Collaborative Options to Improve Drinking Water Quality in Western Boxborough, MA

Possibilities for Implementing Community Based Water Approaches in the western portion of Boxborough, Massachusetts.

An Interactive Qualifying Project submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree of Bachelor of Science.

https://wp.wpi.edu/wroc/collaborative-solutions-to-improve-drinking-water-quality-in-boxborough-ma/

Submitted by:

Michael McGoff
Katherine Vasconcelos
Spencer Vinson
Jacob Wisniewski

Submitted to:

Marielle Stone, Massachusetts Bureau of Water Resources
Robert Bostwick, MassDEP Drinking Water Section Chief
David Boyer, MassDEP Wastewater Section Chief
Laurene Poland, Massachusetts Department of Transportation – Highway Division

Professor Glenn Gaudette, WPI Project Advisor
Professor Scott Jiusto, WPI Project Advisor

April 28, 2019

Abstract

Stakeholders in western Boxborough, Massachusetts face serious water quality challenges due to drinking water contamination from road salt and wastewater discharge. The MassDEP and MassDOT are seeking a collaborative water solution to address these concerns. The goals of this project were to help research possible solutions and create public outreach materials for affected stakeholders to explain possible courses of action and facilitate collaboration. Collaborating with the town of Littleton to drill a new well and extend their water system into Boxborough was identified as most feasible. The project resulted in framework for stakeholders to continue to work towards finalizing a plan for collaborating with Littleton to help remediate water issues.

Acknowledgements

This Interactive Qualifying Project would not have been possible without the efforts and help of many people. We would like to thank:

- Professor Scott Jiusto and Professor Glenn Gaudette, our project advisors, for their feedback, guidance, and encouragement throughout the past fourteen weeks.
- Our sponsors, Marielle Stone from the Massachusetts Department of Environmental Protection and Laurene Poland from the Massachusetts Department of Transportation, who helped us understand drinking water, wastewater, and stormwater issues on a statewide and town-specific level.
- David Boyer, the Massachusetts Department of Environmental Central Massachusetts Wastewater Section Chief and Robert Bostwick, the Massachusetts Department of Environmental Protection Central Massachusetts Drinking Water Section Chief for their insight and first-person experiences of wastewater and drinking water regulations and management.
- Leslie Fox and Bryon Clemence, Boxborough Water Resource Committee Members, for their insight into collaborative water solutions and help conducting a Focus Group with Boxborough stakeholders.
- Corey Godfrey, an environmental engineer from the Littleton Electric Light and Water Departments
- Juliet Swigor, the GIS Mapping Coordinator for the Central Region Massachusetts Department of Environmental Protection

Executive Summary

Boxborough, a rural town between Boston and Worcester, consists of roughly 5,546 people (Towncharts.com, 2016). Currently, Boxborough has no municipal public water systems and is run entirely through privately-owned wells and public water supplies. Both immediately and over time, many problems can arise from these systems. Currently, the intersection of Routes 495 and 111 contains 18 Businesses with drinking water wells located too close to wastewater systems and stormwater infrastructure. As a result, this portion of Boxborough is at a significant risk for major water issues and water-related health and environmental dangers. Raising awareness of the cost benefits, providing potential cooperative water options, and emphasizing health and safety to these businesses might encourage them to work together to create a community-based water system to help solve their water issues (Hinlein, E., Stone, M., and Poland, L., personal communication, January 30, 2019).

The Massachusetts Department of Environmental Protection (MassDEP) and the Massachusetts Department of Transportation (MassDOT) were motivated to work together on this project through their mutual concern of the health and well-being of Boxborough residents. While the MassDOT does provide aid for contaminated drinking water due to high salt levels from MassDOT operations through the Salt Remediation Program, the solutions provided do not solve the immediate danger of contaminated drinking water (Poland, L. personal communication. March 20, 2019), and they only focus on stormwater issues. In addition, many of the western businesses are up for wastewater system permit renewals in 2019, and their current systems would need to be updated in order to comply with new regulations. These government bodies were concerned that Boxborough's current water issues could escalate. By creating a community-based water system in Boxborough, these branches would be able to better monitor water infrastructure and water quality in the town.

Mission, Objectives, and Methods

The goal of this project was to research various water options that would help improve drinking water quality at the Routes 495/111 intersection in Boxborough, Massachusetts and to create public outreach materials to determine which option was most ideal for stakeholders.

Based on this mission, the following objectives were created:

1. Conduct key informant interviews with involved stakeholders to refine the project scope to determine the best water options to pursue.
2. Create a cost-analysis of possible water options to identify costs and cost-benefits.
3. Develop public outreach materials to explain Boxborough's water issues at the Routes 495/111 intersection.
4. Engage the 18 Businesses in a Focus Group setting to determine their thoughts, concerns, and opinions on each water option.

To refine the project scope and create a cost-analysis, involved stakeholders were interviewed to understand the current water issues at the Routes 495/111 intersection in Boxborough, if the implemented solution should focus on drinking water, wastewater, or stormwater, and what the costs of possible water options were. Through research from interviews and MassDEP reports, a

public outreach presentation was created to show to the 18 Businesses during a Focus Group in week 6 to get their feedback regarding this project and discuss which water option would be most feasible for them to implement.

Outcomes

There were two main outcomes from this project:

1. Public Outreach Materials: Two sets of public outreach materials were created. The first was a Focus Group PowerPoint that gave an overview of water systems, water concerns, possible options, and next steps that was meant to be shown to representatives of the 18 Businesses that were able to attend a Focus Group help during week 6. The second set of outreach materials were fliers advertising the MassDOT's Salt Remediation Program.
2. Cost Analysis Spreadsheets: A cost analysis for the possibility of collaborating with Littleton to extend their drinking water system into Boxborough was also created. We focused on how costs could be distributed among the 18 Businesses.

Findings

Based on our research, the following findings were pursued:

1. There are three possible drinking water options that could be implemented: the Do it Yourself Option, collaborating with Littleton, and finding another water supplier.

From key informant interviews, we found that many stakeholders had already begun to discuss possible water options for the 18 Businesses. The three most realistic options were the Do it Yourself Option, where the businesses and living communities fix their own problems, collaborating with Littleton, where Boxborough would connect to the Littleton water system, or finding a new water supplier, where the 18 Businesses could create their own water entity.

2. There is an opportunity for better communication amongst involved stakeholders.

Many of the stakeholders that were interviewed either had different understandings of the drinking water, wastewater, and stormwater concerns at the Routes 495/111 intersection or did not know where discussed solutions currently stood.

3. The MassDOT Salt Remediation Program is underused.

For businesses and living communities with high drinking water salt levels, the MassDOT offers a Salt Remediation Program for those that have been affected by MassDOT winter operations.

4. While the western portion of Boxborough has been hit the hardest with stormwater, wastewater, and drinking water issues, they could become a community-wide problem.

Many of the Focus Group attendees were concerned that high salt levels would begin to spread throughout the entire town of Boxborough, calling for the need for all of Boxborough to need to relocate drinking water sources.

5. Collaborating with Littleton is the best option.

Based on the consensus of the focus ground attendees, they felt that collaborating with Littleton to extend their water system into Boxborough was the preferred option as they felt solving problems individually or finding a new water supplier were not realistic.

Evaluation Factors:	DIY	Littleton	Other Supplier
Water Supply			
Improves water quality for consumption		x	x
Adds system redundancy		x	
Removes need to operate individual Public Water Supply		x	x
Decreases cost for water over time		x	
Water Distribution			
Create and manage a water distribution system			x
Leave water distribution to another entity		x	
Stormwater Concerns			
Mitigates road salt contamination		x	x
Mitigates salt contamination from salt storage facility		x	x
Mitigates salting of other impervious surfaces, like parking lots		x	
Wastewater Discharge			
Reduces risk of toxins in water supply		x	x
Maintains existing permit limits	x		
Reduces wastewater facility standards and costs		x	x
Regulatory Issues			
Increases risk for more stringent permits	x		

Table 1: Qualitative analysis of drinking water options

6. The Water Resources Committee is ready to continue working towards collaborating with Littleton and will take the lead.

At the conclusion of the Focus Group, the Water Resources Committee planned to lead the process going forward.

Recommendations

Based on our findings, the following recommendations were devised:

1. The 18 Businesses should form a Working Group with the Water Resources Committee to pursue the Littleton Option.
2. The 18 Businesses should all apply soon to the Salt Remediation Program.
3. Find other towns that have a similar issue to Boxborough and use Boxborough as an example to encourage them to work together.

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

Boxborough, a rural town between Boston and Worcester, consists of roughly 5,546 people (Towmcharts.com, 2016). Currently, Boxborough has no municipal public water systems. Businesses, companies, schools, government buildings, and homeowners have their own private wells, private public water systems, and private sewage systems to serve their individual needs. Both immediately and over time, many problems can arise from having private wells, including improper well design and construction, incomplete well development, borehole stability problems, incrustation build-up, biofouling (the creation of a thick, irregular layer of slimes and biofilms on a wellbore), corrosion, aquifer problems, and over-pumping (Biology Dictionary Editors, 2017). All these potential problems with private wells can leave businesses or families without clean or safe water for days and in some cases weeks at a time (Nmarowitz, 2018).

