WhiteWater
WATER & WASTEWATER SOLUTIONS

November 8, 2017

Mr. James Purcell
Interim Town Administrator
Town of Leicester
3 Washburn Square
Leicester, MA 01524

Re: Moosehill Reservoir Feasibility Study Update
Final Report

Dear Mr. Purcell,

WhiteWater, Inc. and our project partner, Environmental Partners Group, Inc. are pleased to provide the Town of Leicester with the final report of the Mossehill Reservoir Feasibility Study. This report incorporates all the comments and revisions received from all parties to date.

We thank you for the opportunity to be of service to the Town of Leicester. Should you have any questions or comments regarding the draft report, please do not hesitate to contact me directly at (888) 377-7678.

Sincerely,

Stephen B. Donovan
General Manager

FINAL REPORT

Feasibility Study Update
Moose Hill Reservoir
Town of Leicester, Massachusetts

Prepared for:
WhiteWater, Inc.

July 2017

Prepared By:

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Project Manager

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Environmental Partners GROUP
A partnership for engineering solutions

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MOOSE HILL RESERVOIR FEASIBILITY STUDY UPDATE
TOWN OF LEICESTER, MASSACHUSETTS

1. Introduction

The Town of Leicester (the Town) retained WhiteWater, Inc. (WhiteWater) and their engineering sub-consultant, Environmental Partners Group, Inc. (Environmental Partners) to evaluate the feasibility of developing the Moose Hill Reservoir into a public water supply. The objective of the project is to update the Town's previous feasibility study of this concept that was completed in June 2008 by SEA Consultants, Inc. (SEA).

The scope of the feasibility study update focused primarily on development of the following for the Town's consideration:

1. Planning level capital and operation and maintenance cost estimates for the potential water system infrastructure improvements associated with a new surface water treatment plant at the Moose Hill Reservoir and connection to the Town's existing water system, and;

2. A forecast of the implementation schedule for the project, starting with a more detailed feasibility study through design, permitting and construction completion.

The planning level cost estimates and implementation schedule required developing a thorough understanding of the Town's current public water management structure. The following sources of information were critical in that process and used as the basis of this evaluation:

- Historical Town records concerning the Moose Hill Reservoir's potential development as a public water supply including the 2008 Feasibility Study (SEA) and the 2015 and 2016 Massachusetts Water Resource Outreach Center (Worcester Polytechnic Institute) student research projects analyzing the Town's water management alternatives.
- Meetings with representatives from the Town administration, the Moose Hill Commission (the Commission), the Leicester Water District (LWD), and the Cherry Valley and Rochedale Water District (CVRWD).
- Moose Hill Commission documents including meeting minutes, correspondence with Massachusetts Department of Environmental Protection (DEP), and the Commission's 2012 strategic plan.
- Publically available DEP correspondence with the Town's water districts: LWD, CVRWD, and Hillcrest Water District (HWD).
- State and Local environmental GIS data including resource protection (e.g. wetlands, water supply, and protected open space), property ownership, surface topography, and watershed delineation.
- Regional construction cost indices.
- Site visit to Moose Hill Reservoir and proximate area.

This feasibility study updates the studies the Town has previously completed and participated in.

The following project goals were developed through discussions between the Leicester Town Administrator, WhiteWater, and Environmental Partners:

1. Consider the current state of surface water treatment systems and their associated State (Massachusetts Department of Environmental Protection, DEP) regulation.

2. Identify additional infrastructure improvements that were not previously identified as part of potential surface water treatment facility, and that are necessary for connecting the water supply to the Town's existing water system.

3. Develop a planning level construction cost and operation/maintenance cost estimate and provide a comparison to recently completed water treatment facilities in the region.

4. Identify project implementation critical path elements and milestones.

5. Update the regulatory timeline to reflect the current permitting requirements associated with developing a new public water supply and the design and construction of a surface water treatment plant.

The intent of this report is to provide the Town with a planning level cost estimate and implementation schedule to consider before continuing forward with further evaluation activities and public outreach to determine the feasibility of developing Moose Hill Reservoir as a public water supply.

2. Background

The Town of Leicester is currently served by three (3) independent public water systems: the Leicester Water District (LWD); the Hillcrest Water District (HWD); and, the Cherry Valley and Rochedale Water District (CVRWD). The HWD has one active groundwater supply well with a treatment facility for removal of arsenic, uranium, and hydrogen sulfide. HWD relies upon an interconnection with the LWD to provide water supply redundancy and for the purchase of water to meet summer seasonal demands. Representatives from the LWD reported that they are currently in the process of formally consolidating the HWD into the LWD (May 25, 2017 project meeting). The three water districts all operate as enterprise funds and are independent of the Town's control. Approximately 80% of the Town's 10,970 residents (2010 Census) are served by the Town's public water systems with the remainder relying on private water supply wells. Table 1 summarizes the key characteristics of the three water districts.

Table 1
Summary of Town of Leicester Water Systems

Public Water System	Watersheds	Sources (Approved Capacity)	Average Day Demand	Peak Day Demand	Notes
Leicester Water District	Supply: French and Blackstone Discharge: French	Paxton Wells (0.235 MGD) Whittemore Well (inactive) Rawson Well (0.181 MGD)	0.2 MGD	0.362 MGD	Supplies water to HWD
Hillcrest Water District	Supply: French and Blackstone Discharge: French	Rock Well (0.086 MGD)	0.06 MGD	0.086 MGD	Interconnection with LWD
Cherry Valley and Rochedale Water District	Supply: French Discharge: Blackstone and French	Henshaw Pond (0.375 MGD) Grindstone Well (0.118 MGD)	0.27 MGD	0.58 MGD	Sources currently inactive. Interconnection with City of Worcester active.
Totals		0.995 MGD	0.53 MGD	1.028 MGD	

Notes:
1. MGD = Million Gallons Per Day

Each of the Town's three public water systems are faced with a variety of regulatory and financial challenges. The LWD is currently in the process of upgrading its water treatment and distribution system infrastructure in accordance with Administrative Consent Orders from DEP. The HWD is in the process of being consolidated with the LWD, which has been supplying HWD with the majority of its water in the past few years. The DEP approved an Emergency Declaration for the CVRWD to purchase water from the City of Worcester through their emergency interconnection in response to noncompliance with state drinking water standards and the limited available water due to the 2016 drought conditions. CVRWD is still reliant on the City of Worcester for the supply

of drinking water and is in the process of negotiating a 20-year water supply agreement with the City (Worcester Telegram and Gazette, http://www.telegram.com/news/20170717/worcester-to-sell-water-to-leicester-in-20-year-deal, July 17, 2017). The CVRWD has had to increase its water rates to reflect the wholesale purchase of water from Worcester and has had to invest in upgrading their infrastructure for the emergency interconnection.

In addition to these infrastructure investments, Leicester's groundwater is challenging to treat due to the presence of arsenic, uranium and radium, which require chemical and physical treatment to remove these constituents to concentrations that meet state drinking water standards. The operation and maintenance costs of water treatment facilities are increasing annually and add to the financial burden of the water districts. Therefore, the potential development of Moose Hill Reservoir, which may not have these same difficult treatment requirements as the other sources, could address the Town's current water supply shortage and water quality challenges.

