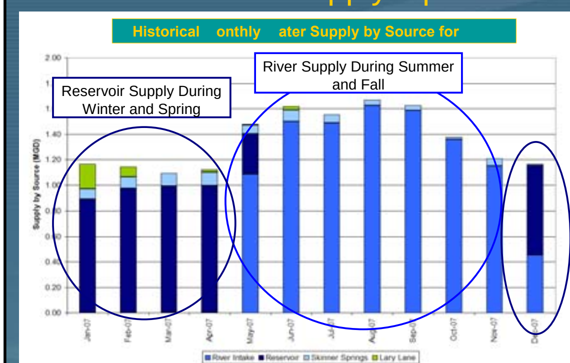
Weston&Sampson

Integrated Management of Water Supply:

- Diversification of water supply sources
- Utilize surface water sources primarily during normal and wet periods
- Use groundwater sources during dry and peak periods
- Also have more options in the event of flooding, contamination or mechanical issues

Weston&Sampson

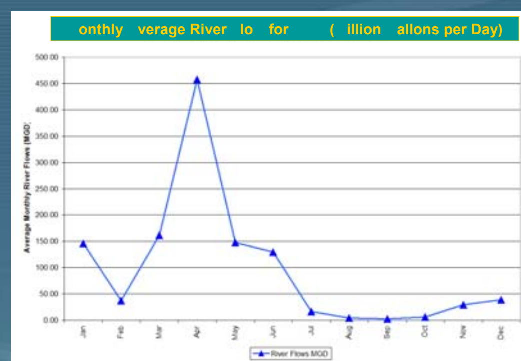
Historical Water Supply Operations



P:\Exeter NH\2070533 - River Study\5-Integrated Management\Historic Water Supply by Source

Weston&Sampson

2007 River Flows



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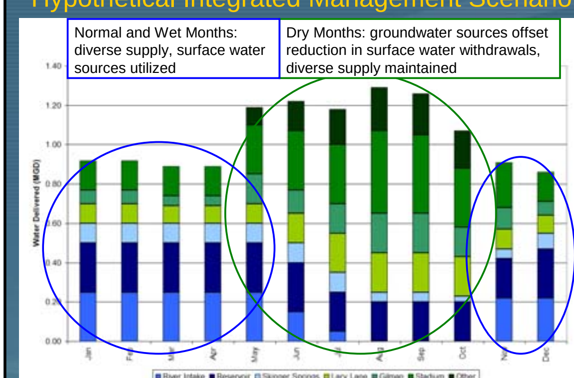
Hypothetical Integrated Management Scenario



P:\Exeter NH\2070533 - River Study\5-Integrated Management\Integrated Management Plan

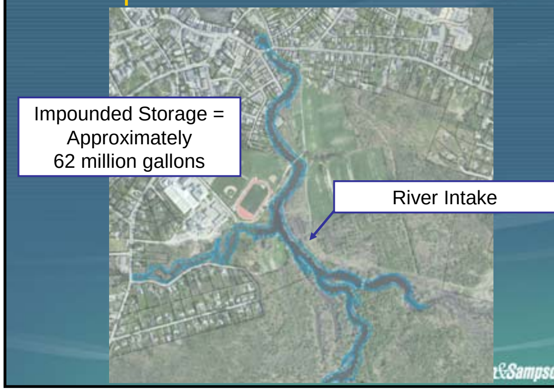
Weston&Sampson

What would happen to the Impoundment?

- Estimated 7 foot elevation difference utilizing data from previous river studies (There is still a natural impoundment due to ledge near High Street Bridge)
- 45 Million Gallon change in storage

Weston&Sampson

Impoundment Area with Dam



Impoundment Area without Dam

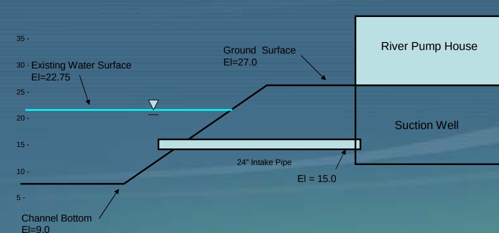
What would happen to the River Intake?

- Drop of approximately 7 feet above the existing intake
- Upgrades to the river pumping station and intake pipe would be necessary
- Water withdrawals would still be possible most of the year because there is a natural impoundment by the existing intake

Weston&Sampson

River Pumping Station

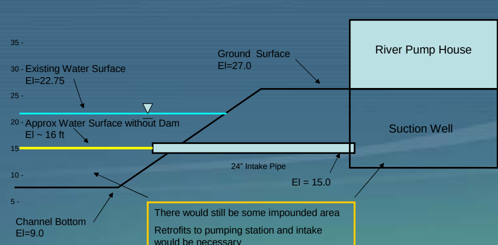
R ER PU P ST T ON CROSS SECT ON (Design)



Weston&Sampson

River Pumping Station

R ER PU P ST T ON CROSS SECT ON (Design)



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How would integrated management work?

- Use river during high and normal flow periods
- Improve the ability to withdraw water from the reservoir during the summer months
- More groundwater in the mix
- Provide more public outreach and updates on the water supply status
- Demand management and water restrictions during droughts and emergencies

Weston&Sampson

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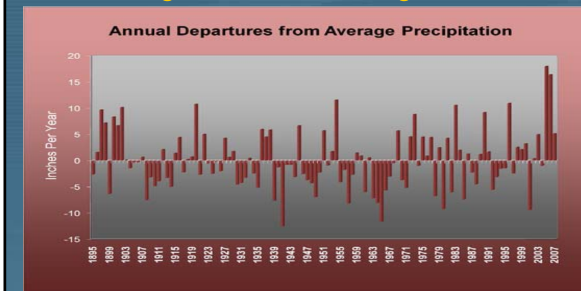
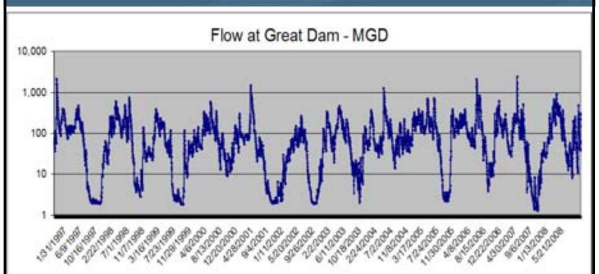
Demand Management During Dry Periods, Drought or Other Emergencies



Excerpt from New Hampshire Water Resources Primer - 2008

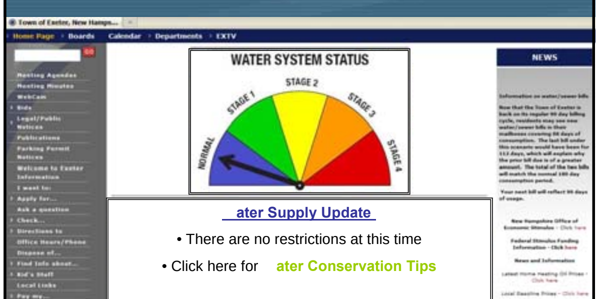
Demand Management During Dry Periods, Drought or Other Emergencies



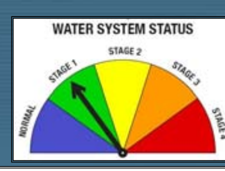
Demand Management

- Provide Up-To-Date Water Supply Information on the Town's Website

Demand Management – Public Outreach



Demand Management

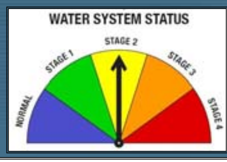


ater Supply Update

• There are no restrictions at this time

• Click here for ater Conservation Tips

Demand Management

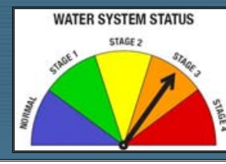


ater Supply Update

- We are Asking for oluntary ater Conservation
- Click here for details and ater Conservation Tips

Weston&Sampson

Demand Management

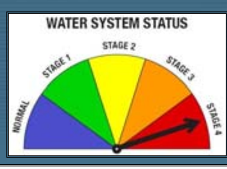


ater Supply Update

- andatory ater Restrictions in Effect
- Click here for details and ater Conservation Tips

Weston&Sampson

Demand Management



ater Supply Update

- ater Emergency in Effect
- Click here for details

Weston&Sampson

Water Options – Capital Cost Estimates

River Intake and Station Upgrades	$0.5 to $1.0 mil.
Reservoir Aeration Upgrade	$0.05 to $0.10 mil.
Gilman, Stadium, Lary Lane Equipment and Piping Connection	$1.8 mil.
Groundwater Treatment (1.5 MGD Facility)	$4.0 to $5.0 mil.
Additional 0.5 MGD Groundwater Source	$1.9 to $2.8 mil.
Upgrades to Existing Surface Water Treatment or New Facility	* ? ? ? *

Weston&Sampson

Cost Comparisons – Treatment

	Surface ater	round ater
	Coagulant	
	Filter Aid	
	pH Adjustment	
	Carbon	
	Permanganate	
	Chlorine	Chlorine
	Orthophosphate	Orthophosphate
Cost per illion allons		

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- **Regional Component and Summary (Ted)**
- What's Next for the Town? (Russ)
- Public Feedback (All)

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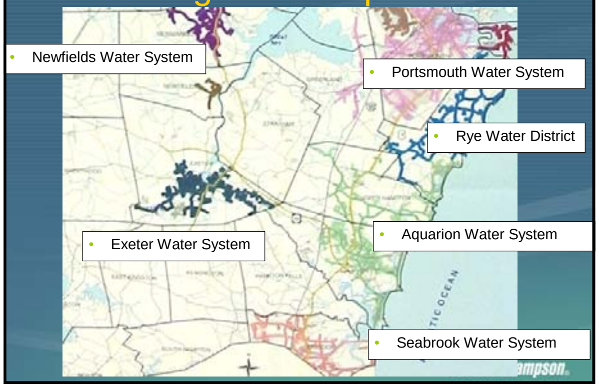
Regional Snapshot



Regional Snapshot

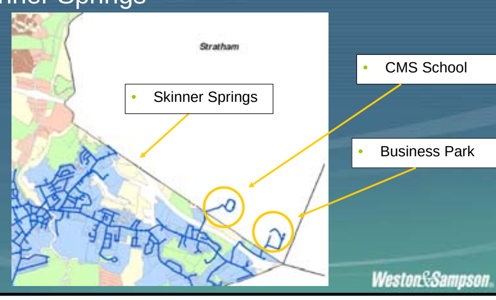
- Seacoast Water System Capital Investments
  - Seabrook just approved a $12 million water treatment facility
  - Aquarion $7 million dollars of investment in their system (2001 to 2006)
  - Rye Water District recently installed a new bedrock groundwater source
  - The Portsmouth Water Division has a six year capital plan that includes approximately $38 million of investment, including the replacement of their 50-year-old water treatment plant

Regional Snapshot

- Seacoast Water System Capital Investments
  - Durham is exploring options for groundwater sources
  - Newmarket is exploring both groundwater and surface water options
  - Newfields has undertaken substantial efforts to rehabilitate their groundwater sources
  - Stratham is creating a fire service district to improve service along Portsmouth Avenue.

Regional Snapshot

- The Exeter Water System already serves portions of Stratham and gets water from Skinner Springs



Regionalization Benefits

- Economies of scale
- Potential partnering in large scale capital costs

Regionalization

- Seacoast Groundwater Study – we have plenty of water, just not always when or where we want it.
- Its all the same watershed.
- Recharge is the key.
- Capital costs are unlikely to decrease
- Demand will slowly increase.
- Move forward carefully.

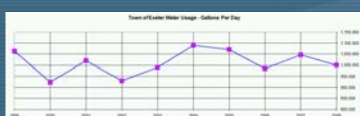
How does all of this relate back to the potential Dam Removal?