Currently, the intersection of Routes 495 and 111 contains many businesses and residential living communities with water supply and wastewater systems that are located too close to one another (Hinlein, E., Stone, M., and Poland, L., personal communication, January 30, 2019). As a result, this portion of Boxborough is at a significant risk for major water issues and water-related health and environmental dangers. Some businesses currently add extra chemicals to purify their water while others need to build an expensive, new purification system to rid their water of organic carbons (Boyer, D., personal communication, March 21, 2019). Many wells have high sodium chloride levels due salt-filled stormwater runoff from the high number of impervious surfaces at the routes 495/111 intersection. Sodium chloride is corrosive, leading to the risk of lead contamination of groundwater supplies through corroding pipes. Furthermore, Boxborough's small population makes financial resources to update its water systems limited and businesses along this intersection are hesitant to spend money to update their own systems even though there are inherent health risks. Raising awareness of the cost benefits, providing potential cooperative water options, and emphasizing and health and safety to these businesses might encourage them to work together to create a community-based water system (Hinlein, E., Stone, M., and Poland, L., personal communication, January 30, 2019).

Since 1974, the United States government has enforced the Safe Drinking Water Act to ensure drinking water quality in the United States is safe (US EPA, O.A., 1986). In addition, Massachusetts has enacted a Water Management Act Program to prevent the overdrawing of water supplies as well as an Industrial Wastewater Program to ensure that any wastewater with health-related contaminants is properly disposed (MassDEP, 2019a). The Massachusetts Department of Transportation (MassDOT) offers a Salt Remediation Program to support businesses in Boxborough that have been heavily impacted by the MassDOT's highway sodium chloride operations and their Boxborough salt storage facility operations. To try to solve the stormwater, wastewater, and drinking water issues in Boxborough, community-based water options were analyzed. Three possible options were found to be most feasible: each business individually solving their own issues, collaborating with Littleton to use their water system, or finding a new water supplier located outside of the affected area.

The Massachusetts Department of Environmental Protection (MassDEP) and the MassDOT were motivated to work together on this project through their mutual concern of the health and well-being of Boxborough residents. The solutions provided by the MassDOT through the Salt Remediation Program do not solve the immediate danger of contaminated drinking water

(Poland, L. personal communication. March 20, 2019), and they only focus on stormwater issues. In addition, many of the western businesses are up for wastewater system permit renewals in 2019, and their current systems would need to be updated in order to comply with new regulations. These government bodies were concerned that Boxborough's current water issues could escalate. By creating a community-based water system in Boxborough, these branches would be able to better monitor water infrastructure and water quality in the town.

This project created public outreach materials for involved stakeholders to explain the current water problems they are facing and to present them with possible water system options they could pursue. Since a drinking water solution was deemed the best approach, a key aspect of the outreach materials was a basic cost-analysis of each drinking water option that the western portion of Boxborough could pursue. To create these materials, interviews with multiple stakeholders were conducted to understand the drinking water solutions that were currently being researched for this area. A preliminary cost analysis report was also composed to begin to consider the costs involved in each possible option that was researched. Finally, a Focus Group composed of businesses along the Routes 495/111 intersection was brought together to present the problem, possible options, and associated costs to gather feedback and encourage collaboration.

This report is divided into seven chapters. In Chapter 2, types of water, water regulations, and the town of Boxborough are discussed. Chapter 3 explores the project objectives and associated methodology that was completed throughout this project. In Chapter 4, research findings from Focus Group opinions are explored. Lastly, Chapter 5 gives recommendations for what Boxborough should plan to do next.

Definitions and Abbreviations

18 Businesses: The key 18 businesses and living communities that are within this project's area of interest at the intersection of Routes 495 and 111, listed in full in section 2.4.3.1.

Aquifer: An underground reservoir of water ("Municipal Water Use", 2005).

CDC: Center for Disease Control and Prevention

Community Water System: A type of public water system that supplies water to consumers year-round. It serves either at least 25 people at their primary residences or at least 15 residences that are considered to be primary residences (for example, municipalities, sub-divisions, mobile home parks) (CDC, 2018b).

Drinking Water: Water that is safe and clean for human consumption and passes Massachusetts water regulations.

EPA: Environmental Protection Agency

Groundwater: Water that is held underground in the soil or in pores/crevices of rocks.

MassDEP: Massachusetts Department of Environmental Protection

MassDOT: Massachusetts Department of Transportation

Municipal-Based Water: A water system, such as the one used in Worcester, MA, that supplies water to residents through piping; it is regulated by the same pre-set list of regulations and owned by the city or town (Bostwick, R., Boyer, D., and Stone, M., personal communication, February 11, 2019).

Non-transient community water system: A water system that serves a building of residence, like an apartment complex. It serves the same community that lives there year-round (Bostwick, R., Boyer, D., and Stone, M., personal communication, February 11, 2019).

Non-transient noncommunity water system: Water that serves a workplace; it involves a group of people that is at a building or place for a large period of time (such as a 5-day work week) but they do not live at the building the water serves (Bostwick, R., Boyer, D., and Stone, M., personal communication, February 11, 2019).

Private Well: A water system, not regulated by the EPA, that contains less than fifteen service connections, serving an average of about twenty-five people. Owners are responsible for making sure the water is safe and filtered (Bostwick, R., Boyer, D., and Stone, M., personal communication, February 11, 2019).

Public Well: Pumped from groundwater; able to provide and serve large amounts of people's drinking water. Decreases contaminant concentrations below levels of potential human-health concern (Bostwick, R., Boyer, D., and Stone, M., personal communication, February 11, 2019).

PWS: Public Water System; a water system that provides water for human consumption through pipes that must serve at least 25 people for at least 60 days a year. May be publicly or privately owned (EPA, 2015).

Sewage: Structures that allow overloaded systems to flow into rivers, lakes, or coastal areas.

Stormwater: Water runoff from rain or snow.

Transient community water system: A water system that serves an establishment that does not have the same set of people that frequent it, such as a restaurant (Bostwick, R., Boyer, D., and Stone, M., personal communication, February 11, 2019).

WRC: Water Research Committee

Wastewater: Typically, water that comes from residential or domestic areas. Usually is collected from activities such as: bathing, cooking, doing laundry, bathroom sewage, and industrial uses (NYWEA, 2013).

Wastewater Treatment Facility: Regulates discharges from treatment plants, industrial facilities, sewers, and other sources. These facilities make sure all septic systems are safe from pollutants and properly tested (Simms, 2006).

Chapter 2: Background

Background Introduction

Boxborough is a small, rural town located between Boston and Worcester. The eastern portion of town contains many single-family homes while the western portion of town, at the Routes 495/111 intersection, has Boxborough's businesses and residential condo communities. However, the water infrastructure in western Boxborough was built before stricter regulations were set by the MassDEP. The current infrastructure, while grandfathered in, does not meet today's standards and poses health and environmental risks. In addition, as more research is conducted, regulations and technology continue to change, only making the current infrastructure more outdated as time passes. To understand why current systems, pose a threat, it is important to understand how different types of water interact.

Drinking water, wastewater, and stormwater are the three key types of water that factor into this project. In Section 2.1, each type of water system is defined. Section 2.2 highlights the types of water regulations in the United States and in Massachusetts. Section 2.3 introduces different types of water management regulations for drinking water, wastewater, and stormwater and how these management types might apply in Boxborough. Section 2.4 outlines this project's area of interest within the town of Boxborough. Finally, Section 2.5 briefly reviews possible drinking water options that could be implemented in this area to help remediate drinking water quality issues.

Section 2.1: Types of Water Systems

The three types of water that affect this project are drinking water, wastewater, and stormwater. Both wastewater and stormwater contaminants affect drinking water quality, leading to the risk for water-borne illnesses and health consequences. The following sections distinguish between and give an overview of each type of water.

Drinking water is what an individual consumes every day. Since many people drink tap water, they also use their drinking water for cooking, bathing, and daily housekeeping actives, such as watering plants.

Drinking water is subject to many regulations and laws to ensure that it does not pose a threat to health. It needs to be put through a filtration system in order to be passed as drinking water for human consumption. Water testing should be conducted by the state or by well owners to analyze drinking water for contaminants and to test if any additional contaminants emerge as people consume it over a longer period (Nmarowitz, 2016).

Wastewater is collected water that has been used in homes and businesses. In homes, wastewater is collected from activities such as bathing, using the toilet, washing dishes, and doing laundry. Commercial wastewater originates from businesses and companies such as car shops, beauty salons, or furniture refining. While all wastewater must be treated, commercial wastewater is taken into special consideration as it is laden with more contaminants. Even after treating commercial wastewater, it cannot be recycled into land or be used for irrigating lawns, filling a pond, or dumped in a cesspool (UNL Water, 2019).