Moose Hill Reservoir:

The Moose Hill Reservoir is located partially in the towns of Leicester and Spencer. A Site Locus is provided as Figure 1. The reservoir was created when the Moose Hill Reservoir Dam was constructed in the 1960s-1970s as a flood control project. The dam is owned by the State of Massachusetts and operated by the Department of Conservation and Recreation. The dam is approximately 2,000 feet long, 71 feet tall, and is capable of storing approximately 785 million gallons of water from Shaw Brook. Shaw Pond is located upstream of the reservoir and it is also dammed as a public water supply for the Town of Spencer.

The Moose Hill dam is classified as a Class 1 High Hazard Large Dam. The reservoir's watershed is generally rural with agricultural, forested open space, and residential properties located within its approximately 5 square mile drainage area. The dam discharges to Sudgen Reservoir, which is a recreational water body located in Spencer.

There is little available water quality data for the Moose Hill Reservoir, however Town records have indicated that previous studies found the reservoir to have water quality consistent with typical New England surface waters. Extensive water quality testing would be required as part of the reservoir permitting and water treatment plant design activities. Table 2 summarizes some of the available Moose Hill data as well as recent data for the Quabbin Reservoir.

Table 2
Summary of Typical New England Surface Water Quality

Water Quality Parameter	Moose Hill 1996	Quabbin Reservoir 2016	Notes
Turbidity	0.5 – 1.5 NTU	0.21-1.6 NTU	Variable, stormwater runoff, lake turnover, algal growth
Color	50-130 CU	NA	Dependent on organic content
pH	5.5-7.0 SU	5.7-7.2 SU	Generally slightly acidic to neutral
Iron	0.07-0.7 mg/L	NA	Typically present in dissolved state, easily oxidized
Manganese	0.03-0.3 mg/L	NA	Can vary seasonally with lake turnover, more difficult to oxidize
Hardness	NA	NA	Typically soft, low alkalinity
Coliform	NA	<1-7 CFU/100ml	Stormwater runoff, water fowl
Organics	NA	0.017-0.174 Absorbance of UV-254 per cm (1998-2015)	Can vary seasonally and depend on type of organic matter present

NTU: Neplometric Turbidity Unit / CU: Color Unit / NA: Not Available / CFU/ml: colony forming unit per milliliter
UV-254/cm: Ultraviolet light at 254 nanometer wavelength absorbed per centimeter surrogate for organic matter
Moose Hill 1996 data: http://wp.wpi.edu/wroc/files/2015/10/WROC-Final-Report.pdf
Quabbin Reservoir 2016 data: http://www.mass.gov/eea/docs/dcr/watersupply/watershed/2016quabbinwqreport.pdf

3. Water Treatment and Distribution System Improvements – Capital and O&M Costs

Surface Water Treatment Processes

The treatment of surface water typically involves a sequence of several physical and chemical treatment processes to remove impurities including common constituents such as iron, manganese, and organic matter, adjusting the pH for treatment optimization and corrosion control, and removal or inactivation of bacteria and viruses. These processes are all required to achieve compliance with the federal and state primary and secondary drinking water standards. The typical water treatment processes for a surface water are:

- Physical Pre-Treatment – Screening of raw water to remove large debris, organic matter, and particles from the raw water. The Moose Hill Reservoir treatment facility would require an intake structure to be constructed either within the reservoir or along the reservoir bank for this purpose.
- Chemical Pre-Treatment – After screening the raw water is typically treated with chemicals to adjust the pH, oxidize dissolved metals or natural organic matter, or improve the treatability of the water in subsequent treatment processes.
- Coagulation and Flocculation – After chemical pre-treatment, a coagulant is added to react with organic material to create particles as the water is first rapidly mixed to distribute the coagulant and then slowly mixed to allow the particles to grow in size as the coagulant reacts with the organic matter and particles floc together (i.e. flocculation).
- Clarification – The particles generated during coagulation/flocculation now need to be removed through clarification, which can be accomplished through a variety of means. Conventional treatment used to focus on the sedimentation of particles. Additional clarification methods have been developed in the past few decades including contact adsorption clarifiers, dissolved air flotation, and inclined plates or tube settlers. As discussed in this section the majority of the surface water treatment plants constructed in the past ten years have utilized dissolved air flotation for clarification.
- Filtration – Clarification results in the removal of the majority of the larger particles present in the treated water. However, additional particles and impurities remain in the water and a separation process is required to remove these additional particles. Filtration can be done either by gravity or pressure. Common granular filtration media are anthracite, sand, and granular activated carbon. Membrane filters have also become more prevalent in drinking water treatment. Depending on the quality of the raw water, it is possible to avoid the clarification process and use direct filtration of the coagulated water.
- Disinfection and Finished Water Chemical Treatment – The final step in the process is the disinfection of the treated water to inactivate or remove microorganisms such as bacteria and viruses. The type of disinfection process utilized can vary depending on the raw water quality and preceding treatment processes used. Typically a chemical disinfect such as chlorine is applied in sufficient concentration to provide a residual in the water distribution system. Other common finished water chemical treatment includes pH adjustment for corrosion control, phosphate addition for corrosion control, and fluoridation for public health.

The 2008 Feasibility Study did not specifically identify the water treatment processes relied upon to develop the construction cost estimate, but the proposed water treatment facility would have included some form of the primary treatment processes outlined above. It is also assumed that the cost estimates developed for the 2008 study relied upon what were then recently completed treatment plants, as well as the industry's construction cost index.

In the years since the 2008 study the drinking water regulations have been revised and additional treatment processes have become necessary to improve the finished water quality, as well as to remain in compliance with these regulatory drinking water standards, in particular the disinfection by-product rule. These additional processes include ozonation, which uses ozone gas for disinfection, oxidation (iron, manganese, organic matter), color removal, taste and odor control, pre-treatment to biological filtration, or control of disinfectant by-products. Several of the recently completed water treatment plants in Massachusetts have used ozonation prior to filtration. Alternative disinfection practices have also become more common including disinfection with ultraviolet light (UV) and advanced oxidation practices (AOPs). UV disinfection is used to physically damage a microorganism's DNA so that it is inactivated and cannot replicate. The Massachusetts Water Resource Authority utilizes UV disinfection at its Carroll Water Treatment Plant. AOP processes generally are the use of some combination of oxidants or disinfectants (e.g. ozone and UV or Ozone and peroxide) for disinfection or to remove chemicals such as pesticides, volatile organic compounds, and taste and odor compounds that can be difficult to treat using traditional water treatment processes.

For the purposes of updating the Feasibility Study and developing the water treatment plant construction cost estimate, it was assumed that the Moose Hill Reservoir water treatment plant would rely upon similar surface water treatment processes to those used at the water treatment plants that have been completed recently in the New England region. The selection of specific treatment processes for a treatment plant at Moose Hill Reservoir would be made following comprehensive analysis of the reservoir water quality and the results of pilot demonstration testing.