- Cost savings of not fixing the Great Dam (less money to remove dam)
- Town will not have to regulate flows at Great Dam or mitigate water quality issues during dry periods (potential operating costs avoided)
- A diverse water supply is less dependent on surface water withdrawals from river

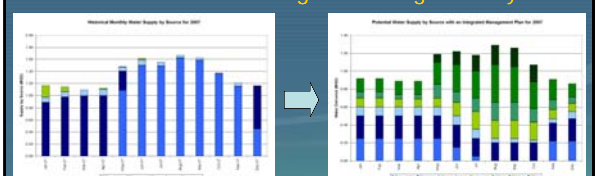
What does this all mean for the dam?

- The dam may be superfluous to water supply in Exeter in the future.
- The dam will be more highly regulated due to water quality and quantity issues.
- There may be cost avoidance to the town.
- Fish will like it, floods may be reduced.
- The river water supply option remains without the dam.
  - Withdrawal is more dependent on flows than impoundment

What is the Take-home Message?



- Demand is not increasing on existing water system



- Integrated Management would diversify supply

Take home messages

- Exeter has options!
- Groundwater is available.
- Demand appears to be level or subject to slow growth.
- Groundwater options may offer regulatory, treatment and supply security
- Integrated management is most likely a feasible future.

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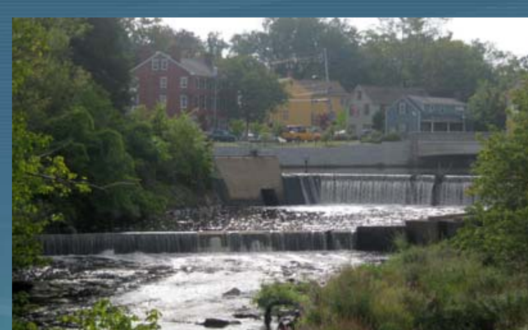
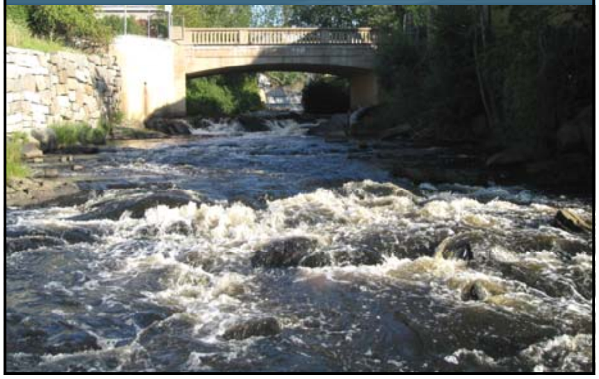
- Demand Management and Costs (Brian)
- Regional Component and Summary (Ted)
- **hat s Next for the To n (Russ)**
- Public Feedback (All)

Next Steps for Exeter?



Public Input – Q/A



Town of Exeter

ater Supply lternatives Study
Exeter River dvisory Committee
Presentation
December

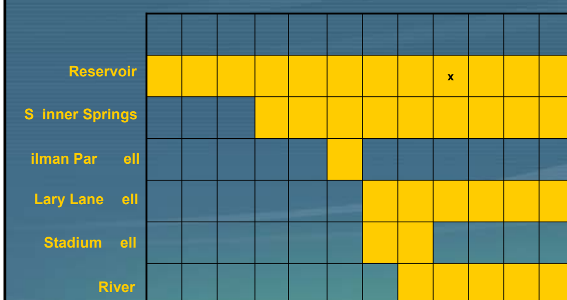
Purpose of Study

If the dam were to be removed, determine:

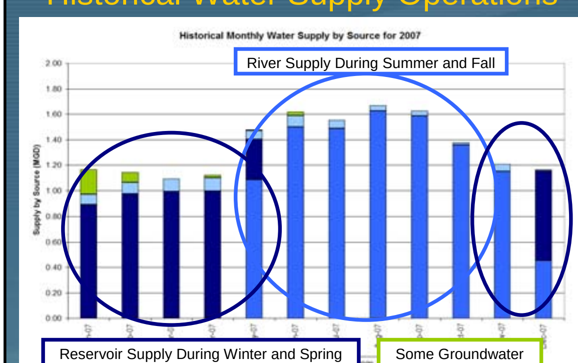
– Reduction of Yield from River Intake for Town's Water Supply
– How Could this reduction be Mitigated?
– What's the Cost to Mitigate?

Preliminary Study Results Presented at Public Forum in September Held at the High School

Source of Supply Timeline

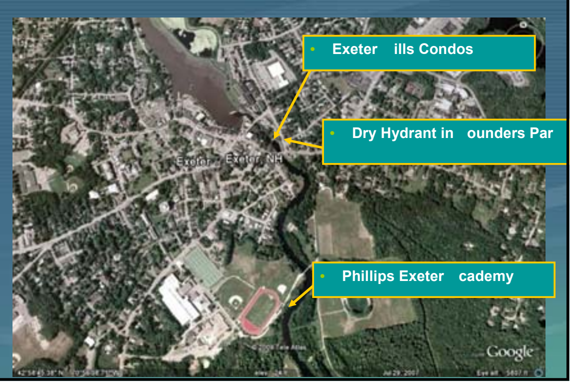


Historical Water Supply Operations



P:\Exeter NH\2070533 - River Study\5-Integrated Management\Exeter Water System Withdrawals 06 to 08

Other Withdrawals From River




Exeter Mills Apartments
Exeter ills
Cooling ater in summer
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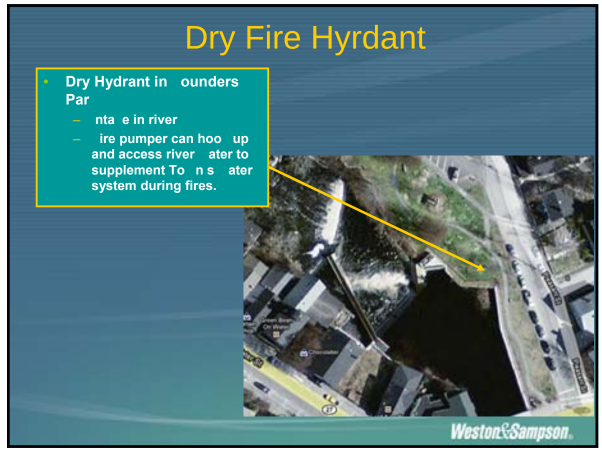
Dry Fire Hyrdant
Dry Hydrant in ounders Par
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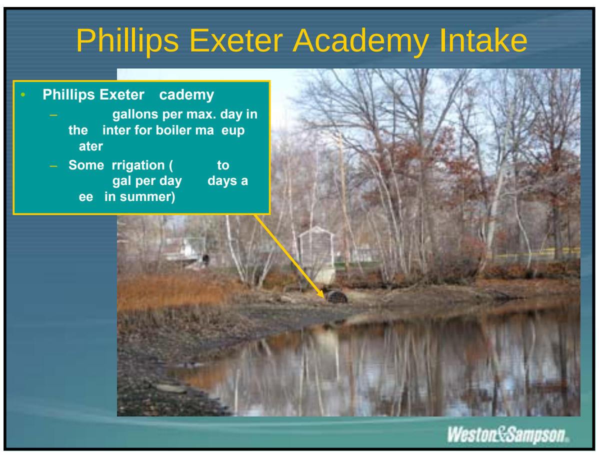
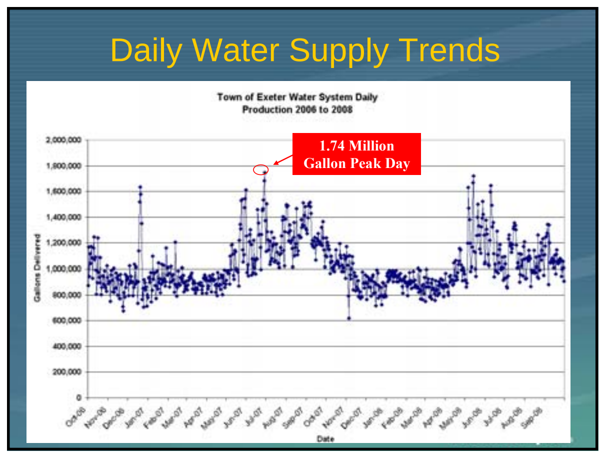
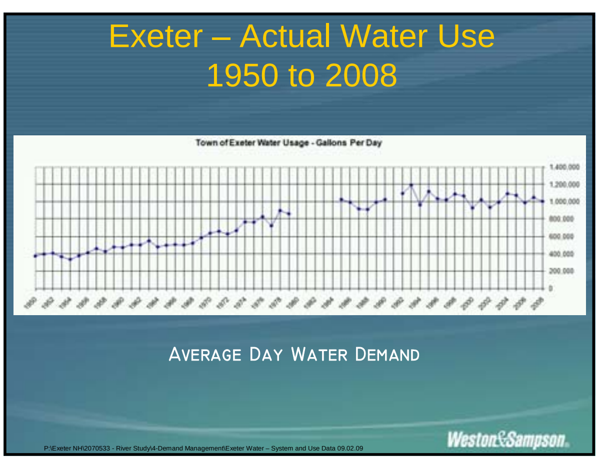
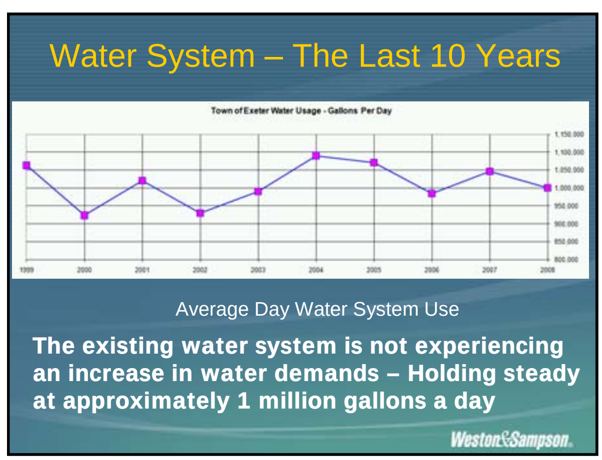
ire pumper can hoo up and access river ater to supplement To n s ater system during fires.

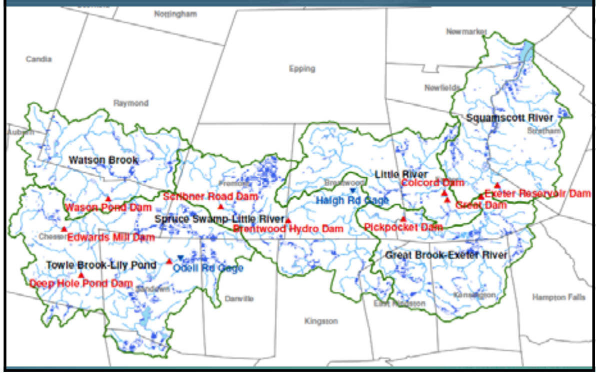

Phillips Exeter Academy Intake
Phillips Exeter cademy
gallons per max. day in the inter for boiler ma eup ater
Some rrigation (to gal per day days a ee in summer)


Daily Water Supply Trends
Town of Exeter Water System Daily Production 2006 to 2008
1.74 Million Gallon Peak Day
Gallons Delivered
Date

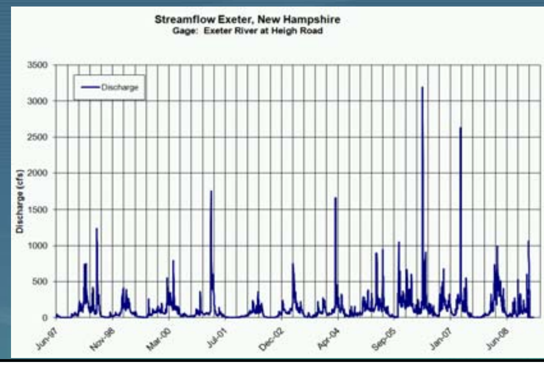

Exeter – Actual Water Use 1950 to 2008
Town of Exeter Water Usage - Gallons Per Day
AVERAGE DAY WATER DEMAND


Water System – The Last 10 Years
Town of Exeter Water Usage - Gallons Per Day
Average Day Water System Use
The existing water system is not experiencing an increase in water demands – Holding steady at approximately 1 million gallons a day