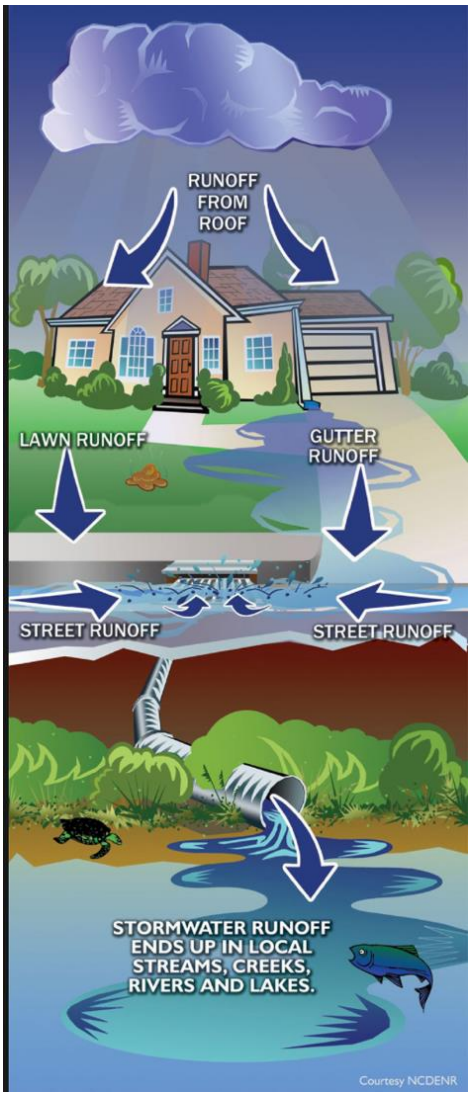

Figure 1: Diagram demonstrating stormwater runoff and where it goes (Beckley Sanitary Board, 2016).

Stormwater is defined as water runoff from rain or snow. When it rains or snows, stormwater runoff becomes the stormwater that does not soak into the ground. Instead, it usually disperses into public drain gutters, streams, lakes, rivers, or creeks. Figure 1 shows the possible pathways that stormwater could follow once it falls from the sky. Stormwater is a major concern as it contaminates water sources with road pollutants and becomes harmful to both humans and aquatic life (Beckley Sanitary Board, 2016).

Section 2.2: Water Regulations

As water often contains many contaminants, it must be treated before it can reach users. The United States, Massachusetts, and Boxborough have all created their own sets of water regulations that must be followed. These laws are enforced by various government agencies and are put in place to protect town residents from health concerns, improve quality of life, and preserve the environment. Regulations exist for drinking water, wastewater, and sewage.

2.2.1: National Water Regulations

Enacted in 1974 by Congress, the Safe Drinking Water Act (SDWA) aims to protect the quality of drinking water in the United States by establishing minimum guidelines for any drinking water source. Every owner or operator of a public water system must comply with the SDWA standards (US EPA, O.A., 1986).

Through the SDWA, the EPA must regulate over 80 water contaminants. This act requires certain surface water systems to filter their water before supplying it to consumers as well as certain groundwater surface systems to use a disinfectant treatment. It also mandated that states must develop laws for protecting land around public drinking water systems to decrease the risk of other contaminants (US EPA, O.A., 2013). These standards mandated a national guideline for all drinking water in order to protect United States citizens from untreated water-born health issues.

2.2.2: Massachusetts Water Regulations

In 1986, Massachusetts released the Water Management Act (WMA). This allows the MassDEP to monitor water quantities withdrawn from surface and groundwater supplies to prevent the overdrawing of water from water supplies so these sources could provide for current and future needs (MassDEP, 2019c).

The WMA created a permit program that states that anyone planning to withdraw an annual average of over 100,000 gallons of water per day or 9 million gallons of water in three months must apply for a WMA Permit. Public water suppliers, golf courses, and industrial users are examples of businesses that generally need to apply for a permit (MassDEP, 2019b).

The MassDEP created its own set of Massachusetts Drinking Water Regulations. These quality regulations protect public water supply sources in Massachusetts by enforcing guidelines that keep drinking water safe for Massachusetts residents. (MassDEP, 2016).

Section 2.3: Water Management Procedures and Treatments

Drinking water, wastewater, and stormwater each have their own sets of water management. However, wastewater and stormwater management systems can both affect future drinking water, making effective drinking water management and treatment imperative. Effective water management will help keep residents healthy and safe from bacteria and chemicals as well as help maintain a robust and healthy environment.

2.3.1: Community Drinking Water Management Treatment Methods

Drinking water sources are easily exposed to contamination and must be treated before being distributed to avoid health related issues. Public drinking water systems use different treatment methods to provide safe drinking water to communities, but the most common steps used by community water systems are coagulation and flocculation, sedimentation, filtration, and disinfection.

Figure 2 illustrates each step in the water filtration and purification process, showing the flow of drinking water from the source, through each of the aforementioned steps, and to its final storage destination.

The first step in water treatment is coagulation and flocculation, which involves the addition of positively charged chemicals to water, where the positive charge will neutralize the negative charge of dirt. This causes the two particles to bind and form large particles called floc.

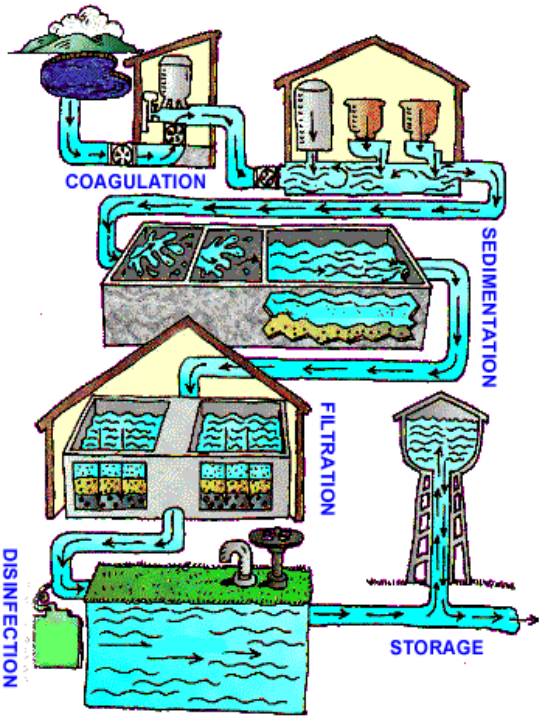

Figure 2: Steps of Drinking Water Filtration (CDC, 2018a)

Sedimentation is the second step in water treatment. During this step, the floc settles to the bottom of the water supply since it is denser then water. A clear water supply is left behind on top of the floc.

The next step is filtration. The clear water passes through sand, gravel, and charcoal filters to remove any extra dissolved particles, dust, parasites, bacteria, viruses, or chemicals.

The final step is disinfection where a disinfectant, like chlorine, is added to the water to ensure that any remaining bacteria is killed. The disinfectant also protects the water from germs as it is piped to its final location (CDC, 2018a).

2.3.2: Wastewater Management

Wastewater management is collecting, treating, and disposing wastewater from various sources. Household uses generally include showering, doing laundry, washing the dishes, teeth brushing, and using the toilet. Businesses and companies generate wastewater from washing machine parts, cleaning the building, completing lab or operation procedures, or other industrial uses (NYWEA, 2013). Most rural areas use decentralized wastewater systems.

Businesses in Boxborough use a decentralized (on-site) wastewater treatment systems to treat and dispose wastewater near its original source (CDC, 2017). They are often used for individual residences, a small group of homes, or a commercial building. Decentralized wastewater treatment systems also include septic systems, which are commonly used throughout the United States in homes and businesses that do not have a centralized wastewater system and lack a

central location to treat collected wastewater. Instead, a septic tank separates solids and liquids. The tank is periodically pumped to remove the solid waste, which will be transported to and treated at an offsite facility. The remaining wastewater is released into a subsurface soil absorption area where bacteria destroys harmful pathogens, rids the wastewater of nutrients, and degrades any solids that were not initially removed. This treated wastewater then moves through the soil into groundwater supplies (Simms, 2006).

Wastewater systems face a few different challenges. First, wastewater in these systems is not uniform. Recently, wastewater from pharmaceuticals has begun to be identified as a concern. Many substances that pharmaceutical companies create are biologically active to allow for uptake in the body. In addition, many are hydrophilic, or water loving, so they can reach their destination in the body without degrading. It is very difficult to purify these substances out of wastewater as they attach to the water molecules and persist through purification treatments. The end result may filter out some of these drugs that entered wastewater through urine, but the ones that remain are usually exceptionally hydrophilic, thus stronger than the rest, and end up in drinking water supplies (Radjenovic, et. al., 2006).

Another issue wastewater systems can face is total organic carbon (TOC). Total organic carbon is the number of carbon-containing compounds in a substance, such as wastewater. If there is a high amount of TOC in a substance, more oxygen is consumed due to an increase in growth of microorganisms. In addition, carbon compounds can be toxic, leading to health concerns (Thermo Electron Corporation, 2003). Due to the dangers of TOC to health, it has become a regulated substance by the MassDEP.

2.3.3: Stormwater Management

Stormwater management is the control and use of stormwater with the goals of protecting the environment, reducing flooding, and protecting stormwater infrastructure (Feehan, 2015). As a community develops, its volume of stormwater increases, thus increasing the need for maintaining a stormwater plan and regulating its collection.