Water Treatment Plant Capacity

The 2008 Feasibility Study evaluated three treatment capacities: 0.5 MGD, 1.0 MGD, and 1.5 MGD. For the purposes of this study, a treatment plant capacity of 1.5 MGD was utilized to be consistent with the reported sustainable yield of the reservoir. The 1.5 MGD capacity also would be capable of meeting the Town's current peak day demands (1.028 MGD) of its three water districts and provide for some additional capacity should water demands increase over time.

Water System Infrastructure Improvements

In addition to the 1.5 MGD surface water treatment plant, the following additional infrastructure improvements were included in developing the construction cost estimate:

- Connection of the Moose Hill Reservoir treatment plant to the Leicester Water District, consisting of 5,500 linear feet of 16 inch diameter ductile iron finished water transmission main to the existing water system at the intersection of Watson Road and Main Street.

- An additional water storage tank (500,000 gallon elevated tank).
- Surface water intake within Moose Hill Reservoir, consisting of 500 linear feet of 16 inch diameter HDPE pipe anchored/ballasted off the reservoir bottom, two (2) 1.5 MGD stainless steel intake screens, and an intake gatehouse on the shore of the reservoir for valves, piping and in-take screen air-burst system.
- Treatment plant residuals management, consisting of 5,500 linear feet of 4 inch diameter PVC force main and a residuals pump station for transmission from the treatment facility to the Leicester Sewer District's sanitary sewer at intersection of Watson Road and Main Street.

Figure 1 presents the approximate location of the water treatment plant that was identified by the Town for the purposes of this study. Also shown is the proposed alignment of the finished water transmission main and residuals force main between the water treatment plant and their connections to the Leicester Water District's water system and Leicester Sewer District's sanitary sewer system. The proposed 500,000 gallon storage tank is not shown on the site locus, but the 2008 study reported that Blueberry Lane was a potential site for the storage tank. The water system master planning effort would include a hydraulic analysis to determine the required storage capacity to meet system demands, fire protection, and water quality requirements. The analysis would also identify suitable locations for water storage tanks.

Capital Cost Estimate

The capital cost estimate was developed based upon the following assumptions and methods:

1. The 2008 Study's $4.5 million cost estimate for the 1.5 MGD treatment plant was escalated from June 2008 to July 2017 using the Boston Construction Cost Index (13787.38) as published by Engineering News Record on July 10, 2017.
2. An additional 35% construction contingency was added to the water treatment facility due to the uncertainty associated with raw water quality of the reservoir and the level of water treatment required. The 2008 study did not indicate if a construction contingency was included in the cost estimate.
3. Land acquisition costs were not included in the cost estimate due to the fact that the Town does not currently own land adjacent to the reservoir or have authorized use of state owned land for siting the water treatment plant (e.g. potential for Article 97 requirements for the lease, purchase, or easement to state land).
4. Site specific development costs were not estimated due to the fact that surficial and subsurface geologic conditions are unknown (e.g. presence of bedrock and unsuitable soil conditions).
5. The 2017 cost estimate for the finished water transmission main was based upon a unit price of $325 per linear foot to furnish and install the 16 inch diameter ductile iron water main. The unit price estimate was developed from Environmental Partners' professional experience and a review of seven (7) publically bid water main construction projects from 2015 to 2017. A 35% contingency was added to account for the unknown subsurface conditions along the transmission main alignment.
6. The 2017 cost estimate for the water storage tank adds a 35% contingency to the 2008 cost estimate due to Environmental Partners' review of four (4) publically bid water storage tank projects between 2009 and 2015 that had an average unit cost of construction of

$3,000,000 per million gallons of storage. The contingency was added due to the unknown height of the tank and unknown subsurface conditions at a potential site.

7. The 2008 cost estimate does not indicate if an intake structure is included within the costs of the water treatment plant. The 2017 reservoir intake structure cost estimate includes a unit cost of $550/linear feet for the 500 linear feet of 16-inch HDPE intake pipe and anchors/ballast, $22,000 for the two (2) 1.5 MGD stainless steel intake screens, $100,000 for the shoreline intake gatehouse and interior process piping/valves, and $70,000 for the intake screen air burst system. In keeping with other project elements a 35% contingency is included due to the unknown reservoir conditions (e.g. slope of the bottom, depth of sediment).
8. The 2008 study does not specify how water treatment residuals would be managed. The 2017 study assumes the residuals would be pumped via a residuals pump station ($250,000) at the water treatment plant through a 5,500 linear foot 4 inch diameter PVC forcemain ($150 per linear feet) to the sanitary sewer system. A 35% contingency is included to account for the unknown subsurface conditions along the sewer forcemain alignment.
9. The 2025 future value of the infrastructure improvements was developed assuming the project is bid and awarded in 2025 (8 years) and there is an annual rate of construction cost escalation of 4% per year. The total escalation rate is thereby 137% = 1.04^8.
10. The 2008 study assumed engineering services to be 20% of the construction sub-total. 2017 and 2025 cost estimates assume engineering services to be 25% of the construction sub-total.
11. Public information and permitting services were not specified as part of the 2008 cost estimate. Environmental Partners has included a cost estimate of $750,000 for these services for the period between 2018 and the start of construction in 2025.
12. No infrastructure construction costs are included for the Town's three water districts for improvements to their distribution systems to integrate the Moose Hill water treatment plant as a water supply source.

Table 3 summarizes the 2017 and 2025 capital cost estimate for the 1.5 MGD Moose Hill Reservoir Water Treatment Plant and appurtenant distribution system improvements and provides the 2008 cost estimate for comparison. The 2008, 2017, and 2025 total capital cost estimates are $8,886,000, $20,173,681, and $27,609,076, respectively.

For quality control purposes the 2017 capital cost estimate was compared against the publically available construction costs for six (6) surface water treatment projects (includes one groundwater under the influence of surface water project) awarded between 2008 and 2015 in Massachusetts, Rhode Island, and New Hampshire. Table 4 summarizes these regional projects, their treatment plant capacities, primary treatment processes, and unit cost per million gallons of capacity. Project costs were escalated to 2017 costs using the Boston ENR Construction Cost Index to normalize the projects to July 2017 costs for comparison.

The unit cost per million gallons of treatment capacity ranged from $3.56 Million per million gallons (private water company project) to $6.48 Million per million gallons (1.7 MGD groundwater under the direct influence of surface water project). There are economies of scale associated with the larger capacity plants. The Moose Hill project's capacity is closer to those of the Acton, MA and Madbury, NH projects, which had the two highest unit costs. The Moose Hill Reservoir project has a unit cost of $6.86 Million per million gallons of capacity, which is just

outside the range of the regional projects, but also includes the 35% contingency associated with the project uncertainties. Therefore, the Moose Hill project is comparable in cost to those recently completed projects.