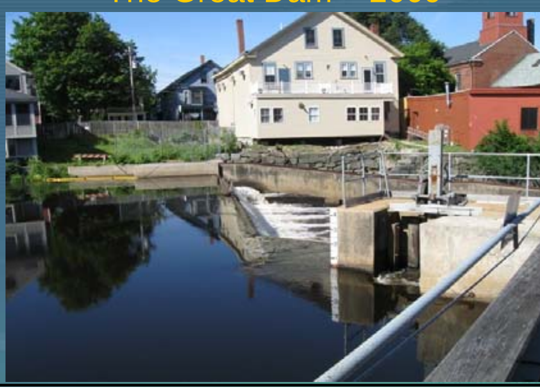
The Exeter River



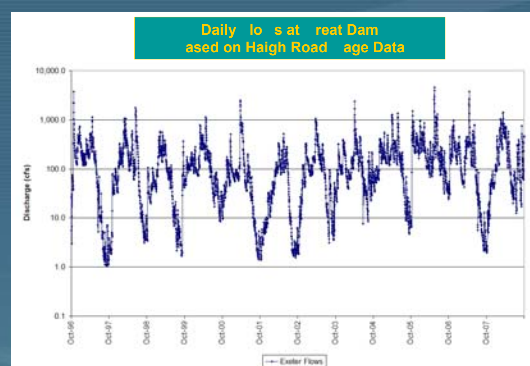
Flows on the Exeter River 1997 to 2009



The Great Dam – 2009



Exeter River Flow Data



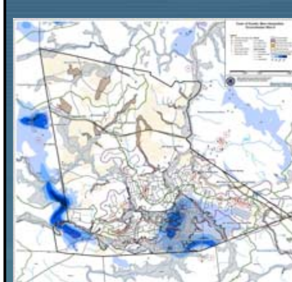
Groundwater Matrix

- Developed in 2007/2008
- Summarize Existing Studies / Information
- Identify All Groundwater Sources Available
- Rank Sites for Comparison

Groundwater Matrix

- Groundwater resources inventory utilizing USGS, GRANIT, DES and Planning Commission information.

Surficial ap



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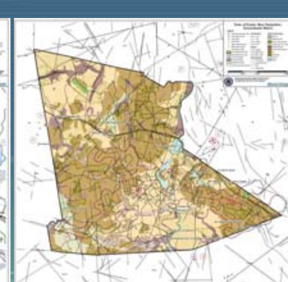


2008-2009 Implementation
Gilman and Stadium Well Rehabilitation
– Production Well Rehabilitation
– Pumping Test and Pilot Treatment Study
– Assess Construction Costs
Well Completion and Treatment System
Weston&Sampson


round ater Source Potential
Existing Groundwater Sources
– Lary Lane = 0.25 MGD
– Skinner Springs = 0.1 MGD
Additional Tested Groundwater Sources
– Gilman & Stadium Safe Yield ~ 1 MGD
Additional Untested Groundwater Sources
– Additional Site(s) w/in Aquifer ~ 0.5 MGD
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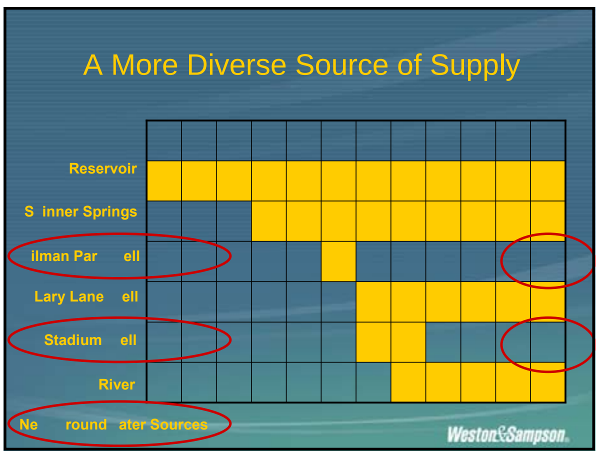
TOT L POTENT L . D
Weston&Sampson


A More Diverse Source of Supply
Reservoir
S inner Springs
ilman Par ell
Lary Lane ell
Stadium ell
River
Ne round ater Sources
Weston&Sampson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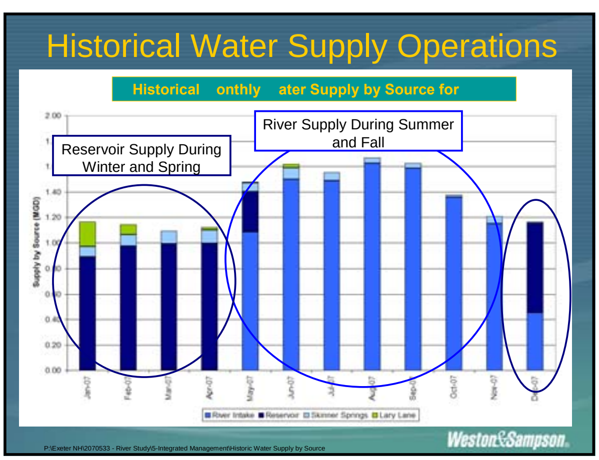
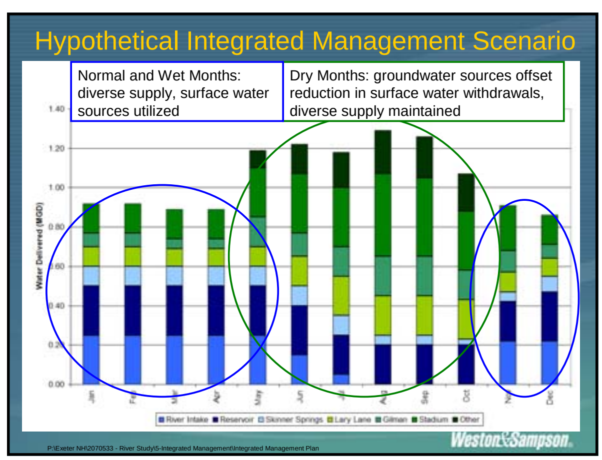
Weston&Sampson


Historical Water Supply Operations
Historical onthly ater Supply by Source for
Reservoir Supply During Winter and Spring
River Supply During Summer and Fall
Weston&Sampson

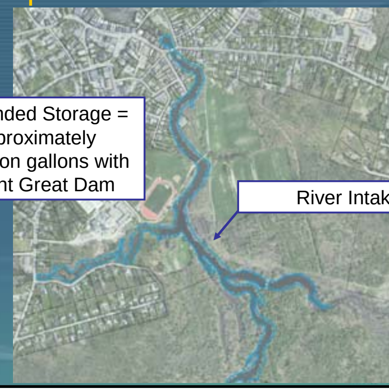

Hypothetical Integrated Management Scenario
Normal and Wet Months: diverse supply, surface water sources utilized
Dry Months: groundwater sources offset reduction in surface water withdrawals, diverse supply maintained
Weston&Sampson

What would happen to the Impoundment?

- Estimated 7 foot elevation difference utilizing data from previous river studies (There is still a natural impoundment due to ledge near High Street Bridge)
- 45 Million Gallon change in storage
  - (Updated Note: This was prior to drawdown in November 2009. During that Drawdown it appears that natural ledge between the Great Dam and Great Bridge creates a natural impoundment at approximately 4 foot of elevation difference from current impoundment)

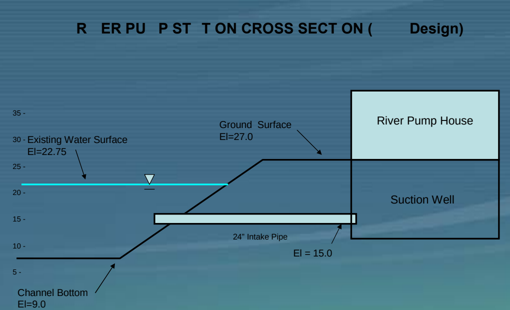
Weston&Sampson

Impoundment Area with Dam



Weston&Sampson

River Pumping Station



Weston&Sampson

2009 Impoundment Drawdown Timeframe

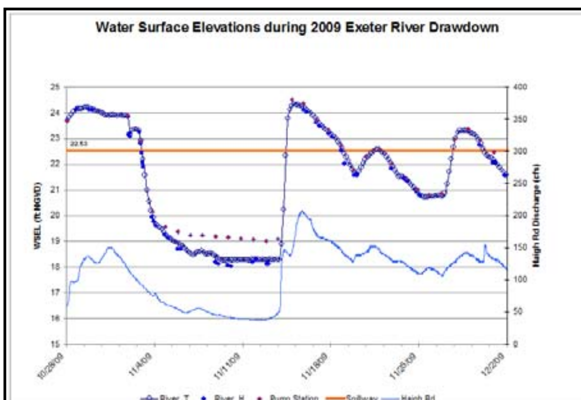
- The gate at the Great Dam was opened on November 1, 2009.
- Water levels at the river pump station and surrounding monitoring wells were measured by the Town's water operators.
- Electronic Transducers monitored water levels at the dam and in other monitoring wells.
- These levels were also compared with the Haigh Road Gage data.

Weston&Sampson

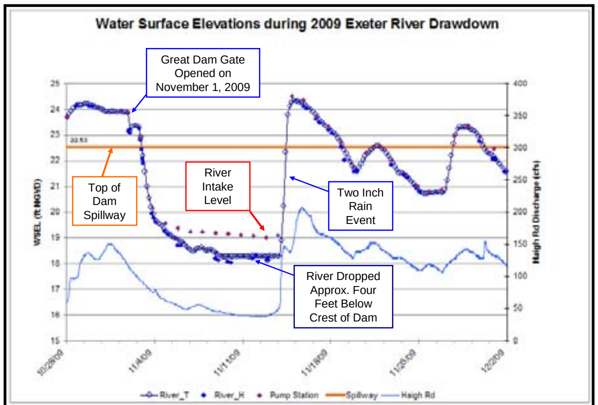
Impoundment Drawdown Questions:

- What would the natural impoundment be without the dam?
- What effect would lower water levels have on the Town's ability to withdraw water at the pumping station?
- What would a lower river look like?
- What effect would a lower impoundment have on the groundwater?