Catch basins, also called storm drains, are circular or rectangular grates found on sides of the street. The catch basins are used to collect stormwater as it runs off of imperviable surfaces. The storm water is then taken for treatment at a stormwater treatment facility, and then released back into the environment.

It is very important to keep storm drains clean and clear from debris or trash. If a pollutant is introduced into the storm drain that is not fit to be treated at the storm water treatment facility, it will be released into the environment and back into the water cycle. (“Stormwater Partners of SW Washington”, 2019)

Section 2.4: Boxborough, Massachusetts

Boxborough, a small, rural town between Boston and Worcester, is the town of interest for this project. According to the most recent demographics data available from the Census Bureau released in December of 2018, the population of Boxborough consists of roughly 5,546 people (Tomcharts.com, 2016). Currently, Boxborough has no public water systems. Businesses, companies, schools, government buildings, and homeowners have their own private wells and

private sewage systems to serve their individual needs. Both immediately and over time, many problems can arise from having private wells, including improper well design and construction, incomplete well development, borehole stability problems, incrustation build-up, biofouling (the creation of a thick, irregular layer of slimes and biofilms on a wellbore) , corrosion, aquifer problems, and over-pumping (Biology Dictionary Editors, 2017). All these potential problems with private wells can leave businesses or families without clean or safe water for days and in some cases weeks at a time (Nmarowitz, 2018). Sometimes, private well owners may not even realize that they have contaminated water since they are not required to regularly test their water.

2.4.1: Boxborough2030: Boxborough's Envisions for the Future

In 2015, Boxborough updated their Master Plan, called Boxborough2030, to reflect the Town and its residents' new goals. From resident surveys, they decided on the overall vision of "a rural, engaged community for all" (Town of Boxborough, 2015a). While residents had multiple objectives and ideas for where they would like to see the town in the next fifteen years, two related directly to water. They wanted the town to plan for long-term water resource management and protection as well as to explore generally improving municipal facilities. In addition, residents hoped for new economic development that would improve overall quality of life, such as gyms, local shops, and restaurants as well as for more moderately priced housing. Creating a community-based water plan could support many of these suggestions.

Boxborough created a detailed action plan to address the town's water concerns. First, they wanted to plan for water resource management and protection by having the Water Resources Committee reconvene, a goal they have already achieved, as well as to plan for long-term water supplies and wastewater management to help both private and municipal entities. Boxborough also hoped to assess the possibility of implementing a public water supply in key areas of the town. Water is a pertinent issue to Boxborough and the town is searching for solutions (MAPC, 2016). In addition, Boxborough created a map, shown in Figure 3, to illustrate its intended future land use as residents had also wanted a village-like area of small shops and restaurants as well as continued development of Boxborough's office parks along Interstate 495 (Town of

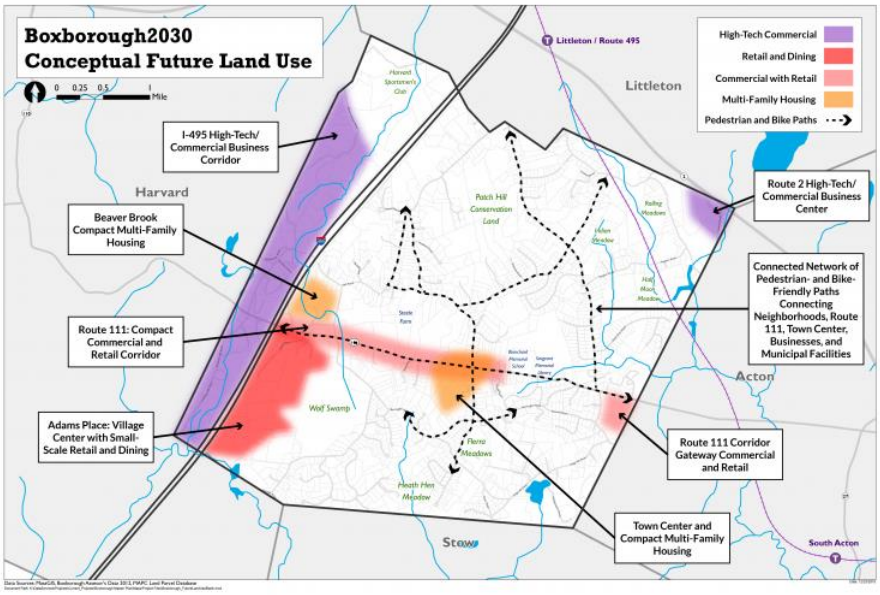

Figure 3: Future land use map of Boxborough (Town of Boxborough, 2013b).

Boxborough, 2013b). Currently, many of the 18 Businesses to be involved in this project are located along 495, leaving Route 111 relatively untouched.

2.4.1.1: Boxborough's Water Resources Committee

Boxborough's Water Resources Committee (WRC) helps the town protect its water resources and they work to meet its long-term water supply needs. The WRC board members try to meet weekly or at least three times a month to discuss the town's goals. The WRC was reinstated in 2016 after Boxborough created its Boxborough2030 plan as a part of Strategy 1.1.4: "Proactively plan for water resource management and protection" (MAPC, 2016). This strategy was created due to residents' wishes to create a plan for long-term water resource management and protection. The main goals of the committee, in accordance with the Boxborough2030 plan, were to "plan for long-term water supply and wastewater management to support private and municipal goals" and to "identify priority areas for receiving a public water supply based on need and feasibility" (MAPC, 2016). To complete these goals, the committee collects and analyzes water data, evaluates water supply needs and potential threats, makes recommendations to town boards and officials, and coordinates plans with various businesses. Occasionally, the WRC will conduct engineering studies by hiring outside experts to help them reach goals decided upon during meetings. All results are reported to the town.

Initially, the committee meetings were private, but as of 2018, the WRC opened their meetings to the residents of Boxborough to gain feedback from the town. On occasion, some businesses and professional water analysts will give their suggestions on what they think Boxborough should do (Town of Boxborough, 2015d).

2.4.2: Boxborough's Current Water Situation

Boxborough does not provide any municipal water or wastewater facilities to its residents. As a result, most of Boxborough's residents and business owners have their own water and septic systems. Most of Boxborough's single-family homes own private domestic wells and septic tanks while businesses and residential developments, like apartments and condominiums, get their water from one of twenty-eight privately owned public water systems scattered throughout the town. While many of Boxborough's 18 Businesses along the Routes 495/111 intersection also have private sewer systems, there is a select grouping that have access to larger wastewater treatment facilities that are regulated by the MassDEP. These businesses include the Boxborough Regency, the Brook Village condominiums, the Codman Hill Road condominiums, the Harvard Ridge condominiums, the Boxborough Meadows housing development, Cisco Systems, and the 80-90 Central Street commercial properties. The library's wastewater facility also collects wastewater from the Blanchard Memorial Elementary School but has the capacity to serve the future need of Boxborough's Fire Station, Police Station, and the Department of Public Waters (which currently have individual septic tanks) (Town of Boxborough, 2015e).

Almost all the water that is available to the town of Boxborough comes from rain that recharges groundwater supplies. Cumulatively, Boxborough receives about 43 inches of rain each year. The town also has ponds and six streams that act as emergency water resources for residents and about a fifth of its geography is composed of wetlands.

Unfortunately, the town's groundwater has tested positively for high levels of iron, manganese, and sodium. These pollutants likely originate from highway stormwater runoff, as Routes 495 and 111 are treated with sodium chloride to help melt snow, as well as from the MassDOT's salt storage facility in Boxborough, which at one point did not have a roof. In turn, the sodium chloride begins to degrade stormwater infrastructure when stormwater runs through storm drains, causing lead to leak into the water and later, into groundwater supplies. Nitrates, pathogens, MTBE, perchlorates, and radiological contaminants have also affected some parts of the town from a blasting zone that was meant to facilitate the construction of a new wastewater treatment plant at a condominium complex (MassDEP, 2005). These contaminants not only concern residents and business owners but also cause the need for water treatments. Unfortunately, many private well owners have been struggling to comply to the MassDEP's drinking water regulations (Town of Boxborough, 2015c).

In addition, in the western part of Boxborough (especially along Codman Hill Road), there are water quality issues due to sodium-chloride runoff from the MassDOT salt storage silo off Swanson Road. This area houses the 18 Businesses for this project and this issue causes them to have to either treat their water with expensive reverse-osmosis systems or buy bottled water (Fedderman, 2015).

2.4.3: Project Area of Interest: Intersections of Routes 495 and 111

Boxborough is roughly bordered by two major limited access highways, with Route 495 running through the western edge of the town, and Route 2 just on the far side of the northern border. Boxborough's main arterial road is Route 111, also known as Massachusetts Avenue, begins in Acton from the east and traverses the entire width of Boxborough, intersecting with I-495 before ending in Harvard to the west. After examining the town of Boxborough for the best possible location for a community-based water system, the MassDEP recognized the Routes 495/111 intersection as the best possible location. According to the MassDEP, there are 18 Businesses that have been invited to participate in this opportunity that are all located around the Routes 495/111 intersection (Hinlein, E. Stone, M., and Poland, L., personal communication, January 30, 2019). A map showing this location can be found in Appendix E: Maps from the MassDEP .