Operational Costs

WhiteWater developed the projected operational costs per 1.0 MGD based upon two active water treatment facilities in Massachusetts. The operational costs include electrical power, treatment plant labor, supplies and expenses, maintenance of buildings and equipment, and small tools and equipment. Table 5 summarizes these operational cost estimates for 2017 and 2025, which assumes a 1.30 escalation rate over the 2017 costs. The operational cost estimates in 2025 average $530,715 per MGD, which is equivalent to $796,072 for the 1.5 MGD Moose Hill facility.

TOWN OF LEICESTER
MOOSE HILL RESERVOIR FEASIBILITY STUDY
TABLE 3 - CAPITAL COST ESTIMATE OF WATER TREATMENT PLANT AND DISTRIBUTION SYSTEM IMPROVEMENTS

Item	Description	2008 Capital Cost Estimate[1]	2017 Capital Cost Estimate[2]	2025 Capital Cost Estimate[8]
1A	**1.5 Million Gallon Per Day (MGD) Surface Water Treatment Plant**	*$4,500,000*	**$10,233,945**	***$14,005,860***
1B	**Land Acquisition and Site Specific Development Costs[9]**	*Not Specified*	**Not Included**	***Not Included***
2	**5,500 Linear Feet of 16" Ductile Iron Finished Water Transmission Main[1,3,4]**	*$1,375,000*	**$1,787,500**	***$2,446,317***
3	**500,000 Gallon Elevated Water Storage Tank[1,5]**	*$1,530,000*	**$2,065,500**	***$2,826,779***
4	**Surface Water Intake[6] 500 Linear Feet of 16" HDPE Pipe**	*Not Included*	**$600,750**	***$822,168***
5	**5,500 Linear Feet of 4" PVC Residuals Force Main to Sanitary Sewer and Residuals Pump Station[4,7]**	*Not Included*	**$1,451,250**	***$1,986,136***
	Sub-Total	*$7,405,000*	**$16,138,945**	***$22,087,261***
	Engineering Services - Design, Procurement, and Construction Services[10]	*$1,481,000*	**$4,034,736**	***$5,521,815***
	Public Outreach and Permitting Services[11]	*Not Specified*	**$750,000**	***$750,000***
	Total	*$8,886,000*	**$20,173,681**	***$27,609,076***

Notes:

1	Infrastructure improvements and cost estimates reported in SEA Consultants, Inc. report titled *Moose Hill Reservoir Feasibility Evaluation* (June 2, 2008). Construction contingency not specified.
2	2017 Cost Escalation Factor = July 2017 ENR Boston Construction Cost Index / June 2008 ENR Construction Cost Index; 13788.38 / 8185 = 168.46%. A 35% contingency added due to unknown reservoir water quality and required treatment processes.
3	2017 Cost Estimate based upon unit price of $325 per linear foot of water main to furnish and install large diameter transmission main. Unit price estimate developed from professional experience and review of seven (7) publically bid projects from 2015-2017 and includes a 35% contingency due to unknown subsurface conditions along transmission main alignment.
4	Transmission mains assumed to connect to Leicester Water District system at intersection of Watson Road and Main Street.
5	2017 cost estimate includes a 35% contingency to the 2008 estimate as Environmental Partners review of recently publically bid water storage tank projects (4 projects, 2009 to 2015) had an average unit cost of $3,000,000 per million gallons of storage. Contingency added due to unknown height of storage tank, and unknown subsurface conditions at potential site.
6	Town's 2008 report does not specify accommodations for the water treatment plant's surface water intake. Environmental Partners assumed the following: (1) 500 linear feet of 16" HDPE raw water main anchored/ballasted off reservoir bottom ($550/lf). (2) Two (2) 1.5 MGD stainless steel intake screens, 16" diameter, T-shaped ($11,000 each). (3) Intake gatehouse ($100,000) on reservoir shoreline for valves, piping, and intake screen air-burst system ($70,000). (4) 35% contingency due to unknown reservoir conditions.
7	Town's 2008 report does not specify how water treatment residuals would be managed. Environmental Partners assumed residuals would be pumped from the facility to the Leicester Sewer District. Estimate assumes 5,500 linear feet of 4" PVC pressure sewer, unit price estimate of $150 per linear foot to furnish and install pipe. Includes $250,000 for a residuals pump station at the WTP and a 35% contingency due to unknown subsurface conditions along sewer forcemain alignment.
8	The 2025 future value of the capital improvements assumes projects bid and awarded in 2025 (8 years). Annual escalation rate of 4% per year. 1.04^8 = 137%
9	WTP cost does not include costs associated with land acquisition (e.g. Potential Article 97 requirements) and site-specific construction contingencies (e.g. bedrock and unsuitable soil conditions)
10	Engineering Services in 2008 Cost Estimate was 20% of construction sub-total. 2017 and 2025 Cost Estimate assumes 25% of construction sub-total.
11	Public Information and Permitting Services assumed to be required between 2018 and start of construction in 2025.

TOWN OF LEICESTER
MOOSE HILL RESERVOIR FEASIBILITY STUDY
TABLE 4 - SUMMARY OF CONSTRUCTION COSTS FOR RECENTLY CONSTRUCTED SURFACE WATER TREATMENT PLANTS

Water System	Location	Bid Year	WTP Capacity MGD	Treatment Technology	Awarded/ Reported Construction Cost[1]	Cost per MG, $M/MGD Bid Year	Construction Cost per July 2017 ENR Construction Cost Index[2]	Cost per MG, $M/MGD, 2017	Comments
Weymouth	Weymouth, MA	2008	8.0	Dissolved Air Flotation, Pre-Ozonation Biological Activated Carbon Filtration	$32,484,775	$4.06	$44,595,379	$5.57	Pre-procurement of Dissolved Air Flotation equipment, construction cost does not include $647,000 in demolition of former WTP
Falmouth	Falmouth, MA	2015	8.0	Dissolved Air Flotation Pre-Ozonation Biological Activated Carbon Filtration	$40,925,150	$5.12	$45,256,717	$5.66	Under construction and scheduled for start-up spring 2017
Portsmouth	Madbury, NH	2009	4.0	Dissolved Air Flotation Dual Media Filtration	$20,000,000	$5.00	$25,647,289	$6.41	LEED Silver Certified
Acton Water District	Acton, MA	2015	1.7	Aeration Towers, Coagulation Direct Membrane Filtration	$9,967,677	$5.86	$11,022,668	$6.48	Groundwater Under the Direct Influence of Surface Water
Newport	Portsmouth, RI Newport RI	2012	16.0	Dissolved Air Flotation Granular Activated Carbon Filtration Granular Activated Carbon Contactors	$67,000,000	$4.19	$76,767,869	$4.80	Alternative Project Delivery - Design Build, 1 new 7MGD surface water plant and upgrades to an existing 9 MGD surface water plant. Advanced DBP treatment with GAC contactors.
Milford Water Company	Milford, MA	2012	5.4	Dissolved Air Flotation Granular Activated Carbon Filtration	$16,800,000	$3.11	$19,249,257	$3.56	Water system is not publically owned and project was not subject to public procurement laws (e.g. prevailing wage rates; filed sub-bids)
					Minimum	$3.11		$3.56	
					Maximum	$5.86		$6.48	
					Median	$4.59		$5.62	
					Average	$4.56		$5.41	