Weston&Sampson



Weston&Sampson



Impoundment Drawdown Questions

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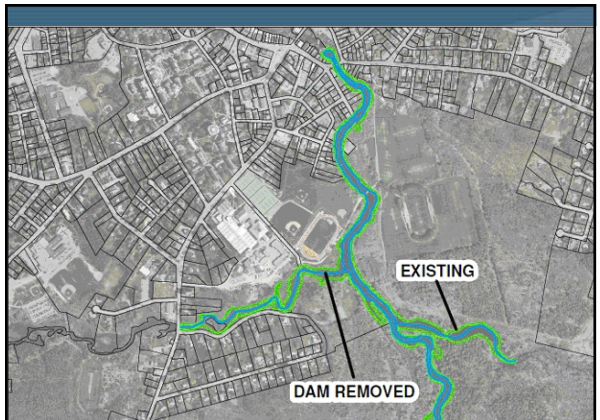
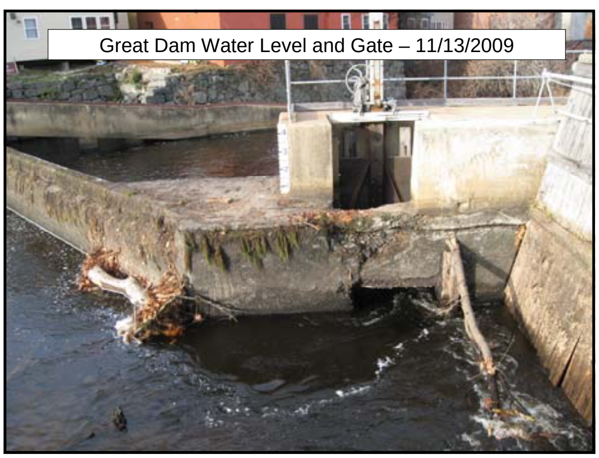
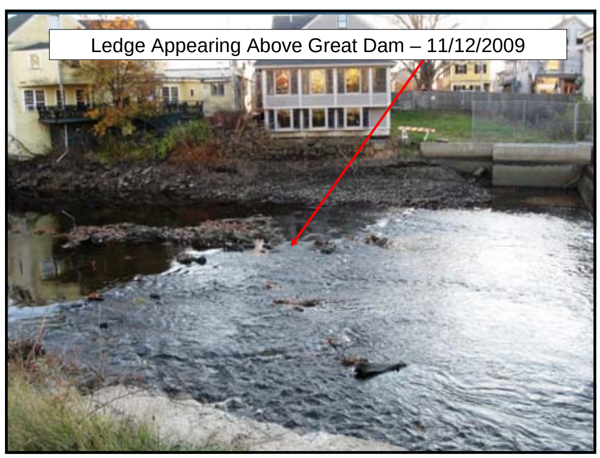
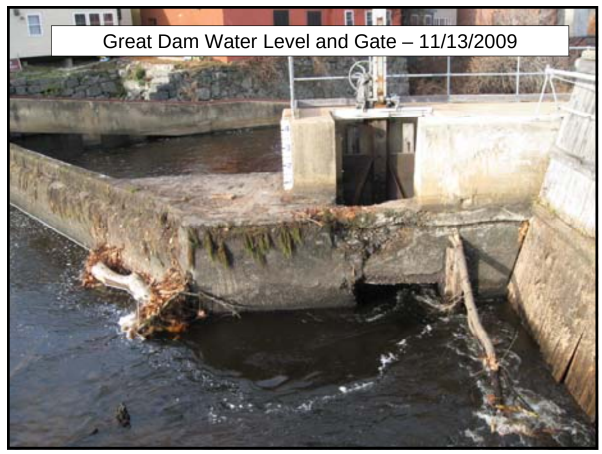
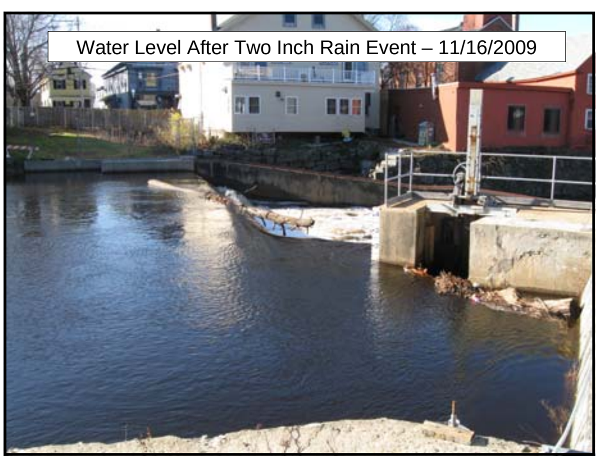


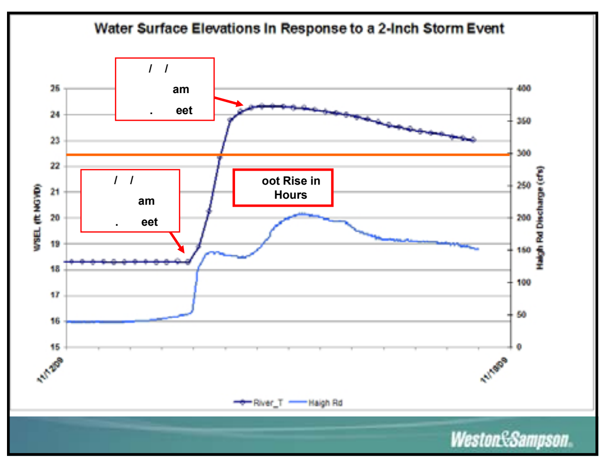




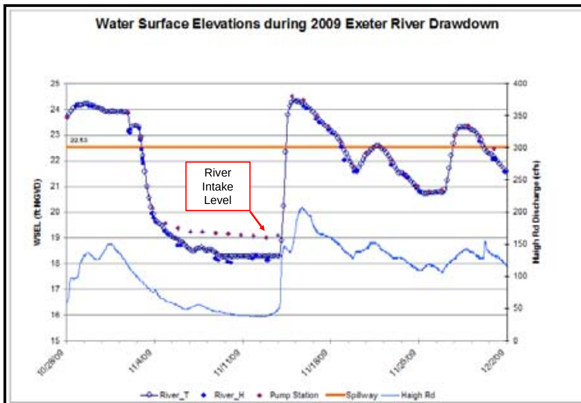

Ledge Appearing Above Great Dam – 11/13/2009


Great Dam Water Level and Gate – 11/13/2009

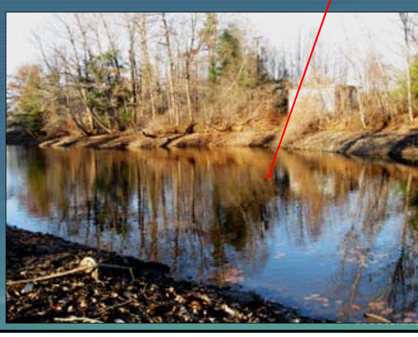

Water Level After Two Inch Rain Event – 11/16/2009


Water Surface Elevations In Response to a 2-Inch Storm Event
/ /
am
. eet
/ /
am
. eet
oot Rise in Hours
WSEL (ft NGVD)
Haigh Rd Discharge (cfs)
26
24
23
22
21
20
19
18
17
16
15
400
350
300
250
200
150
100
50
0
River_T
Haigh Rd
Weston&Sampson

- What effect would lower water levels have on the Town's ability to withdraw water at the river pumping station?

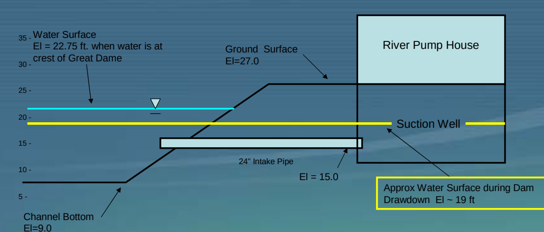


- The water system was still able to pump from the river, even at its lowest level during the drawdown – Approx. 1.0 to 1.3 Million Gallons a Day:

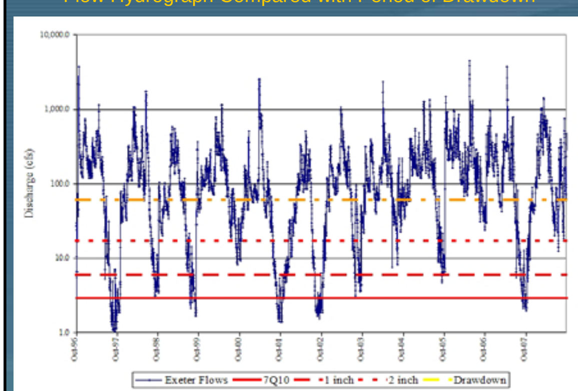


River Pumping Station

R ER PU P ST T ON CROSS SECT ON (Design)



Flow Hydrograph Compared with Period of Drawdown



What would happen to the River Intake?

- Water withdrawals would still be possible most of the year because there is a natural impoundment by the existing intake.
- Upgrades to the river pumping station and intake pipe would most likely be necessary to get water from the river during very low flow periods.

Impoundment Drawdown Questions

- What effect would a lower impoundment have on the groundwater?

We are just beginning to evaluate that data.

- If dam was removed, Groundwater would really be necessary to supplement water system during low flows

Preliminary Cost Estimates to Mitigate Effects of Dam Removal

River Intake and Station Upgrades	$0.75 to $1.0 mil.
Reservoir Aeration Upgrade	$0.05 to $0.10 mil.
Replace Founders Park Dry Hydrant by installing secondary fire system upstream	$0.125 to $0.250 mil.
Lower Phillips Exeter Academy Intake and pump station	$0.10 to $0.25 mil.
Exeter Mills - Retrofit irrigation, fire suppression and cooling system *Fire system could be integrated with Founders Park System	$0.25 to $0.50 mil.
Gilman, Stadium, and Lary Lane Well – Equipment, Piping and Groundwater Treatment	$5.80 to $6.80 mil.
Total Estimate	**. to . mil.**

Estimates for these items are preliminary and funding may come from various sources or offsets (ederal oney).

- Cost savings of not fixing the Great Dam (less money to remove dam)
- Town will not have to regulate flows at Great Dam or mitigate water quality issues during dry periods (potential operating costs avoided)
- A diverse water supply is less dependent on surface water withdrawals from river

Estimates for these items are preliminary and funding may come from various sources or offsets.

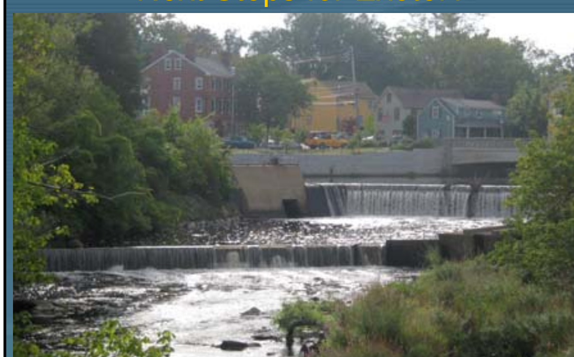
- Fix the dam cost estimates:
  - $1.273 million
- Remove dam cost estimate:
  - $0.962 million

Estimated 2011 Construction Costs

What does this all mean for the dam?

- The dam most likely will be more regulated in the future due to water quality and quantity issues.
- There may be cost avoidance to the town. (Operations and Maintenance)
- Fish will like it, small floods may be reduced.
- The river water supply option remains without the dam.
  - Withdrawal is more dependent on flows than impoundment

Next Steps for Exeter?