2.4.3.1: Boxborough's 18 Businesses to be Involved in This Project

Table 2 shows the 18 Businesses provided by the MassDEP and MassDOT that will be involved in this project. Bolded company names are companies that attended a preliminary meeting with the MassDEP and MassDOT to discuss this project. Appendix F: Table of the 18 Businesses' Information presents the businesses in a larger table with addresses, contact information, size, and current water challenges, and current water treatments (as the table was too large to include here).

Name	Population	Type of Drinking Water System	Groundwater Discharge Location?
Codman Hill Condominiums	360	Non-Transient Community	x
Harvard Ridge Condominiums	350	Non-Transient Community	x
Brook Village Condominiums	400	Non-Transient Community	x
Boxborough Regency	500	Non-Transient Non-Community	x
LPCH Boxborough, LP	400	Non-Transient Non-Community	x
SYNQOR	100	Non-Transient Non-Community	
Sentra Systems Inc.	278	Non-Transient Non-Community	
Boxborough Executive Center	60	Non-Transient Non-Community	
Express Employment Professionals	150	Non-Transient Non-Community	
60&70 Codman Hill Road	300	Non-Transient Non-Community	
Winstanley Enterprise	40	Non-Transient Non-Community	
altE	150	Non-Transient Non-Community	
Boxboro Green	75	Transient Non-Community	
Mass. Ave Gulf	100	Transient Non-Community	
National Technical Systems	25	Non-Transient Non-Community	
Bright Horizons Daycare	90	Non-Transient Non-Community	
Paddock Estates	724	Non-Transient Community	x
Cisco Systems, Inc.	1,100	Non-Transient Non-Community	x

Table 2: List of Boxborough's 18 Businesses and their current water status (Stone, M. Personal communication. 2019, January 31).

Figure 4 shows the location of each of the 18 Businesses on a map. The map also depicts the locations of each wellhead the 18 Businesses use, the type of well (green for a community well,

red for non-community), zone 1 and zone 2 drinking well protection zones (the blue and purple circles, respectively), and sewer system locations (yellow and white). It clearly shows that sewer systems are within wellhead protection zones, causing drinking water contamination.

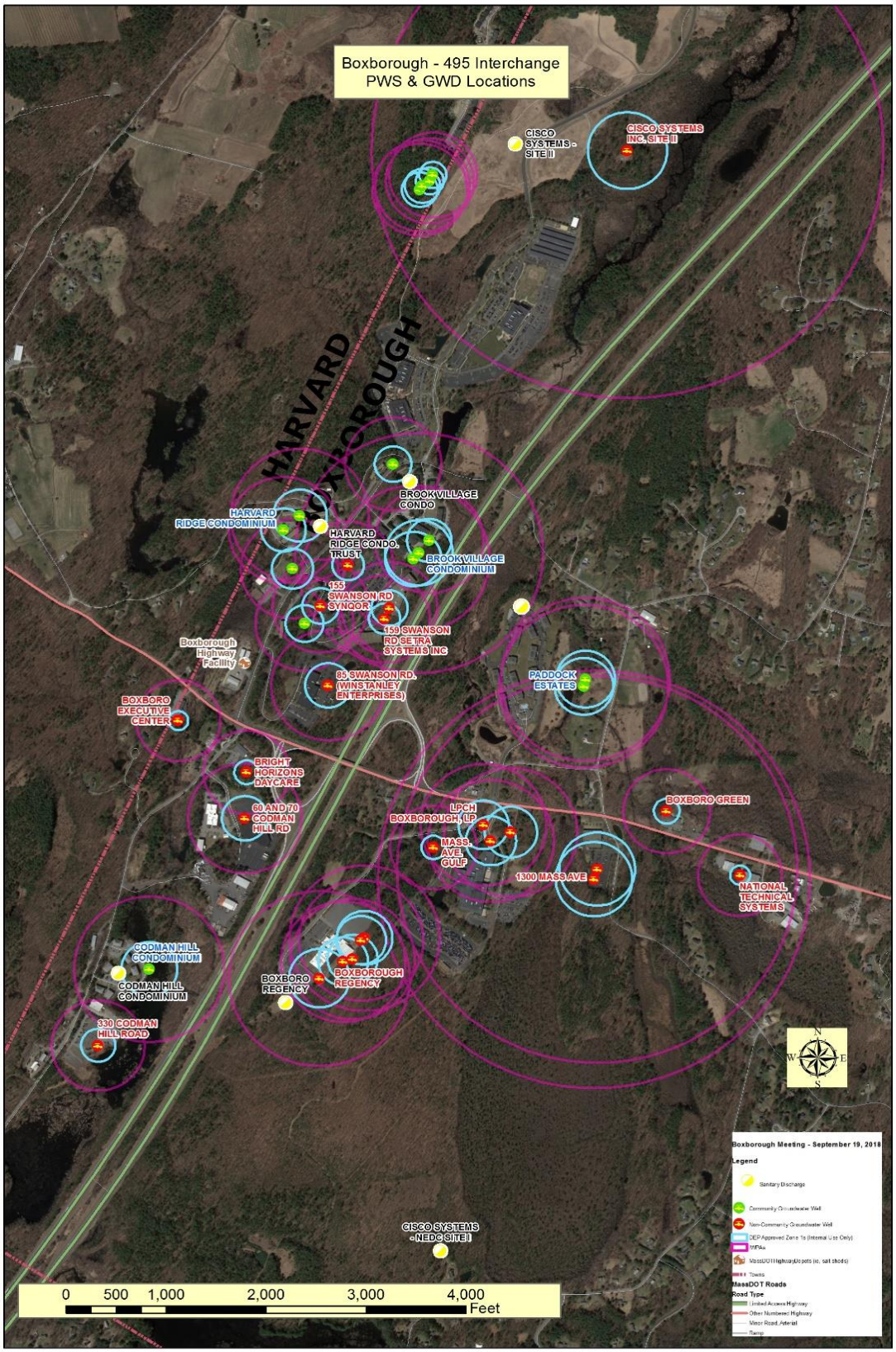

Figure 4: Map from MassDEP labeling the 18 Businesses' locations as well as well heads and sewage systems.

Section 2.5: Possible Drinking Water Options for Boxborough

Although drinking water, wastewater, and stormwater are all pertinent to this project, it was determined that finding drinking water options would also help solve the wastewater and stormwater issues this area of Boxborough is facing. This section gives a brief introduction of each solution that was researched, but a more in-depth explanation of each can be found in Chapter 4. The following solutions were pursued:

1. The Do it Yourself Option
2. Collaborate with Littleton
3. Find a New Water Supplier

2.5.1: The Do it Yourself Option

The do it yourself option focuses on what the businesses can do individually in order to comply with MassDEP or state regulations. Essentially, this solution will focus on what companies will need to do in order to get by for now. Each business would be responsible for updating their own systems and finding their own financing

2.5.2: Collaborate with Littleton

Two different collaboration paths with Littleton were explore as potential options. The first involved drilling a new well and building a water treatment plant at the well site while the second also involved building a new well but treating the water at Littleton's water treatment plant.

2.5.2.1: Build a new well and treatment plant at the Harvard Sportsmen's Club

CDM Smith Inc. is an engineering solutions company that explored different water solutions for the town of Boxborough in 2008. The plan consisted of several different options that the town could pursue in order to install a public water system. As a part of the study, CDM drilled two test wells at the Harvard Sportsmen's Club (HSC), located just outside of Boxborough in Harvard, MA. Since the wells pulled over 1 million gallons per day, CDM felt that drilling a well at this location would be best for Boxborough.

The suggested solution was to buy a plot of land from the HSC, large enough to have aquifer safe zones, to drill new wells. The land would then be used to build a water treatment plant that would be able to purify the water before it was piped to businesses and storage tanks to supply water to the western portion of town (CDM, 2008).

2.5.2.1.1: Centralized New Drinking Water Source

When it comes to treatable drinking water sources, there are two main options: groundwater and surface water. Groundwater is defined as water that is located underground in large aquafers. Surface water is defined as above ground water found in rivers, lakes, or streams (Goulds Water Technology, 2015). Both groundwater and surface water are within range of this project to be used as a connection source for water treatment.

In most cases, groundwater, such as the source identified in the CDM study, is a much more reliable source than surface water for several reasons. First and foremost being that it is typically much easier to clean, and cheaper to treat compared to surface water. Groundwater is typically

much cleaner because it is not above ground and exposed to nature. Groundwater is also more likely to maintain volume during periods of drought (Hancock, 2016).

2.5.2.2: Build a new well at the Harvard Sportsmen's Club and use Littleton's treatment plant

Based off the 2008 CDM study, the Littleton Water Department and Boxborough Water Resources Committee have been collaborating on their own iteration of the CDM Solution. Rather than building a water treatment plant in Boxborough, the water from the HSC well would be piped to the Littleton treatment plant to be treated there. The clean water would then be supplied to Boxborough by Littleton (Clemence, B., Godrey, C., and Fox, L., personal communications).