Notes:

1. Awarded/Reported Construction Costs as readily available via publicly available records from MA Central Register, Water System websites, or local news articles
2. WTP Construction Cost's escalated to July 2017 values using ENR Construction Cost Indices for Boston

	Capacity	July 2017 Construction Cost	Cost per MG, $M/MGD, 2017	Comments
Moose Hill Reservoir WTP	1.5 MGD	$10,233,945	$6.82	Estimate falls just outside of range of recently constructed WTPs ($3.56M/MGD - $6.48M/MGD)

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MOOSE HILL RESERVOIR FEASIBILTY STUDY

TABLE 5 - PROJECTED OPEATIONAL COSTS BASED ON TREATMENT TECHNOLOGIES

DESCRIPTION	5.2 MGD DISSOLVED AIR FLOTATION TECHNOLOGY (DAF) BASED ON 2017 PROJECTIONS	6.0 MGD UPFLOW CLARIFIER / DIRECT FILTRATION TECHNOLOGY BASED ON 2017 PROJECTIONS	2025 ESCALATION FACTOR = 1.30	5.2 MGD DISSOLVED AIR FLOTATION TECHNOLOGY (DAF) BASED ON 2025 PROJECTIONS	6.0 MGD UPFLOW CLARIFIER / DIRECT FILTRATION TECHNOLOGY BASED ON 2025 PROJECTIONS
Annual Water Production	855,730,000	660,000,000		855,730,000	660,000,000
Total Kilowatt Hours	469,200	110,000		469,200	110,000
Purification Labor	$194,200	$288,632	1.30	$252,460	$375,221
Supplies and Expenses	$497,000	$229,168	1.30	$646,100	$297,918
Maint Bldgs & Equipment	$227,000	$65,000	1.30	$295,100	$84,500
Electricity	$63,314	$110,000	1.30	$82,308	$143,000
Small Tools / Other Equipment	$15,000	$15,000	1.30	$19,500	$19,500
Total Annual Cost	$996,514	$707,800	1.30	$1,295,468	$920,140
Treated Gallons Annually	855,730,000	660,000,000		855,730,000	660,000,000
Average Daily Cost	$2,730	$1,939	1.30	$3,549	$2,521
Average Daily Demand	2,344,466	1,808,219		2,344,466	1,808,219
AVG COST PER GALLON	$0.00116	$0.00107	1.30	$0.00151	$0.00139
AVG COST PER 1.0 MGD	$1,165	$1,072	1.30	$1,514	$1,394
ANNUAL COST FOR 1.0 MGD	$425,050	$391,435	1.30	$552,564	$508,865

AVERAGE ANNUAL COST FOR 1.0 MGD	$530,715
PROJECTED ANNUAL COST FOR 1.5 MGD	$796,072

4. Project Implementation Schedule and Regulatory Pathway

Years 1 and 2

The project's implementation program and schedule are outlined in Figure 2. The key components of the program and schedule are in the first two years of the program, when the Town would evaluate the project's feasibility in more detail to ultimately decide whether it is a viable water supply management program for the community by developing a concept-level system design and cost estimate that would be the basis for soliciting public input on the program.

A key first step in this effort will be identifying the land needs and ownership approach would be for the Moose Hill Reservoir treatment plant. The parcel being considered for the treatment plant is owned by the Commonwealth, therefore the use of this property by the Town needs to be discussed with the Department of Conservation and Recreation (DCR) and the Article 97 implications need to be understood. Procuring this land, either through a lease arrangement or fee ownership, will require an Act of the Legislature, will likely add significant costs to the project and require at least a couple of years to complete. The Town would have to complete some preliminary environmental due diligence to identify if the reservoir and the potential treatment plant site are vulnerable to any nearby environmental hazards such as oil and hazardous material release sites, landfills/junkyards, or other sites/facilities of environmental concern.

As part of the concept-level design planning the specific treatment and infrastructure needs for this program would be identified in more detail then developed in this feasibility study, their associated capital and operating costs would be revisited. These costs would be used as the basis for developing a more refined understanding of what the financial burden would be to the community, and what various cost-allocation scenarios would translate into for property owners.

A third aspect of this initial planning phase would consist of developing a strategy for enjoining the three existing water districts together with the rest of the community to establish a Town-wide system. Gaining a general agreement between the three districts on how this is to be achieved will be central to whether a Town-wide water system can be implemented.

During this time a series of meetings would be recommended to discuss the project among the various Town Boards, Departments and committees that would be involved in the permitting, construction, and operation of the water system. This would also include discussions with the sewer districts regarding management of the treatment residuals. Similarly, preliminary meetings should be held with the State regulatory agencies to confirm the regulatory pathway for program elements such as land acquisition, new surface water source approval, water management

It is anticipated that during the first two years there would be an extensive public outreach program, the purpose of which would be to educate the community on the water management program that is being considered, solicit concerns and feedback on the program, and to gauge the public's interest in moving forward. We would anticipate that this initial planning and public information phase would culminate in a Town Meeting article that solicits the Town's interest in proceeding, and providing the funding necessary for the next implementation steps.

Years 3 and 4

The focus of Years 3 and 4 would likely be on land acquisition, and moving through the Article 97 Land Disposition Process with DCR and the Executive Office of Environmental Affairs. Acquiring land through Article 97 requires that a detailed land appraisal be performed by DCR, review through the Massachusetts Environmental Policy Act (MEPA) process and, as described above, approval by an Act of the Legislature. This process is conservatively estimated to require a minimum of two years to complete and could take longer. It is recommended that the subsequent design and permitting phases of the treatment plant and infrastructure improvements be taken in measured steps until there is assurance that the land acquisition process will be successful.

Years 5, 6 and 7

The next phase of the water system development would consist of the initial design and permitting activities, including the DEP New Source Approval process for the surface water reservoir. The process for applying for new source approval is outlined in Chapter 3 of DEP's Guidelines and Policies for Public Water Systems. Meeting with DEP early on in this phase is recommended to DEP to confirm the specific aspects of their permit program that will apply to the project, and would likely be similar to those outlined in DEP's November 2008 letter to the Moose Hill Commission. The new source approval process would be supported by the previously completed system planning task, and would be supplemented with data of the raw water quality that would be used as the basis for developing the water quality goals for the treatment plant, and identifying the treatment technologies necessary for achieving these goals.

Pilot testing of these technologies is required as part of DEP's New Source Approval process, and would need to be conducted over two seasons (summer and winter) to evaluate their performance under a variety of seasonal and water quality conditions. This pilot testing phase requires up to 15 months to complete, following which the infrastructure design can be performed in parallel with the New Source Approval process.