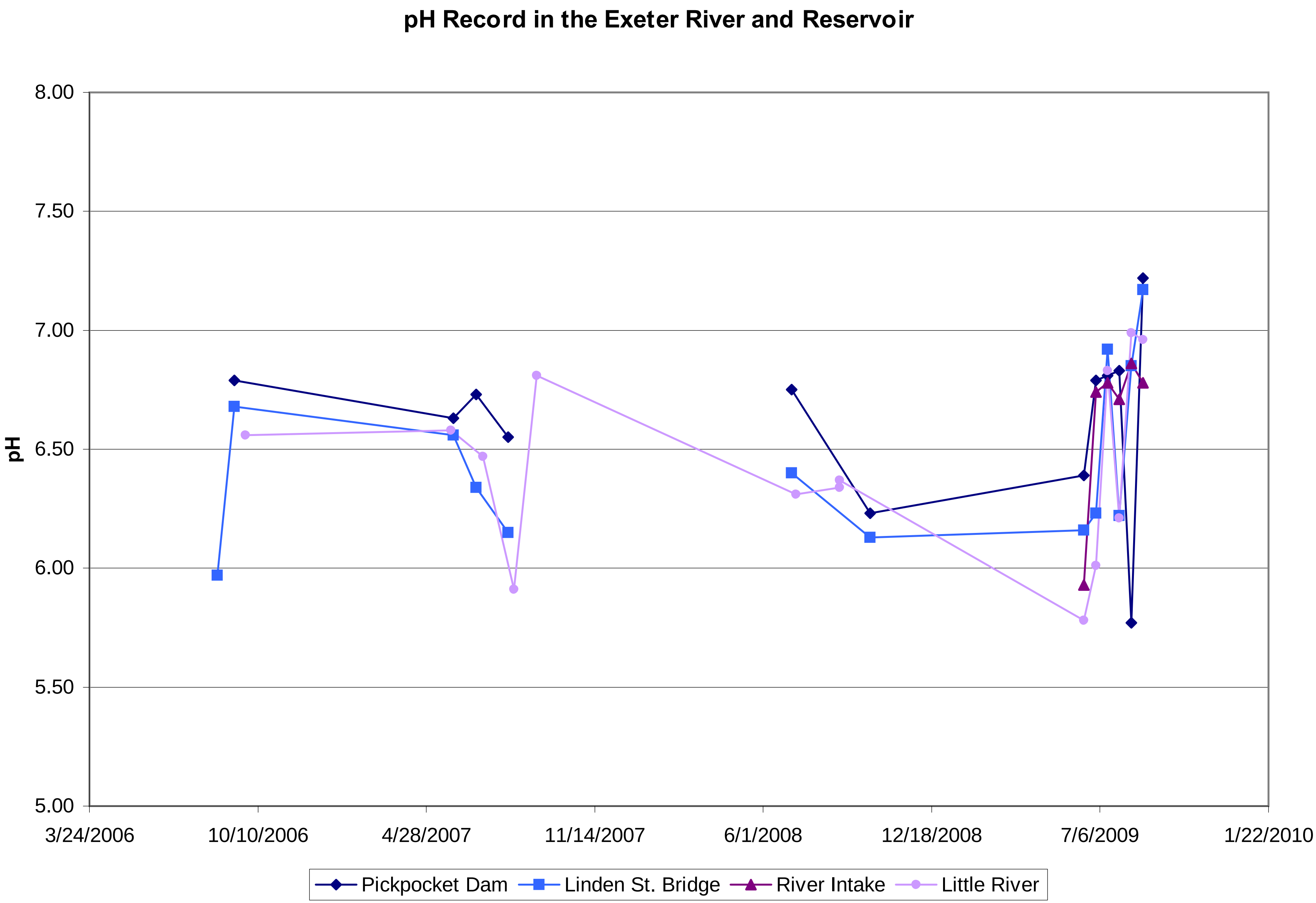


APPENDIX B

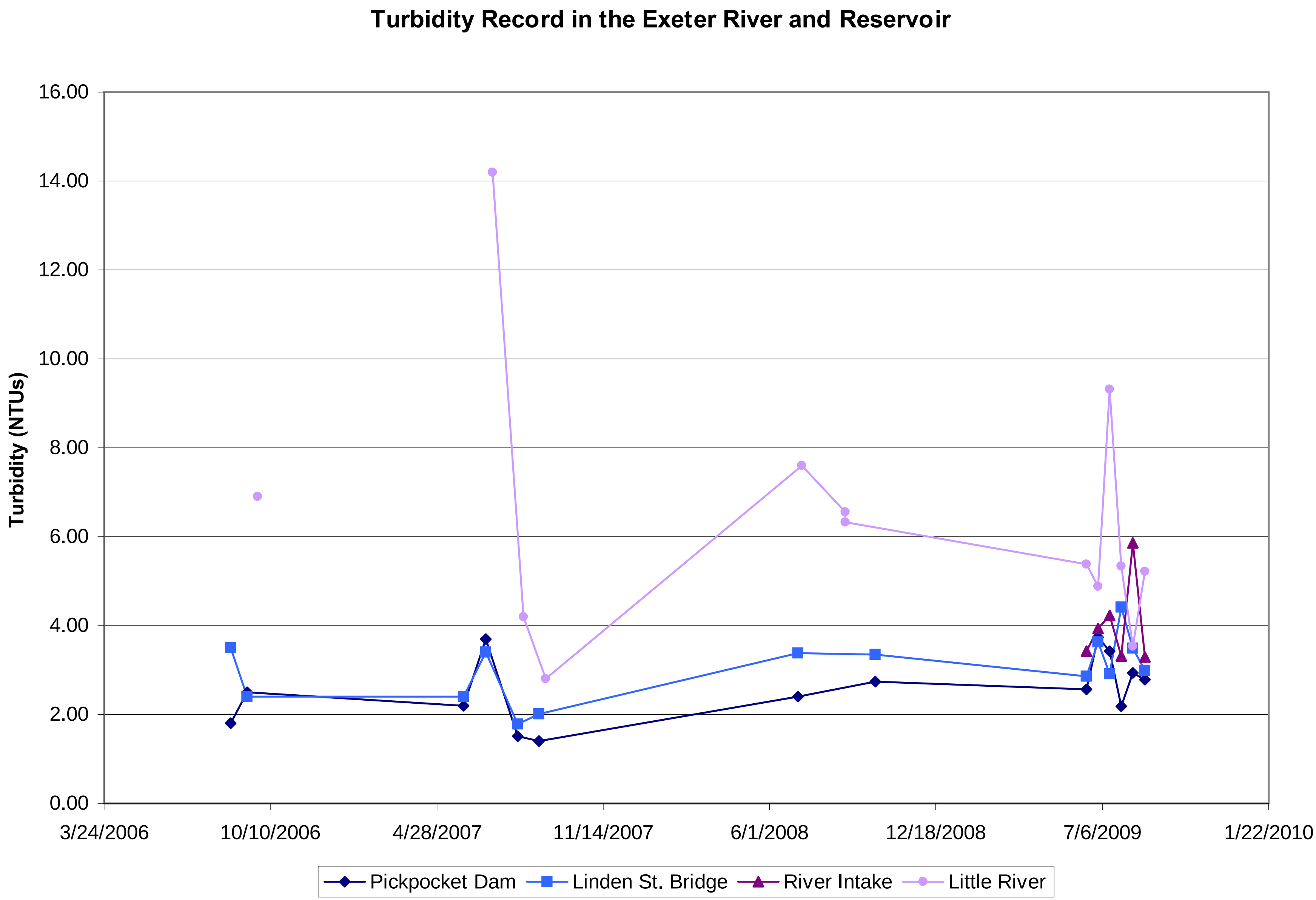
2009 Water Quality Sampling Data

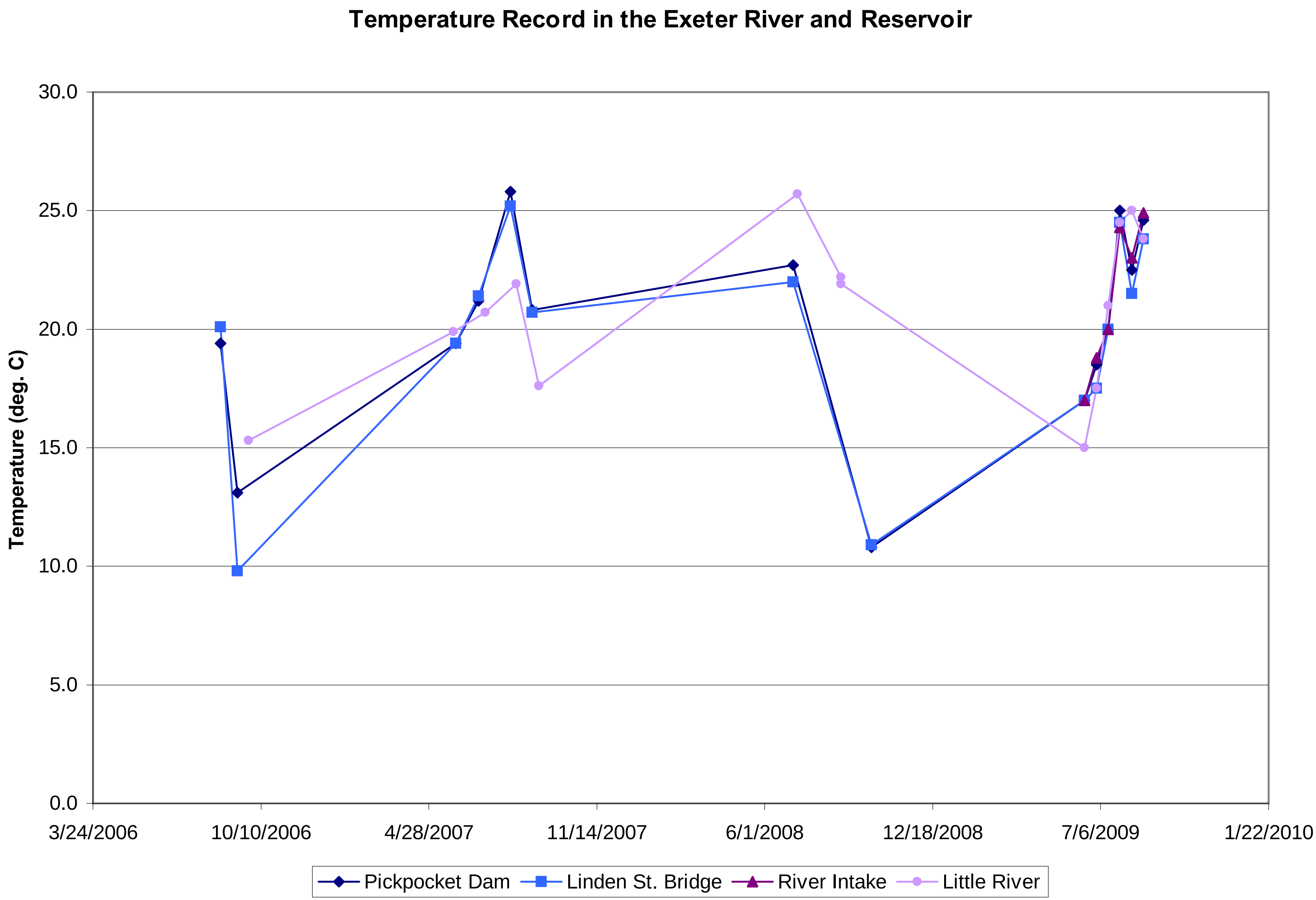
LOCATION	DATE	TIME	pH	ALKALINITY	COLOR		TURBIDITY	HARDNESS	CHLORIDE	IRON		MANGANESE		TEMP	CONDUCTANCE	RIVER FLOW	SOURCE
				mg/l	raw	filtered	NTU	mg/l	mg/l	raw	filtered	raw	filtered	field	us/cm	cfs	
PICKPOCKET	**8/23/2006**	**7:40 AM**					1.80							19.4	130.4	95.0	VRAP
	9/12/2006	**7:45 AM**	6.79				2.50							13.1	160.4	28.0	VRAP
	5/30/2007	**7:55 AM**	6.63				2.20							19.4	139.9	83.0	VRAP
	6/26/2007	**7:40 AM**	6.73				3.70							21.2	156.6	38.0	VRAP
	8/3/2007	**7:45 AM**	6.55				1.51							25.8	187.3	7.7	VRAP
	8/29/2007	**7:35 AM**					1.40							20.8	199.8	2.5	VRAP
	7/5/2008	**9:15 AM**	6.75				2.40							22.7	180.3	46.0	VRAP
	10/6/2008	**9:35 AM**	6.23				2.74							10.8	136.1	157.0	VRAP
	6/17/2009	**10:00 AM**	6.39	9.5	101	85	2.57	30	2	0.53	0.36	0.032	0.022	17.0		149.0	WTP/W&S
	7/1/2009	**9:30 AM**	6.79	18.0	124	118	3.74	45	2.5	0.74	0.51	0.084	0.070	18.5		171.0	WTP/W&S
	7/15/2009	**10:00 AM**	6.81	13.5	113	101	3.42	28	2.5	0.66	0.49	0.092	0.086	20.0		106.0	WTP/W&S
	7/29/2009	**11:30 AM**	6.83	12.0	126	108	2.18	24	2.5	0.59	0.38	0.088	0.035	25.0		148.0	WTP/W&S
	8/12/2009	**8:30 AM**	5.77	16.5	104	94	2.94	30	2.5	0.68	0.52	0.098	0.095	22.5		49.0	WTP/W&S
	8/26/2009	**10:00 AM**	7.22	22.0	87	72	2.78	34	3.5	0.98	0.78	0.296	0.271	24.6		24.0	WTP/W&S
LINDEN ST.	**8/23/2006**	**8:25 AM**	5.97				3.50							20.1	136.4	95.0	VRAP
	9/12/2006	**8:15 AM**	6.68				2.40							9.8	136.1	28.0	VRAP
	5/30/2007	**8:35 AM**	6.56				2.40							19.4	142.5	83.0	VRAP
	6/26/2007	**8:20 AM**	6.34				3.40							21.4	172.2	38.0	VRAP
	8/3/2007	**8:25 AM**	6.15				1.78							25.2	199.4	7.7	VRAP
	8/29/2007	**8:20 AM**					2.01							20.7	231.7	2.5	VRAP
	7/5/2008	**10:00 AM**	6.40				3.38							22.0	186.2	46.0	VRAP
	10/6/2008	**10:05 AM**	6.13				3.35							10.9	146.2	157.0	VRAP
	6/17/2009	**10:30 AM**	6.16	9.5	99	83	2.86	34	2	0.52	0.36	0.051	0.054	17.0		149.0	WTP/W&S
	7/1/2009	**9:50 AM**	6.23	18.0	108	92	3.63	38	2.5	0.78	0.59	0.083	0.078	17.5		171.0	WTP/W&S
	7/15/2009	**10:30 AM**	6.92	14.5	114	100	2.91	26	2.5	0.60	0.44	0.062	0.057	20.0		106.0	WTP/W&S
	7/29/2009	**11:45 AM**	6.22	12.5	135	113	4.41	21.5	2	0.59	0.41	0.074	0.028	24.5		148.0	WTP/W&S
	8/12/2009	**8:50 AM**	6.85	17.5	112	93	3.49	30	2.5	0.55	0.47	0.078	0.069	21.5		49.0	WTP/W&S
	8/26/2009	**10:45 AM**	7.17	23.0	78	68	2.99	38	2.5	0.91	0.73	0.137	0.134	23.8		24.0	WTP/W&S