2.5.3: Find a New Water Supplier

Since it could be difficult to convince the HSC to sell a piece of their land for a well, there is also the option of buying a new piece of land somewhere else. This solution has many different avenues, from finding a different water supplier to tapping a well at a different location and creating a water district in western Boxborough. This solution represents the 18 Businesses wanting to collaborate, but only collaborate with each other and take charge of a new drinking water system and its management. As a very preliminary option, it would have an extremely long timeline.

2.5.4: The Salt Remediation Program

Aside from the four future solutions that were researched, applying for the Salt Remediation Program is a solution that the 18 Businesses could pursue immediately. Sponsored by the MassDOT, the Salt Remediation Program helps remediate salt complaints due to MassDOT operations (MassDOT, 2019). The Salt Remediation Program helps both private wells and public water supplies. As the 18 Businesses this project is focused on all have public water supplies, they would benefit from applying to this program, regardless of the solution that is pursued.

Businesses that apply to the Salt Remediation Program are asked to fill out a short application and provide drinking water sodium levels. After the application is submitted and the MassDOT approves it, the MassDOT will begin a year-long monitoring process to determine the best way to provide the business with help to mediate their drinking water quality issues (MassDOT, 2019). The cost of this program is funded by the MassDOT, so the businesses would not be paying any additional funds, other than the cost to test their sodium levels, to follow this option. Table 3 shows the drinking water salt levels of the 18 Businesses.

Name	Current Sodium Chloride Level (mg/L)
Codman Hill Condominiums	37-51
Harvard Ridge Condominiums	3.2-342
Brook Village Condominiums	180-330
Boxborough Regency	10-14.3
LPCH Boxborough, LP	79-131
SYNQOR	210-376
Sentra Systems Inc.	209-415
Boxborough Executive Center	816-1,109
1300 Mass. Ave	13.4-19.7
60&70 Codman Hill Road	119-125.7
Winstanley Enterprise	128-313
330 Codman Hill Road	24.1-24.4
Boxboro Green	43.9-53.4
Mass. Ave Gulf	88-100
National Technical Systems	20.7-26.6
Bright Horizons Daycare	169-286
Paddock Estates	20-24.4
Cisco Systems, Inc.	30-33.3
MassDEP Guideline	20 mg/L

Table 3: Sodium Chloride Levels in the wells of the 18 Businesses (MassDEP, 2019)

2.5.4.1: Reverse Osmosis Filtration System

One of the more popular remediation techniques used through the Salt Remediation Program is a reverse osmosis filtration system. The process of "reverse osmosis" (RO) filters out the harmful elements found inside of well water (the solute) and diverts its path to a wastewater drain. The reverse osmosis process uses a semi-permeable membrane that allows only the pure drinking water to pass through, leaving everything else behind. After that, the water is then treated with chemicals to remove any microscopic bacteria or elements that remain in the water after filtration. The remaining solvent is pure, clean drinking water. Reverse osmosis does occur naturally in nature; an example would be a plant sucking up ground water in soil through its roots to supply itself with water (Pure Aqua, 2019).

The reverse osmosis process is a highly favored water filtration process because of many reasons. First and foremost, the system itself is extremely easy to setup and maintain. There are only a few parts in the system, and it comes entirely assembled in shipping containers from most companies. Also, with 4-5 different filters on the reverse osmosis system, the water has been described "to have a better taste" (Berkey, 2019).

Chapter 3: Methodology

The goal of this project was to analyze options and to develop a cost-analysis for community-based water options for the town of Boxborough that were cost-effective and aimed at supplying drinking water services to an urbanized area at the Routes 495/111 intersection by bringing nearby businesses together to collaborate on this opportunity.

The objectives of this project were to:

1. Conduct key informant interviews with involved stakeholders to determine the best solutions to pursue.
2. Create a cost-analysis of each possible solution to identify costs and cost-benefits.
3. Develop public outreach materials to explain Boxborough's water issues at the Routes 495/111 intersection.
4. Engage the 18 Businesses to determine their thoughts, concerns, and opinions on each solution.

Figure 5: Diagram of methods

Project Objective:	Weeks							
	Prep	1	2	3	4	5	6	7
Conduct informant interviews with involved stakeholders								
Develop Cost Analysis								
Develop Public Outreach Materials								
Engage the Businesses to determine their thoughts/opinions								

Table 4: Timeline of objectives

3.1: Conduct key informant interviews with involved stakeholders to refine the project scope to determine the best solutions to pursue.

To refine this project's scope, we met with the MassDEP early in week one. From this meeting, we discovered that Boxborough has reinitiated conversations with Littleton to see if Boxborough could connect to Littleton's Water Department. In 2008, CDM conducted a study in Boxborough to analyze the town's current water and related systems to give Boxborough a recommendation for how to improve their water infrastructure. At the completion of the study, CDM recommended that Boxborough work with Littleton to create an inter-municipal water system that would supply the western portion of Boxborough with drinking water, thus easing the stormwater and wastewater issues this area was facing. This option had not been pursued in 2008 due to the $26 million price tag. However, after receiving this information, it became clear that relocated drinking water sources would help ease the majority of the water issues the 18 Businesses were facing. Using the CDM study as a case study, other stakeholders in the area were interviewed to verify that drinking water was the best area to focus on.

Key informant interviews (University of Illinois Extension, 2019) with various stakeholder groups were conducted to gain further insight. Stakeholders local to Boxborough were interviewed since these groups of people know more about Boxborough, their needs, the residents' needs, the town's needs, and research that has already been done.

Each interview was opened with an informal version of the informed consent statement (Appendix G: Informed Stakeholder Consent) to explain the research that has been done and how we intended to use interview information. Questions then transitioned into the interviewees' role in his or her organization and about the problems facing the western portion of Boxborough. Later portions of the interview delved into specific questions based on the individual or group that was being interviewed (University of Illinois Extension, 2019). Interview questions and notes can be found in Appendix C: Interview Summaries.

Interviews with one interviewee were conducted with one interviewer and one note-taker. Interviews with more than one interviewee or with a specific stakeholder group were conducted with the whole group present, with one or two members conducting the interview while the others took notes. This plan allowed for the most accurate note-taking while refraining from

overwhelming the interviewee(s) with questions (University of Illinois Extension, 2019). A description of each of the stakeholders we interviewed can be found in the following section.

3.1.1: List of Stakeholder Groupings

Stakeholder groupings and descriptions can be found below. This list is included to give a brief overview of each group to explain their expertise and give context to why they were interviewed.

MassDEP and Massachusetts Bureau of Water Resources
The MassDEP was one of the sponsors of this project. Three representatives worked closely with us: Marielle Stone (Bureau of Water Resources), David Boyer (Wastewater Section Head), and Robert Bostwick (Drinking Water Section Head). All three individuals have been closely involved with the 18 Businesses in Boxborough to make them aware of their water issues.

MassDOT
Laurene Poland (Salt Remediation Program Supervisor) was another sponsor for this project. As supervisor for the MassDOT's Salt Remediation Program, she assists residents and municipalities that have been impacted by salt runoff through snow and ice operations. Ms. Poland has been closely involved with the stormwater issues in the western portion of Boxborough through the Salt Remediation Program.

Boxborough Water Resources Committee
Boxborough's Water Resources Committee continuously researches the town's water in order to protect Boxborough's water resources and help the town meet its long-term water supply needs. Leslie (Les) Fox and Bryon Clemence are two of the three members of the committee that have been working with the 18 Businesses and the town of Littleton to find water solutions for the 18 Businesses.

Littleton Water Department
The Littleton Water Department provides water to over 2800 customers throughout Littleton. The department is in charge of the entire water system's management, from installing new connections to billing customers. They have been working closely with the Boxborough Water Resources Committee to create a joint Boxborough/Littleton water solution for the 18 Businesses in Boxborough (Littleton Electric Light & Water Departments, 2016).

Engineers that work with the 18 Businesses
The engineers that work with the 18 Businesses are the most knowledgeable about current water systems as well as costs associated with them.

We interviewed the MassDEP and MassDOT on multiple occasions to gather information about water regulations, current water systems in place in Boxborough, stakeholders to contact, possible solutions, as well as items to include in the cost analysis. We spoke to Les Fox and Bryon Clemence on multiple occasions as well to get a better understanding of their own possible solution ideas, project funding concerns, possible collaborations with Littleton, and current water research done in Boxborough. The Littleton Water Department spoke to us about their plans for working with Boxborough to create an inter-municipal water solution, the costs associated with their plans, and their collaborations with the Water Resources Committee. Finally, engineers associated with the 18 Businesses were contacted to get a better understanding

of the costs the businesses are currently paying for their water systems and the costs they will have to pay to upgrade them.

3.2: Create a cost-analysis of each possible solution to identify costs and cost-benefits.

In order to compare the different water options for the 18 Businesses, we created a cost-analysis. Since money is a driving factor for many projects, a preliminary list of costs and cost-benefits could encourage the 18 Businesses to work together on a solution versus working independently. Figure 6 depicts the areas that were considered when creating the cost-analysis.