Project permitting, including the Massachusetts Environmental Protection Act (e.g. Environmental Notification Form and Environmental Impact Statement), the Water Management Act and its associated Sustainable Water Management Initiative, and the Interbasin Transfer Act would be undertaken as the design progresses. The complexity of these permitting programs to the project will in part be a function of the competing uses of the watersheds that contribute to the Moose Hill Reservoir with other water supply uses and the natural resource characteristics of these watersheds. This effort would include discussions with the Town of Spencer in regards to its Shaw Pond water supply, which is located upstream of Moose Hill, and the Sudgen Reservoir, which is located downstream of Moose Hill.

The design approvals from DEP include those for the construction of a treatment plant greater than 1 MGD (BRP WS 24) and distribution system modifications for systems that serve more than 3,300 customers (BRP WS 32). Modifications to the dam at Moose Hill Reservoir, which could be necessary, would be subject to the review and approval of the Massachusetts Office of Dam Safety, a division of DCR. The intake structure at the reservoir will be subject to additional approvals by the U.S. Army Corps of Engineers and the DEP. At the local level, the project will

require approvals from the Town's Conservation Commission for wetlands protection, Building Department for building code, and Planning and Zoning for site plan approval.

Overall, it is estimate that this permitting and design phase will take approximately 3 years to complete.

Years 8, 9, and 10

After receiving all the necessary local, state, and federal permit approvals, the final phase of the project would begin with the bidding of the project. The water treatment plant would be bid in accordance with the requirements of Massachusetts General Laws Chapter 149 and, because it exceeds cost thresholds under this law (construction projects greater than $10 Million), the bidding will involve pre-qualification of contractors, selection of an Owner's Project Manager (OPM) (for construction projects greater than $1.5 Million), and filed sub-bid categories of applicable building trades such as masonry, electrical, and plumbing (for those aspects of the project that require sub-trade construction with costs greater than $25,000). The OPM must be designated early in the project so as to oversee the project from design and permitting through bidding, construction, and commissioning.

Given the breadth of these requirements involved in the bidding of the project, a total of 9 months is provided for the bidding phase to be completed. Following completion of the bidding and award of the project, it is estimated that construction of the water treatment facility, transmission mains, and water storage tank would be completed over the course of two years. Final start-up and commissioning of the water treatment plant would be expected to take up to 3 months following completion of construction.

5. ***Summary and Recommendations***

The 2017 Feasibility Study Update has evaluated the potential capital and operation costs associated with developing the Moose Hill Reservoir Water Treatment Plant and its appurtenant distribution system improvements. The capital cost estimates have been escalated from 2017 to 2025 to be consistent with the program implementation schedule that estimates the start of construction in 2025. The capital cost estimate provides the Town with a planning level estimate to consider as the feasibility of the project is evaluated further with the objective of the Town making a go/no go decision within the next 12 months. The capital cost estimate is qualified by various assumptions and includes a conservative contingency of 35% for construction costs in light of the project uncertainties and early stage of planning. The cost estimate would be revised throughout the program as these uncertainties are eliminated. Overall the capital cost of the 1.5 MGD surface water treatment plant and distribution system improvements are summarized in Table 6.

Table 6.
Project Capital Cost Estimate Summary, as prepared in 2008, for 2017 and extended to 2025 (assumed construction start date).

Item	Description	2008 Capital Cost Estimate	2017 Capital Cost Estimate	2025 Capital Cost Estimate
1A	1.5 Million Gallon Per Day (MGD) Surface Water Treatment Plant	*$4,500,000*	**$10,230,000**	***$14,000,000***
1B	Land Acquisition and Site Specific Development Costs	*Not Specified*	**Not Included**	***Not Included***
2	5,500 Linear Feet of 16" Ductile Iron Finished Water Transmission Main	*$1,375,000*	**$1,790,000**	***$2,450,000***
3	500,000 Gallon Elevated Water Storage Tank	*$1,530,000*	**$2,070,000**	***$2,830,000***
4	Surface Water Intake 500 Linear Feet of 16" HDPE Pipe	*Not Included*	**$600,000**	***$820,000***
5	5,500 Linear Feet of 4" PVC Residuals Force Main to Sanitary Sewer and Residuals Pump Station	*Not Included*	**$1,450,000**	***$1,980,000***
	Sub-Total	*$7,405,000*	**$16,140,000**	***$22,080,000***
	Engineering Services - Design, Procurement, and Construction Services	*$1,481,000*	**$4,040,000**	***$5,520,000***
	Public Outreach and Permitting Services	*Not Specified*	**$750,000**	***$750,000***
	Total	*$8,886,000*	**$20,180,000**	***$27,600,000***

Note: Refer to Table 3 or Section 3 of this report for a summary of key assumptions/methods used in developing the cost estimate.

As shown in Table 6, the capital costs are significant. These estimated costs were compared to several recently-completed surface water treatment plant projects from the past ten years that have parallels to that for the Moose Hill Water Treatment Plant, translated into units of dollars per million gallons per day of treatment capacity for each facility, shown in Table 4. In general, the Moose Hill facility's estimated cost ($6.82 Million per MGD) is slightly above the high range of the costs of the other treatment plants ($6.48 Million per MGD), but when accounting for the 35% contingency the project falls within the range of the recent projects.

The potential operating costs for the 1.5 MGD facility have been estimated based upon WhiteWater's experience at several local surface water treatment plants. The estimated annual operating cost in 2025 is $796,072 for the 1.5 MGD Moose Hill facility.

The program implementation plan and schedule encompasses an estimated total of ten years to complete the project planning, permitting, design, bidding, and construction. The key preliminary planning measures are focused on three key elements: 1. developing consensus among project stakeholders as to whether it is in the Town's best interest to develop Moose Hill as a public water supply; 2. Identifying the land ownership opportunities for the treatment plant site at the Moose Hill Reservoir; and 3. Beginning public outreach to educate the community about the Town's water management structure and challenges.

The key regulatory provisions associated with project permitting are:

- **DEP New Source Approval Process (310 CMR 22.00, BRP WS 17)** — Multi-step process including preliminary planning, a site examination, and a final report including supporting documentation on water system planning, proposed infrastructure improvements, surface water quality, water system governance, project schedule, and cost estimates for capital and operation costs.

- **DEP Water Management Act Permit (310 CMR 36.00, BRP WM 030)** – As part of the new source approval process the Town would need to complete a permit application for the authorized withdrawal of more than 100,000 gallons per day of surface water from the Moose Hill Reservoir. This effort would be coordinated with the new source approval process and include provisions for compliance with the Sustainable Water Management Initiative (SWMI), which were created in 2010.

- **Interbasin Transfer Act (313 CMR 4.00)** – The Moose Hill Reservoir may be subject to the requirements of the Interbasin Transfer Act (IBTA) due to the transfer of water between river basins. The reservoir is located within the French River basin. The Town of Leicester's three sewer districts discharge wastewater to the French and Blackstone basins. The applicability of the IBTA to the project should be determined through discussions with the Massachusetts Water Resources Commission as certain exemptions may be applicable to the project depending on the volume of water withdrawals, supply of water outside the Town boundaries, continued use of withdrawals from sources in other basins, and potential for increases in the volumes of discharges to other basins.