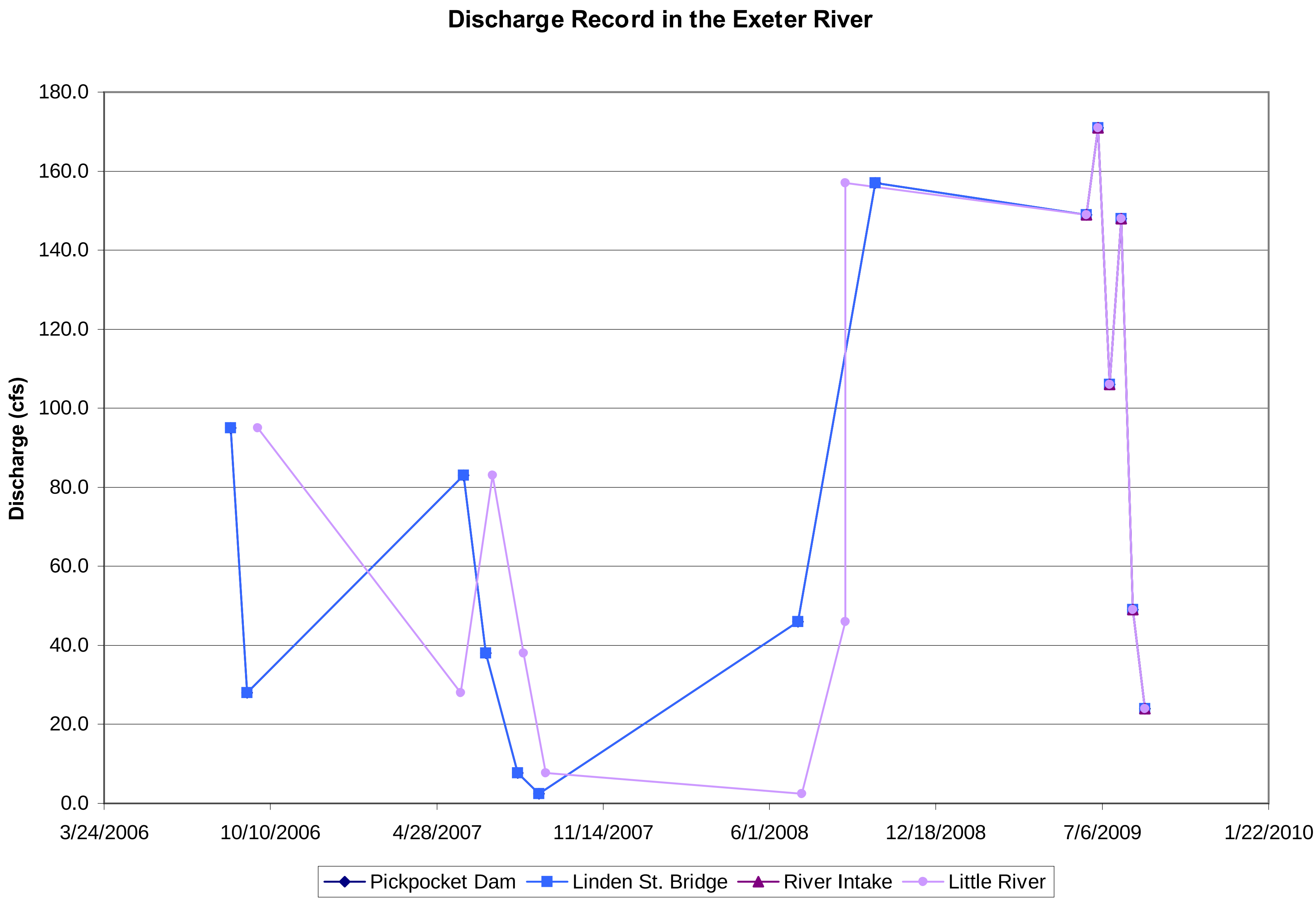
LOCATION	DATE	TIME	pH	ALKALINITY	COLOR		TURBIDITY	HARDNESS	CHLORIDE	IRON		MANGANESE		TEMP	CONDUCTANCE	RIVER FLOW	SOURCE
				mg/l	raw	filtered	NTU	mg/l	mg/l	raw	filtered	raw	filtered	field	us/cm	cfs	
PUMP STATION	**6/17/2009**	**2:00 PM**	5.93	12.0	106	83	3.42	38	2	0.60	0.38	0.071	0.067	17.0		149.0	WTP/W&S
	7/1/2009	**10:30 AM**	6.74	19.5	128	105	3.93	34	2.5	0.82	0.57	0.076	0.048	18.8		171.0	WTP/W&S
	7/15/2009	**12:25 PM**	6.78	15.5	124	90	4.23	30	2.5	0.71	0.54	0.087	0.082	20.0		106.0	WTP/W&S
	7/29/2009	**12:00 PM**	6.71	14.0	138	102	3.31	26	2	0.71	0.50	0.143	0.033	24.3		148.0	WTP/W&S
	8/12/2009	**9:10 AM**	6.86	18.0	110	91	5.86	28	2.5	1.24	0.81	1.440	1.060	23.0		49.0	WTP/W&S
	8/26/2009	**12:00 PM**	6.78	28.0	104	78	3.29	38	2.5	0.94	0.65	0.315	0.315	24.9		24.0	WTP/W&S
LITTLE RIVER	**9/25/2006**	**7:45 AM**	6.56				6.90							15.3	204.7	95.0	VRAP
	5/27/2007	**10:30 AM**	6.58											19.9	162.3	28.0	VRAP
	7/4/2007	**8:20 AM**	6.47				14.20							20.7	256.2	83.0	VRAP
	8/10/2007	**8:25 AM**	5.91				4.20							21.9	246.9	38.0	VRAP
	9/6/2007	**8:30 AM**	6.81				2.80							17.6	294.8	7.7	VRAP
	7/10/2008	**9:00 AM**	6.31				7.60							25.7	250.1	2.5	VRAP
	8/31/2008	**10:00 AM**	6.34				6.55							22.2	254.4	46.0	VRAP
	8/31/2008	**10:15 AM**	6.37				6.33							21.9	254.2	157.0	VRAP
	6/17/2009	**8:30 AM**	5.78	17.0	126	83	5.38	42	3	0.91	0.59	0.116	0.105	15.0		149.0	WTP/W&S
	7/1/2009	**10:15 AM**	6.01	28.0	144	128	4.88	58	3	0.92	0.63	0.102	0.084	17.5		171.0	WTP/W&S
	7/15/2009	**10:50 AM**	6.83	29.0	148	106	9.31	40	3.5	1.34	0.88	0.172	0.131	21.0		106.0	WTP/W&S
	7/29/2009	**12:40 PM**	6.21	24.5	159	124	5.34	36	2.5	1.28	0.63	0.145	0.035	24.5		148.0	WTP/W&S
	8/12/2009	**9:25 AM**	6.99	18.5	96	84	3.53	32	2.5	0.53	0.49	0.095	0.093	25.0		49.0	WTP/W&S
	8/26/2009	**11:20 AM**	6.96	31.5	93	54	5.22	42	3	0.21	0.19	0.162	0.151	23.8		24.0	WTP/W&S
RESERVOIR	**6/17/2009**	**12:00 PM**	6.37	28.0	44	28	4.08	60	6.5	0.32	0.18	0.207	0.189	21.0		149.0	WTP/W&S
	7/1/2009	**12:00 PM**	6.75	26.5	62	54	3.98	65	6.5	0.42	0.30	0.209	0.209	19.5		171.0	WTP/W&S
	7/15/2009	**12:00 PM**	7.01	28.5	94	83	3.30	96	5	0.79	0.46	0.170	0.145	21.0		106.0	WTP/W&S
	7/29/2009	**12:00 PM**	6.34	23.5	113	101	2.67	83	3	0.61	0.38	0.184	0.055	28.0		148.0	WTP/W&S
	8/12/2009	**12:00 PM**	5.28	18.5	120	98	4.01	36	2.5	0.81	0.62	0.141	0.030	22.5		49.0	WTP/W&S
	8/26/2009	**12:00 PM**	7.16	28.0	87	65	2.56	94	4.5	0.97	0.88	0.409	0.388	26.5		24.0	WTP/W&S



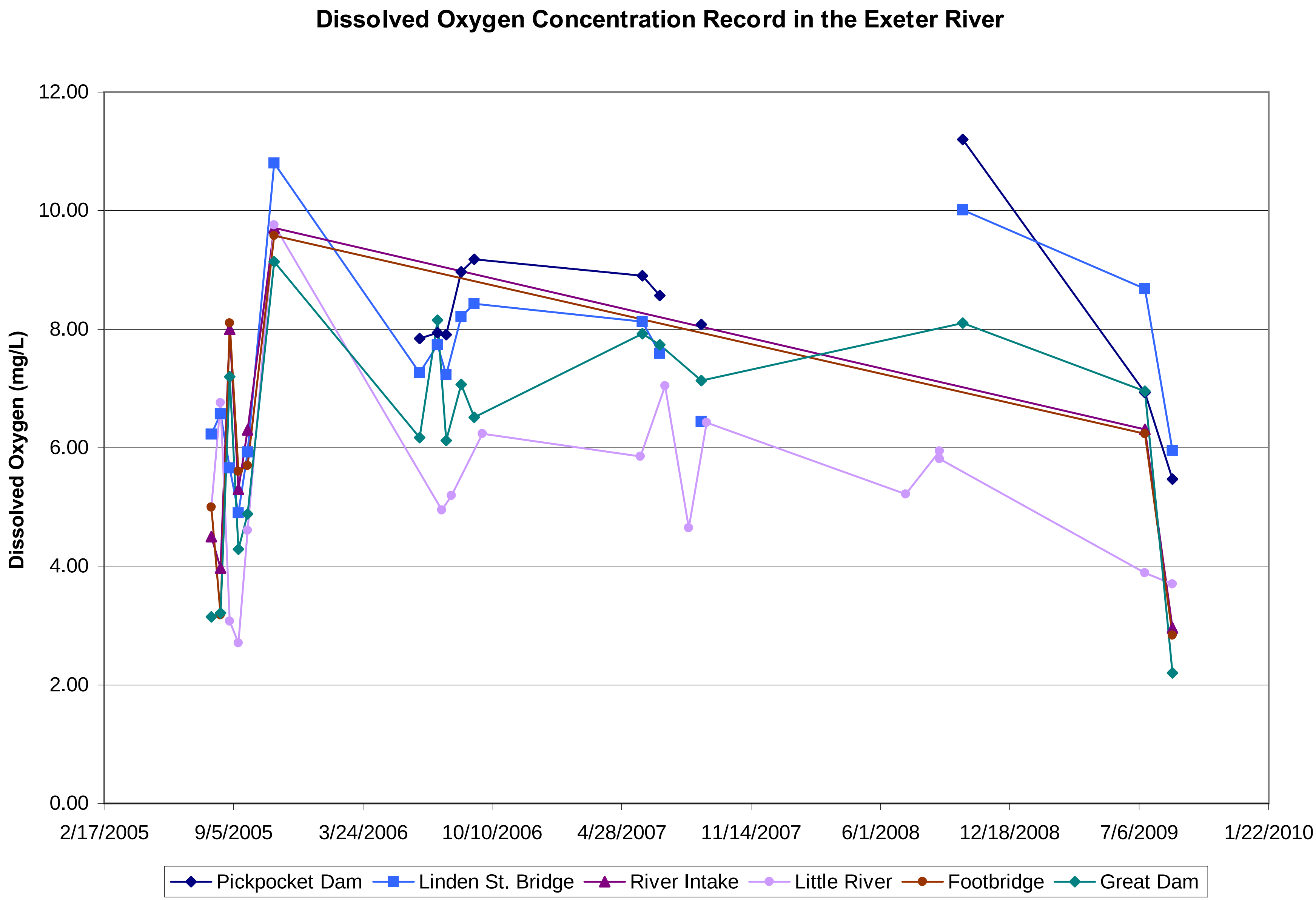
pH Record in the Exeter River and Reservoir
pH
8.00
7.50
7.00
6.50
6.00
5.50
5.00
3/24/2006
10/10/2006
4/28/2007
11/14/2007
6/1/2008
12/18/2008
7/6/2009
1/22/2010
Pickpocket Dam
Linden St. Bridge
River Intake
Little River