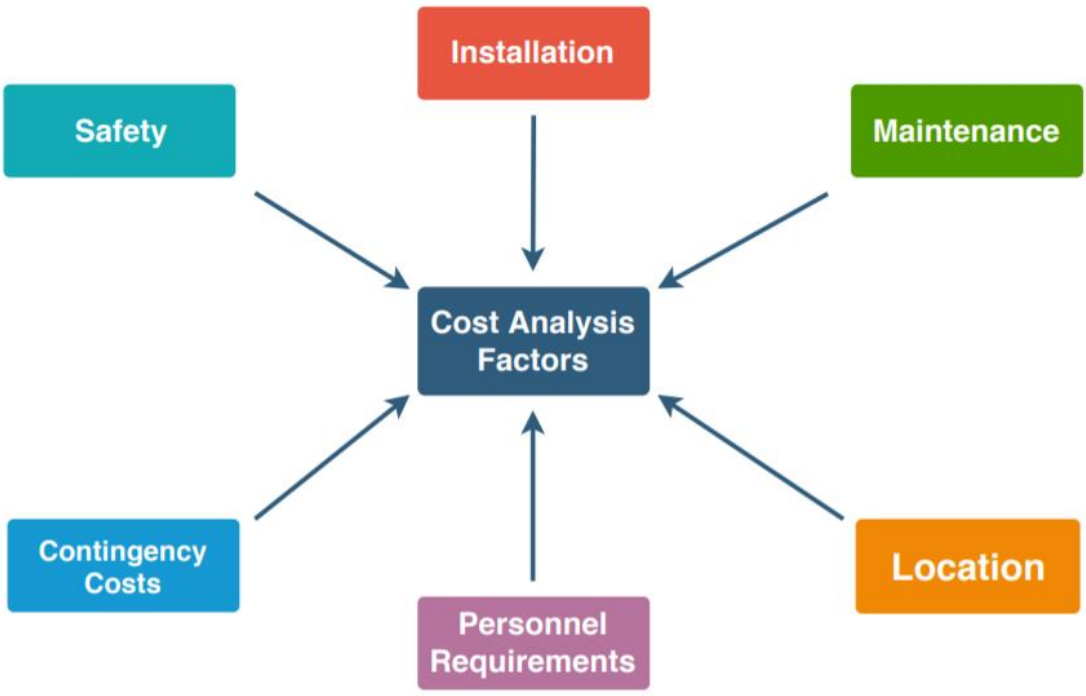

Figure 6: Cost analysis factors

Interviews and case studies were conducted to create the cost analysis. A 2008 Boxborough CDM Feasibility study was used as a model for the cost-analysis we created. Interviews with the Littleton Water Department and Boxborough Water Resources Committee provided us with current material costs and connection/installation fees. Costs were then broken down into unit costs to help with comparison.

The current version of the cost analysis focuses on the collaborating with Littleton option. It breaks down the cost of constructing the new system with connection fees by the amounts each stakeholder would pay. Payment amounts were determined by the amount of water each stakeholder uses annually (those that used more water paid more and vice versa).

Although we were able to gather data through interviews and case studies for the cost analysis to help compose the analysis, it is not complete. A complete cost analysis was not able to be created for a few different reasons. First, we were not able to retrieve all the necessary numbers needed to create a comprehensive estimate of the cost of each option. The biggest challenge we faced in trying to gather the necessary numbers were with engineers. Certain costs, especially for the systems that the 18 Businesses currently have in place, were deemed sensitive information and could not be shared with the group. Even if the information had been gathered from the engineers, they would not have been able to provide us with an exact cost breakdown as we were not paying them to do this work. Due to this difficulty, we were unable to get numbers for the Do it Yourself Option.

Legal fees presented the next challenge. As we are not law experts, we could only create a list of some possible legal fees without any actual cost numbers. A law expert would need to have been hired to obtain and exact cost.

Water mains, water tanks, and pumps were other issues that quickly became apparent as they can vary depending on tank sizes, infrastructure, and amount of water used. Prices were very variable and only guesses could be made at what systems the 18 Businesses had installed.

Finally, sources of funding are missing from the analysis. Although the analysis breaks down the price if the 18 Businesses were to fund the project themselves, other sources of funding were not identified.

3.3: Develop public outreach materials to explain Boxborough's water issues at the Routes 495/111 intersection.

A set of public outreach materials was developed for the 18 Businesses and the Town of Boxborough for the Focus Group that was held in week six. While the businesses were already aware of the water issues, we wanted to convey its severity to encourage discussion on possible water plans and encourage stakeholders to agree on some next steps. Two main outreach pieces were developed:

1. Focus Group Presentation: The main purpose of the presentation was to convince the 18 Businesses to collaborate on this opportunity in order to get more momentum for the project. The presentation opened with a video that explains the water issues the western portion of Boxborough is facing. It then transitioned into maps of the Routes 495/111 intersection which depicted the water systems, wastewater systems, stormwater drains, and impervious surfaces in the area to further show the poor water infrastructure planning in the area. The next piece of the presentation showed different stormwater and wastewater data from the 18 Businesses to show that their water had high salt levels and that their wastewater systems would need to be updated in the near future. Following the data was an explanation of each of the options we found to be the best for the 18 Businesses to pursue, along with the cost analysis of each one. Finally, we explained the dangers of what could happen to their water if they do not act on the problems soon.
2. Salt Remediation Program Materials: A pamphlet that included information about the Salt Remediation Program was created to encourage the 18 Businesses to apply for the

program. Currently, only one business in Boxborough has qualified for the program and one other has applied for the program (Poland, Laurene, personal communication, April 1, 2019). If other businesses were to apply to the program, then the potential for further funding for a joint water solution for the 18 Businesses would become more feasible. The flyer contained information about where to find the application as well as a brief timeline of events. The flyer can be found in Appendix A.

3.4: Engage the 18 Businesses to determine their thoughts, concerns, and opinions on each solution.

At the end of the project term, a Focus Group was held on April 18, from 6-8 pm, at Boxborough Town Hall to discuss the conducted research and to discuss stakeholders' opinions on next steps. The following steps were used to hold the Focus Group.

1. Create the Focus Group presentation: As mentioned in Section 3.3, a Focus Group presentation was created to re-explain the current water issues in the area, present possible water options they could pursue, suggest next steps, and foster discussion about what was presented. A copy of the presentation can be found in Appendix A.
2. Create a Focus Group agenda: Below is the focus-group agenda for the meeting. The Focus Group agenda was modified from *Focus groups: a practical guide for applied research* (Krueger, 1994).

Purpose of the focus roup

The purpose of the Focus Group was to gather stakeholder feedback on the research we have done regarding water quality issues in western Boxborough and to discuss their thoughts and opinions on possible water options that they could pursue to help lessen the issues. The most important part of this Focus Group is to get feedback on if the stakeholders want to work together to find a combined solution to the water issues, or if they are more apt to work alone.

Introduction, at about 6:05

At the beginning of the Focus Group presentation, we briefly explained what an IQP is, what we have been working on over the past twelve weeks, what we would be overviewing during the presentation, and that discussion was the most important part of the Focus Group.

PowerPoint Presentation – All team members, begin after the introduction.

A copy of the presentation can be found in Appendix A.

Group Discussion - Three points for stopping for discussion in the PowerPoint

Moderator: Katie Vasconcelos

Assistant Moderator: Jake Wisniewski

Note-Takers: Spencer Vinson and Mike McGoff

A copy of the Focus Group notes can be found in Appendix D: Focus Group Discussion Summary.

Conclusion – should start no later than 7:50

We ended the presentation with final questions, thanking those that attended, and explaining what the group's next steps were for the final project week.

3. Email the 18 Businesses: About a week and a half before the Focus Group, an email was sent to the 18 Businesses that explained who the group was and the project, requested their attendance to the upcoming Focus Group, and briefly discussed the informed consent forms we also sent with the email.
4. Follow-up with the 18 Businesses: The week after the email was sent, follow-up emails and phone calls were made to each Boxborough Stakeholder that did not reply to remind them of them Focus Group and re-ask for their attendance.

Chapter 4: Key Accomplishments and Findings

Based on the research conducted throughout the project term, including interviews and the end of project Focus Group, the following key areas and findings were pursued:

1. Assessed the current state of Boxborough water and collaboration amongst stakeholders.
    a. There is an opportunity for better communication amongst stakeholders.
    b. The Salt Remediation Program is underused.
2. Identified and organized three main drinking water options.
    a. Option 1: Do it Yourself option
    b. Option 2: Collaborate with Littleton
    c. Option 3: Find a new water supplier
3. Assessed stakeholder perspectives on options and future steps, mainly through the end of project Focus Group.
    a. Collaborating with Littleton is the preferred option.
    b. The Water Resources Committee is ready to continue working towards collaborating with Littleton and will take the lead.
    c. While the western portion of Boxborough has been hit the hardest with stormwater, wastewater, and drinking water issues, they could become a community-wide problem.
    d. The Boxborough stakeholders are concerned about wastewater permitting if they pursue a collaborative option.
4. Developed a preliminary analysis of stakeholder costs for the Littleton Collaboration Option.
    a. There are lots of variable cost and considerations, so the Littleton cost analysis spreadsheet is only in its preliminary stages.
    b. It is difficult to compare cost analysis studies completed by different parties.
    c. Stakeholders nonetheless found value in the preliminary analysis which modeled a variety of key considerations and assumptions
    d. Recommendations for the cost analysis
        i. Contact engineers and/or engineering firms to get more exact quotes and prices.
        ii. Talk to lawyers to get a better understanding of the legal fees that would be involved in creating a cross-municipal agreement.
        iii. Talk to RCAP solutions to determine more concrete sources funding.
        iv. Revise the cost analysis to reflect any future updates.