- **Massachusetts Environmental Protection Act Regulations (301 CMR 11.00)** – The project would require submission of an Environmental Notification Form (ENF)

identifying the project's potential environmental impacts in regards to categories including land development, water supply/treatment, wastewater, and resource protection. The potential for an interbasin transfer in excess of 1 MGD would be the regulatory threshold that would trigger the mandatory Environmental Impact Report (EIR). The regulatory framework and scope of an EIR would be outlined in the State's response to the ENR.

- **Wetlands Protection Act (310 CMR 10.00)** – The project would likely include both temporary and permanent disturbance to regulated wetland resource areas, which would require filing of a Notice of Intent with the Leicester Conservation Commission. Depending on the scale of any construction within the Moose Hill Reservoir, a supplemental filing for a 401 Water Quality Certification (BRP WW 07 or BRP WW 08) with DEP may be required depending on the volume of dredging required within the reservoir.

- **Army Corps of Engineers (Section 404 of Clean Water Act)** – The project's raw water intake structure would potentially require filing a permit application with the Army Corps of Engineers (ACOE) under Section 404 of the Clean Water Act. The scope of the Section 404 application and any required mitigation activities would be determined through discussions with the ACOE. This effort would be coordinated with the DEP Water Quality Certificate and Wetlands Protection Act filings.

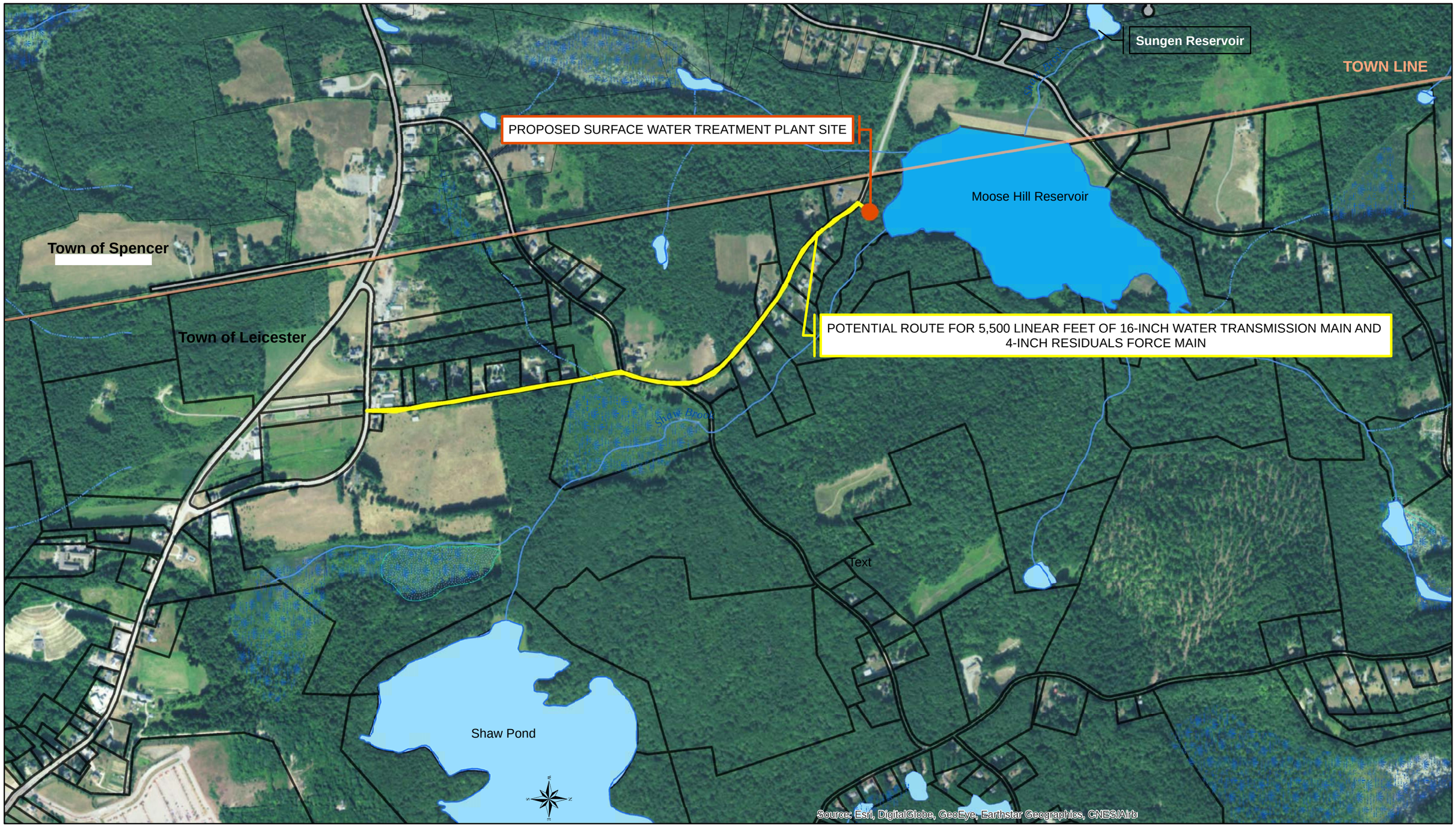
Based upon the update of the Moose Hill Reservoir Feasibility Study, WhiteWater and Environmental Partners make the following recommendations for the Town to consider implementing over the course of the next 12 months:

1. Solicit feedback on Feasibility Study Update from Moose Hill Reservoir stakeholders including representatives from the Town administration, Moose Hill Commission, and the Town's water/sewer districts.
2. Begin public outreach program by hosting a public info session to discuss the Town's current public water system organization, capital improvement programs, and regulatory challenges.
3. Determine the ability of the Town to secure property at Moose Hill Reservoir through the Article 97 process, and the associated cost and timing implications.
4. Begin preparing a Town-wide water system master plan that evaluates the development of Moose Hill Reservoir, investment in current public water systems (LWD, HWD, CVRWD), and development of alternative water supplies (e.g. new groundwater sources, purchase of water from City of Worcester or other adjoining water systems) as potential solutions to addressing the Town's water management challenges. The water system master plan should also evaluate the capital needs of the Town's existing three water districts, and the governance structure of a Moose Hill water system that is either independent of or integrated with some or all of the Town's other water systems.
5. Complete a baseline financial analysis evaluating the cost allocation alternatives (e.g. water rates, betterments, or municipal tax base) for funding the development of the Moose Hill water treatment plant and infrastructure improvements.
6. Host a meeting with representatives from the Massachusetts Executive Office of Energy and Environmental Affairs to discuss the regulatory pathway for developing Moose Hill

Reservoir as a public water supply including the Article 97 process, New Source Approval, MEPA process, Interbasin Transfer Act, and Water Management Act.

7. Make go/no-go decision of proceeding with additional master planning activities based upon feedback from project stakeholders and general public.
8. Continue developing the Town's relationship with Massachusetts Water Resource Outreach Center to identify opportunities for sponsoring additional research into water management including Moose Hill water quality studies, water system master planning, and water resource mapping and assessment.