Turbidity Record in the Exeter River and Reservoir
Turbidity (NTUs)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
3/24/2006
10/10/2006
4/28/2007
11/14/2007
6/1/2008
12/18/2008
7/6/2009
1/22/2010
Pickpocket Dam
Linden St. Bridge
River Intake
Little River


Temperature Record in the Exeter River and Reservoir
Temperature (deg. C)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
3/24/2006
10/10/2006
4/28/2007
11/14/2007
6/1/2008
12/18/2008
7/6/2009
1/22/2010
Pickpocket Dam
Linden St. Bridge
River Intake
Little River

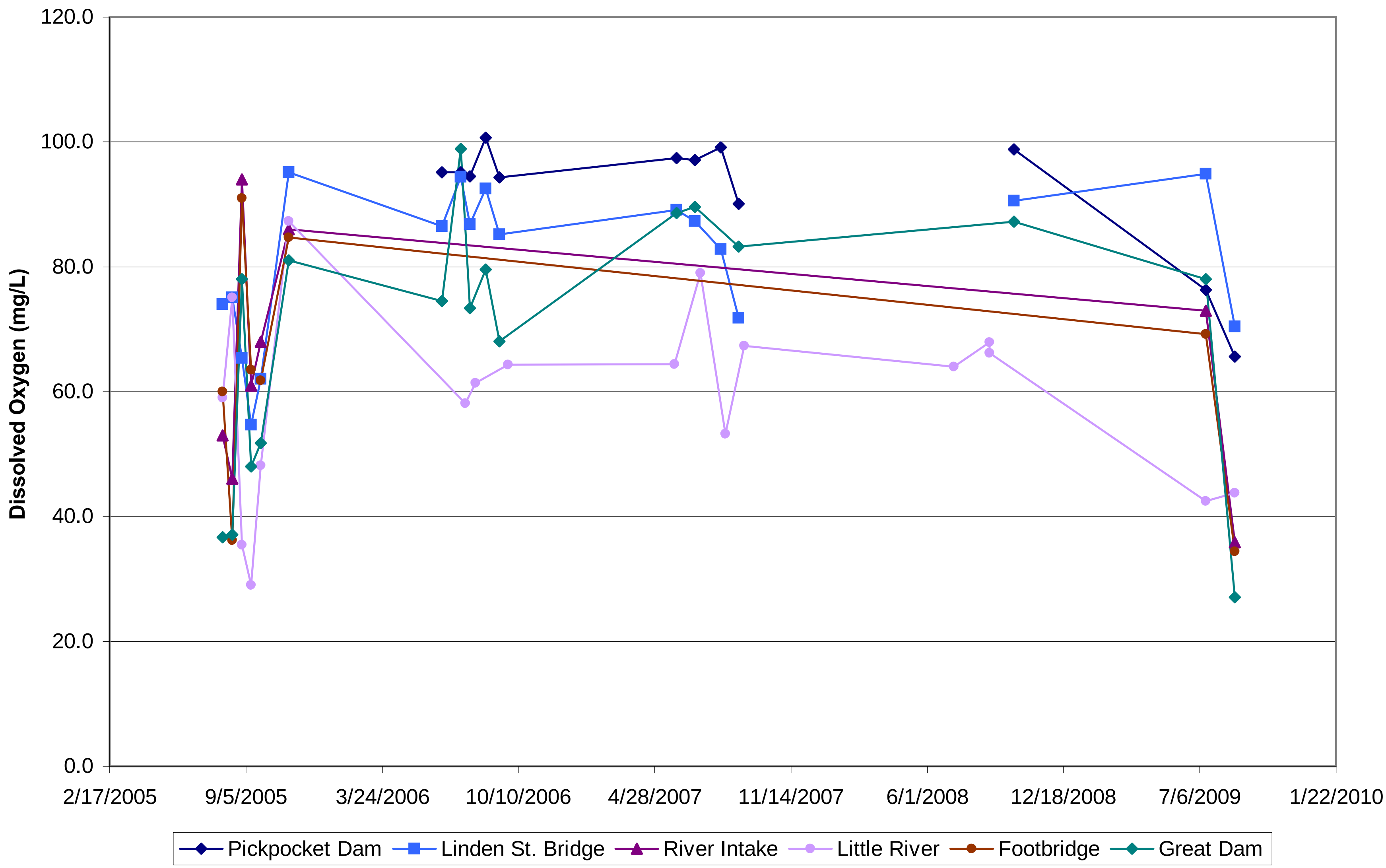


Discharge Record in the Exeter River
Discharge (cfs)
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
3/24/2006
10/10/2006
4/28/2007
11/14/2007
6/1/2008
12/18/2008
7/6/2009
1/22/2010
Pickpocket Dam
Linden St. Bridge
River Intake
Little River



Dissolved Oxygen Concentration Record in the Exeter River
Dissolved Oxygen (mg/L)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
2/17/2005
9/5/2005
3/24/2006
10/10/2006
4/28/2007
11/14/2007
6/1/2008
12/18/2008
7/6/2009
1/22/2010
Pickpocket Dam
Linden St. Bridge
River Intake
Little River
Footbridge
Great Dam

Dissolved Oxygen Percent Saturation Record in the Exeter River



LOCATION	DATE	TIME	DO mg/L	DO % Sat.	TEMP field	SOURCE
PICKPOCKET	6/20/2006	8:10 AM	7.84	95.1	21.7	VRAP
	7/17/2006	7:40 AM	7.94	95.1	23.1	VRAP
	7/31/2006	7:45 AM	7.91	94.5	20.8	VRAP
	8/23/2006	7:40 AM	8.97	100.7	19.4	VRAP
	9/12/2006	7:45 AM	9.18	94.3	13.1	VRAP
	5/30/2007	7:55 AM	8.90	97.4	19.4	VRAP
	6/26/2007	7:40 AM	8.57	97.1	21.2	VRAP
	8/3/2007	7:45 AM		99.1	25.8	VRAP
	8/29/2007	7:35 AM	8.08	90.1	20.8	VRAP
	7/5/2008	9:15 AM			22.7	VRAP
	10/6/2008	9:35 AM	11.20	98.8	10.8	VRAP
	7/15/2009	10:00 AM				
	spillway		6.93	76.3	19.8	W&S
	walkway @ 5 ft deep		4.03	46.0	19.8	W&S
	walkway @ 3 ft out		3.29	36.3	19.8	W&S
	8/26/2009	10:00 AM				
	spillway		5.47	65.6	24.6	W&S
	walkway @ 5 ft deep		2.71	32.7	24.4	W&S
	walkway @ 3 ft out		1.95	23.5	24.3	W&S
LINDEN ST.	8/2/2005	2:05 PM	6.23	74.0	24.0	W-P/W
	8/16/2005	9:50 AM	6.57	75.1	21.9	W-P/W
	8/30/2005	1:40 PM	5.66	65.4	22.8	W-P/W
	9/13/2005	11:05 AM	4.90	54.7	19.4	W-P/W
	9/27/2005	3:10 PM	5.93	62.0	17.4	W-P/W
	11/7/2005	1:00 PM	10.80	95.1	9.7	W-P/W
	6/20/2006	8:45 AM	7.26	86.5	20.6	VRAP
	7/17/2006	8:25 AM	7.74	94.4	24.4	VRAP
	7/31/2006	8:26 AM	7.23	86.8	17.2	VRAP
	8/23/2006	8:25 AM	8.21	92.5	20.1	VRAP
	9/12/2006	8:15 AM	8.43	85.2	9.8	VRAP
	5/30/2007	8:35 AM	8.13	89.1	19.4	VRAP

LOCATION	DATE	TIME	DO	DO	TEMP	SOURCE
			mg/L	% Sat.	field	
	6/26/2007	**8:20 AM**	7.59	87.3	21.4	VRAP
	8/3/2007	**8:25 AM**		82.8	25.2	VRAP
	8/29/2007	**8:20 AM**	6.44	71.8	20.7	VRAP
	7/5/2008	**10:00 AM**			22.0	VRAP
	10/6/2008	**10:05 AM**	10.01	90.6	10.9	VRAP
	7/15/2009	**10:30 AM**	8.68	94.9	19.9	W&S
	8/26/2009	**10:45 AM**	5.95	70.4	23.8	W&S
PUMP STATION	**8/2/2005**	**11:17 AM**	4.50	53.0	24.7	W-P/W
	8/16/2005	**8:35 AM**	3.97	46.1	22.7	W-P/W
	8/30/2005	**1:15 PM**	8.00	94.0	23.4	W-P/W
	9/13/2005	**10:20 AM**	5.30	61.0	21.7	W-P/W
	9/27/2005	**2:35 PM**	6.30	68.0	19.5	W-P/W
	11/7/2005	**11:58 AM**	9.71	86.0	9.7	W-P/W
	7/15/2009	**12:25 PM**	6.31	73.0	21.5	W&S
	8/26/2009	**11:05 AM**	2.96	35.9	24.3	W&S
LITTLE RIVER	**8/2/2005**	**1:30 PM**	5.00	59.0	23.4	W-P/W
	8/16/2005	**9:35 AM**	6.76	75.1	20.5	W-P/W
	8/30/2005	**1:30 PM**	3.07	35.5	23.2	W-P/W
	9/13/2005	**10:50 AM**	2.71	29.0	19.2	W-P/W
	9/27/2005	**3:00 PM**	4.61	48.2	17.8	W-P/W
	11/7/2005	**12:50 PM**	9.76	87.3	10.4	W-P/W

LOCATION	DATE	TIME	DO	DO	TEMP	SOURCE
			mg/L	% Sat.	field	
	7/24/2006	**7:50 AM**	4.95	58.1	19.5	VRAP
	8/8/2006	**8:15 AM**	5.19	61.4	22.1	VRAP
	9/25/2006	**7:45 AM**	6.24	64.3	15.3	VRAP
	5/27/2007	**10:30 AM**	5.85	64.4	20.6	VRAP
	7/4/2007	**8:20 AM**	7.04	79.0	20.7	VRAP
	8/10/2007	**8:25 AM**	4.65	53.2	21.9	VRAP
	9/6/2007	**8:30 AM**	6.42	67.3	17.6	VRAP
	7/10/2008	**9:00 AM**	5.22	64.0	25.7	VRAP
	8/31/2008	**10:00 AM**	5.94	67.9	22.2	VRAP
	8/31/2008	**10:15 AM**	5.81	66.2	21.9	VRAP
	7/15/2009	**10:50 AM**	3.89	42.5	19.2	W&S
	8/26/2009	**11:20 AM**	3.70	43.8	23.8	W&S
FOOTBRIDGE	**8/2/2005**	**11:45 AM**	5.00	60.0	25.1	W-P/W
	8/16/2005	**8:55 AM**	3.18	36.2	22.4	W-P/W
	8/30/2005	**12:50 PM**	8.10	91.0	23.5	W-P/W
	9/13/2005	**9:50 AM**	5.60	63.5	21.0	W-P/W
	9/27/2005	**2:20 PM**	5.70	61.8	19.3	W-P/W
	11/7/2005	**11:34 AM**	9.58	84.7	9.7	W-P/W
	7/15/2009	**12:45 PM**	6.24	69.2	20.5	W&S
	8/26/2009	**11:30 AM**	2.84	34.4	23.8	W&S
GREAT DAM	**8/2/2005**	**8:55 AM**	3.15	36.7	23.3	W-P/W
	8/16/2005	**8:15 AM**	3.21	37.1	22.2	W-P/W
	8/30/2005	**12:20 PM**	7.20	78.0	23.5	W-P/W
	9/13/2005	**8:30 AM**	4.29	48.0	20.5	W-P/W
	9/27/2005	**1:30 PM**	4.88	51.8	18.2	W-P/W
	11/7/2005	**10:35 AM**	9.14	81.0	9.6	W-P/W
	6/20/2006	**9:20 AM**	6.17	74.5	22.1	VRAP
	7/17/2006	**9:00 AM**	8.15	98.9	24.7	VRAP
	7/31/2006	**9:15 AM**	6.12	73.4	21.3	VRAP
	8/23/2006	**9:05 AM**	7.07	79.6	19.9	VRAP

LOCATION	DATE	TIME	DO	DO	TEMP	SOURCE
			mg/L	% Sat.	field	
	9/12/2006	**8:50 AM**	6.51	68.1	11.4	VRAP
	5/30/2007	**9:35 AM**	7.92	88.6	20.6	VRAP
	6/26/2007	**8:50 AM**	7.74	89.6	22.5	VRAP
	8/29/2007	**9:10 AM**	7.13	83.2	23.1	VRAP
	10/6/2008	**10:55 AM**	8.10	87.2	11.9	VRAP
	7/15/2009	**11:50 AM**				
	near gage @ surface		6.95	78.0	21.0	W&S
	edge of dam, 3 ft down		6.46	72.5	20.8	W&S
	8/26/2009	**12:00 AM**				
	near gage @ surface		2.20	27.1	24.2	W&S
	edge of dam, 3 ft down		2.08	25.5	24.2	W&S
RESERVOIR	**7/15/2009**	**1:00 PM**				
	near outfall, 3 ft down		5.01	56.4	20.7	W&S
	bubblers, 3 ft down		4.90	55.2	20.8	W&S
	on top of bubbles		4.97	55.4	20.6	W&S
	8/26/2009	**12:30 AM**				
	outfall @ surface		4.32	52.2	26.7	W&S
	outfall @ 3 ft		2.46	31.8	25.9	W&S

APPENDIX C

Great Dam Operation and Maintenance Plan

Town of Exeter
Operation & Maintenance Plan
Great Dam - Exeter, NH
Dam #082.01

Seasonal Operation:

Period	Operational Goals & Considerations
April 1 through June 30	The water level will be maintained at approximately 6 inches above the concrete spillway crest, insofar as reasonable and diligent monitoring, gate operations and gate capacity will allow. This period is the primary upstream migration period for anadromous fish. NH Fish & Game recommends that the water level be maintained approximately 6 inches above the elevation of the concrete spillway for efficient migration. May is also typically the month when the river becomes the primary source for drinking water supply. The heavy spring rains associated with snowmelt generally provide the greatest susceptibility to upstream flooding, so diligent monitoring and timely operations are crucial.
July 1 through October 30	The water level will be maintained at approximately 2 inches above the concrete spillway crest, insofar as reasonable and diligent monitoring, gate operations and gate capacity will allow. Try to maintain an adequate pool level for drinking water supply, recreation and downstream fish passage. Generally, two inches of flow over the spillway will provide the necessary flow for downstream passage. Heavy rains associated with hurricanes or severe thunderstorms can cause flooding; however, extensive periods without rainfall can cause drought.
November 1 through March 31	The water level will be maintained at approximately the level of the concrete spillway crest, insofar as reasonable and diligent monitoring, gate operations and gate capacity allow. Drinking water, recreation and fish passage considerations are less important during this period. Operations should be geared toward keeping the water level at or near the elevation of the spillway crest, although ice formation on the gate outlet or stem may prevent gate operations.

Contact information related to the operation of the dam:

Dam Owner: Town of Exeter

Dam Owner Designates	Contact	Office Phone	Cell (*Dispatch)
Lead Operator	Jay Perkins, Highway Supt	(603) 773-6157	(603) 512-1974
Alternate Operator	Scott Lebeau, General Fore	(603) 773-6157	(603) 944-3238
Emergency Operator	Brian Comeau, Fire Chief	(603) 773-6131	(603) 772-1212*

Contact information for other interested parties:

Organization	Contact	Office Phone	Cell
Exeter Elms Campground	Eric & Carol Waleryszak	(603) 778-7631	
Exeter Mills	Richard Moscatelli	(781) 829-4451	(781) 837-4300
Town of Exeter	Russ Dean, Town Manager	(603) 778-0591	(603) 580-1973h
Town of Exeter	Jennifer Perry, Town Engr	(603) 773-6157	(603) 463-3085h
Exeter Water/Sewer Dept	Victoria Del Greco, Supt.	(603) 773-6157	(603) 770-0469
Exeter Water Treatment Plant	Tony Calderone, Chief Op.	(603) 773-6169	(603) 599-7375
NHDES Dam Bureau	Steve Doyon	(603) 271-3406	(603) 731-0146
NH Fish & Game	Cheri Patterson	(603) 868-1095	
Phillips-Exeter Academy	Bob Kief	(603) 772-4311	

Operational Protocols:

A representative of the dam owner will visit the dam as often as necessary to ensure that the appropriate operational goals contained in the Seasonal Operation section are being met. When the low level gate is open visits will be made on a daily basis. At each visit the date, time, water level and gate opening shall be recorded in an observation logbook. In addition, any deficiencies noted or maintenance completed should be recorded in the logbook. Operations made that cause the water level to vary significantly from the goals established in the Seasonal Operation section may need to be coordinated with other water users.

To meet the seasonal goals defined above the Town of Exeter will operate the gated low level outlet at the dam, to the extent possible, to reduce both high and low water situations. It should be noted that the maximum capacity of the low level gate is approximately 310 cubic feet per second with the water level 2" to 8" above the spillway crest (the highest desirable operating range). Therefore, at river flows larger than this value the water elevation upstream of the dam must necessarily rise to keep pace. Attached to this document are rating curves for both the overflow spillway and the single low level gated outlet. These tools, along with the observation log, should be used to help determine when and to what degree the gate should be operated.

In addition to the operational resources noted above, the operator may gain insight into potential conditions at the Exeter River dam by tracking flows at the Exeter River stream gage near Haigh Road in Brentwood, NH and by monitoring developing weather conditions and forecasts issued by the National Weather Service and/or local media. NHDES Dam Bureau staff can provide additional insight into dam operations when needed.

The low level gate operating wheel is chained and locked while not in operation. Exeter DPW EN6 key is needed to open the lock.

When conditions require operation of the low level gate at Great Dam, consideration will also be given to the operation of gates at the Exeter Reservoir Dam and Colcords Pond Dam. Refer to the Operation and Maintenance Plans for those facilities for detailed information.

Operation and maintenance of the fish ladder and lower dam (weir) is the responsibility of NH Fish & Game Department. No modifications shall be made to the fish ladder and/or lower dam (weir) by Town personnel.

General Procedures:

High water: When the water level exceeds or is expected to exceed the target elevation as indicated in the Seasonal Operation section, the operator will manipulate the gate to keep the level at or near the (approximate target range) specified target elevation. If anticipated meteorological conditions warrant, the water level may be drawn down 1" to 2" range (above dam crest) below the seasonal target elevation in advance of additional inflow during fish migration periods (April 1 through October 30). Since the maximum capacity of the low level gate is approximately 350 cfs, inflows above this value will cause water levels to rise.

Low water: As the water level drops, either due to an open gate or low inflow conditions, the gate will be closed as necessary to achieve the approximate target elevation as indicated in the Seasonal Operation section. In addition, the operator will work with NHF&G and other water users, to prevent waste through the fish passage system or for other reasons.

Potential damage due to cresting of water over abutments:

Cresting of water over the abutments could lead to scouring of embankments adjacent to the abutments. In this emergency situation, effective water barriers (sandbags, etc.) shall be used to confine flow and protect embankments.

Maintenance Program:

At each visit:

- Record the information noted in the Operational Protocols section (date, time, water level, gate opening, and gate operations) into the logbook.
- Note any maintenance deficiencies in the logbook and address as necessary. Example deficiencies may include, but are not limited to, the presence of floating debris that restricts flow over the spillway or through the low level gate, leakage/seepage through concrete sections or abutments, undesirable vegetative growth on the abutments, damaged gate mechanisms and erosion of earthen abutment areas.

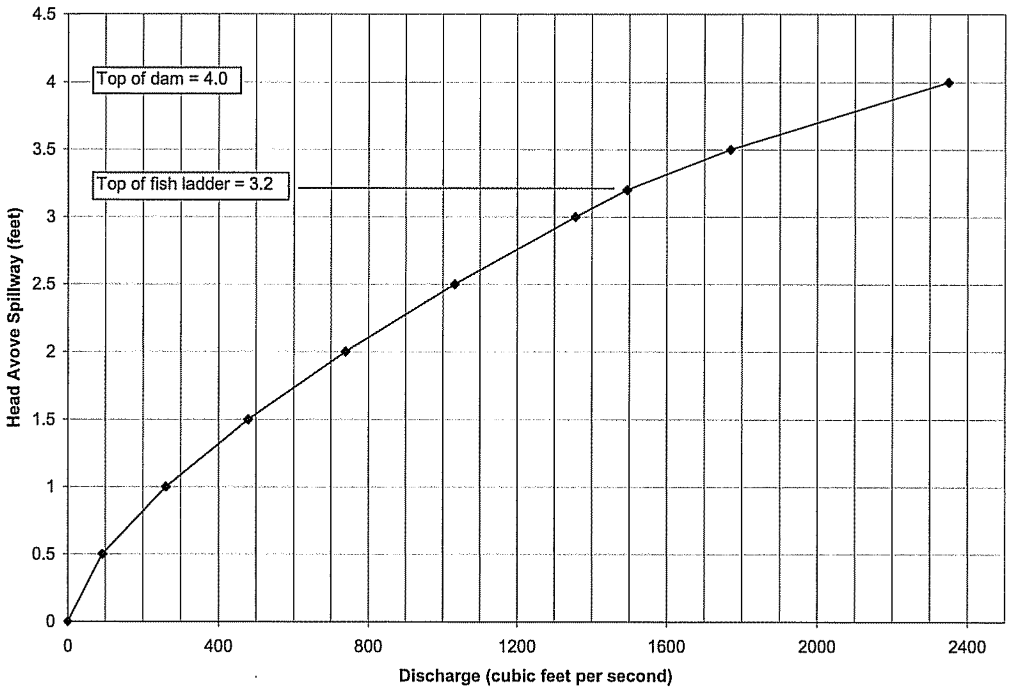
Semi-annually:

- Remove any undesirable vegetation growing on abutment areas.
- Check for and repair any erosion to earthen sections of both abutments.
- Inspect the gate operating mechanism and any visible portions of the gate panel and repair as necessary.
- Inspect previously identified seepage areas and compare findings with past inspections. Estimate leakage/seepage amount and note in logbook.
- Inspect all safety equipment, rails, stays and harnesses and repair or replace as necessary.

Annually:

- Perform a detailed visual inspection of the entire dam and schedule such maintenance or repairs as may be required.
- Adjust and lubricate the gate operating mechanism.
- Consult with NH Fish & Game on the operation and condition of the fish ladder.
- Consult with NH Fish & Game and NHDES if water levels need to be lowered below the crest of the dam.

Exeter River Dam - Spillway Rating Curve



Exeter River Dam - Gate Rating Curves