Figures



1 inch = 800 feet

0 1,050 2,100 4,200 Feet

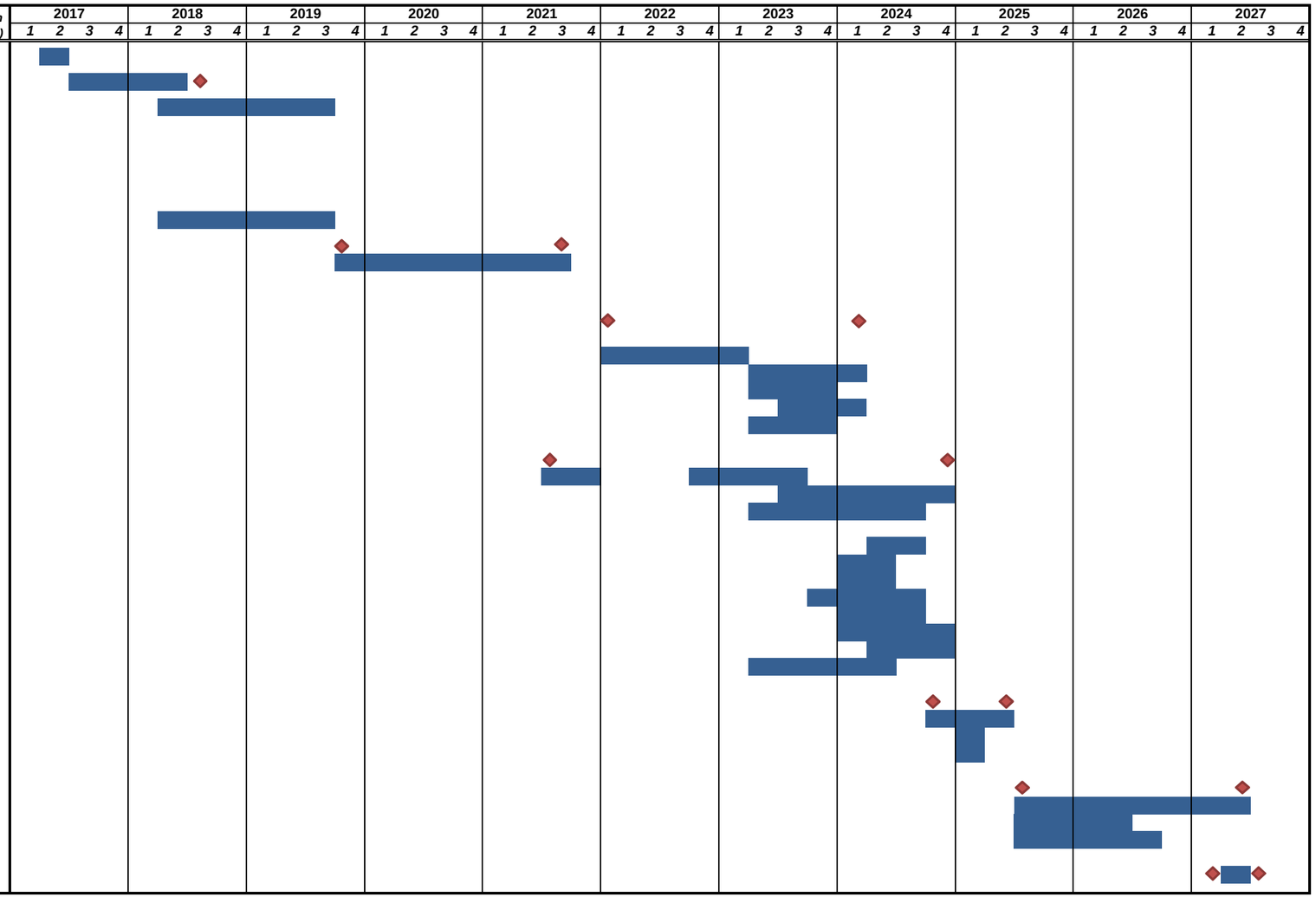
Environmental Partners GROUP

FIGURE 1: LOCUS MAP
PROPOSED MOOSE HILL RESERVOIR WATER SYSTEM IMPROVEMENTS
LEICESTER, MA

Town of Leicester
Moose Hill Reservoir Feasibility Study
Figure 2 - Implementation Program and Schedule

Version: July 2017

Project Task	Notes	Duration (months)
Feasibility Study		3
Town Go/No Go Decision		12
System Planning	1,2	18
System Master Planning and Alternatives Analysis		
Preliminary Design and Capital Needs		
Financial Planning and System Proforma		
Governance Structure		
Cost Allocation		
Public Information/Participation and Authorization		18
Land Ownership/Easement/Lease for Moose Hill Reservoir Parcel	3	24
DCR Property - Article 97 Land Disposition Process		
EEA Appraisal, MEPA Review, EEA Secretary Approval		
Legislative Action		
System Design		
Treatment Plant		
Pilot Studies	4	15
Treatment Plant Design		12
Intake Infrastructure		9
Transmission Mains		9
Storage Tank		9
Permitting (DEP, Mass DOT, Conservation Commission)		
DEP New Source Approval for Moose Hill Reservoir	5	27
MEPA - Expanded ENF, EIR	6	18
DEP Water Mgmt. Act	7	18
DEP Construction and Final Approvals		
Treatment Plant with Intake		6
Transmission Mains		6
Storage Tank		6
US Army Corps of Engineers - Individual Permit	8	12
DCR Office of Dam Safety	9	9
Mass DOT	10	12
Wetlands Protection Act - Conservation Commission NOIs		9
DEP Interbasin Transfer Act	11	15
Bidding		
Treatment Plant with Intake	12	9
Transmission Mains		3
Storage Tank		3
Construction		
Treatment Plant with Intake		24
Transmission Mains		12
Storage Tank		15
System Startup & Testing / WTP On-line		3



Notes:	
1	Identify system sources (retain wells; decommission wells) and integration of Leicester Water District, Hillcrest Water District, and Cherry Valley & Rochdale Water District
2	Incorporate Sanitary Survey and Unilateral Order requirements of LWD, Hillcrest WD and Cherry Valley & Rochdale WD into system planning to identify additional distribution system improvements
3	Need to determine status of Leicester's land rights at Moose Hill Reservoir and DCR involvement
4	Requires warm-weather and cold-weather piloting
5	Includes Request for Site Exam, hydrogeological study, bathymetry survey, modeling of water level drawdowns
6	Includes endangered species (MESA) and historic/archaeologic (Section 106) assessments
7	Assumes no increase in overall withdrawals, but Water Mgmt. Act permit may be need to be modified due to change in sources. To be determined.
8	For intake structure in Moose Hill Reservoir
9	Required if dam at Moose Hill Reservoir is modified
10	For transmission mains on State Roads
11	Interbasin Transfer Act is triggered if Leicester properties connected to Town-wide water system, served by Moose Hill Reservoir, are connected to sewer districts outside of Leicester (ex: Oxford-Rochdale) and results in a flow increase to those sewer districts.
12	Includes pre-qualification of Contractors, filed sub-bids, General Contractor bids