4.1: Assessed the current state of Boxborough water and collaboration amongst stakeholders

During the first few weeks of the project term, key informant interviews were conducted to better narrow the scope of this project and determine possible water remediation options for western Boxborough. Although we had spoken to the MassDEP and MassDOT to understand their concerns, it was equally as important to understand the opinions and concerns of stakeholders living and working in Boxborough. From MassDEP and MassDOT meetings with stakeholders,

it was their understanding that stakeholders in Boxborough were aware of the water issues but were not motivated to collaborate as no one had approached the MassDEP about possible solutions.

However, while conducting these interviews, it became clear that some possible solutions for the 18 Businesses were already being pursued. Options ranged from collaborating with nearby towns or Boxborough businesses with unused water capacities to expanding unused water systems. As possible options were researched, two key findings presented themselves. First, that there is an opportunity for better communication amongst stakeholders and second, that the Salt Remediation Program was underused, both discussed below, and which helped set the context for later work.

4.1.1.: There is an opportunity for better communication amongst stakeholders.

Even though the common water issues faced by the 18 Businesses and stakeholders put them in similar positions, we noticed through interviews and meetings that there is an opportunity for better communication between involved parties. Many stakeholders were unaware of who was researching possible solutions to this problem and their current statuses.

These gaps in knowledge were preventing plans for possible drinking water options from moving forward, so we met weekly with the MassDEP to synthesize key information and plan a Focus Group (discussed below). After holding these meetings, more stakeholders seemed to have a better understanding of the current work that is being done.

4.1.2: The Salt Remediation Program is underused.

After speaking to Laurene Poland from the MassDOT, we discovered that very few businesses had applied to the MassDOT salt remediation program. This is a government funded program that provides salt remediation to well owners that have high salt levels due to MassDOT operations. Many of the 18 Businesses have high salt levels partially due to salting of major roads and highways, parking lots, and operations of the MassDOT salt storage facility. Section 5.1.1 fully discusses the 18 Businesses' salt contamination levels, stakeholder opinions on applying, and recommendations to apply.

4.2: Identified and organized three main drinking water options

Through using existing project proposals and studies to identify proposed options and assessing Boxborough's current water situation, three main drinking water options were identified as possible solutions for western Boxborough.

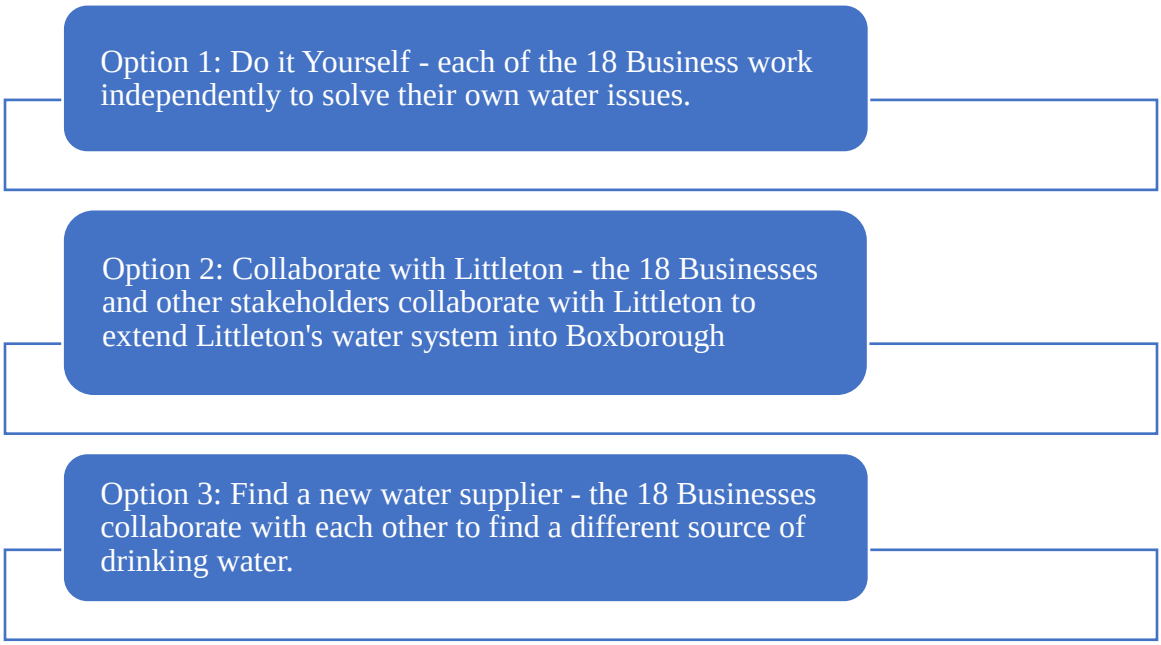

Figure 7: The three drinking water options

To compare the three different options, Table 5 shows some of the benefits each of the systems have. Collaborating with Littleton not only has the most benefits but was the most wanted options by attendees at the Focus Group, deeming it the best option to pursue.

Evaluation Factors:	DIY	Littleton	Other Supplier
Water Supply			
Improves water quality for consumption		x	x
Adds system redundancy		x	
Removes need to operate individual Public Water Supply		x	x
Decreases cost for water over time		x	
Water Distribution			
Create and manage a water distribution system			x
Leave water distribution to another entity		x	
Stormwater Concerns			
Mitigates road salt contamination		x	x
Mitigates salt contamination from salt storage facility		x	x
Mitigates salting of other impervious surfaces, like parking lots		x	
Wastewater Discharge			
Reduces risk of toxins in water supply		x	x
Maintains existing permit limits	x		
Reduces wastewater facility standards and costs		x	x
Regulatory Issues			
Increases risk for more stringent permits	x		

Table 5: Qualitative analysis of drinking water options

4.2.1: The Do it Yourself (DIY) Option

The Do it Yourself Option focuses on what the 18 Businesses would need to do to solve their water problems individually. Under the current situation, this is the option that the 18 Businesses are pursuing and will pursue if no action is taken. Right now, each business ensures that they regulate their systems and maintain existing permit limits as, since this option is a non-collaborative, single-entity solution, the MassDEP cannot regulate all 18 Businesses as they do not have the operating capacity to do so.

For the Brook Village Condominiums, Harvard Ridge Condominiums, Codman Hill Condominiums, and Cisco, this solution could potentially involve more stringent permits on their wastewater systems through needing to add a TOC system. In addition, high sodium chloride levels still plague many of the 18 Businesses' drinking water. Sodium chloride can corrode pipes, which would lead to lead and manganese leaking into drinking water, posing a threat to health.

The current water infrastructure would not allow for the commercial development the town hoped for in the Boxborough2030 plan. The high number and large radii of the well protection zones would prohibit any further drinking wells from being built in this area, so expansion would be extremely difficult.

4.2.2: Collaborating with Littleton

There are currently two options to collaborate with Littleton. In either option, the Littleton water system would be extended into western Boxborough to provide water to the 18 Businesses through the Littleton system. Littleton would oversee water distribution while stakeholders would pay to have water delivered.

4.2.2.1: Collaborate with Littleton and Build a Water Treatment Plant in Boxborough

In 2008, CDM (an engineering solutions company) conducted a water system feasibility study for the western portion of Boxborough that concluded that the best alternative for Boxborough was a "regional system starting west of I-495" (CDM, 2008). This solution would involve creating an agreement with Littleton to create a regional water system through Boxborough providing Littleton with a new water source located at the Harvard Sportsmen's Club in exchange for Littleton extending their water system into Boxborough.

In the first step of this approach, a new well and water treatment plant would be built by Boxborough on the Harvard Sportsmen's Club Property. This facility is located just outside of the western portion of Boxborough in Harvard, MA. Next, Boxborough would connect to the Littleton Water distribution system at Monarch Drive in Boxborough. Then, water mains would be built south on Beaver Brook Road, Swanson Road, and Codman Hill Road in Boxborough. These three streets would receive their water from the Oak Hill storage tank in Littleton. Finally, water mains would be built east on Route 111 to the intersection of 111 and Whitcomb Road in Boxborough.

The reason that this solution was never pursued in 2008 was the price. At the time, the CDM estimated that this approach would cost the town about $18,600,000. Due to the high price tag and economic downturn, the town did not want to pursue this solution. However, the water issues, and the price tag, have only increased since 2008 (CDM, 2008).

4.2.2.2: Collaborate with Littleton and Use Their Water Treatment Plant

Working off the CDM proposal, the Littleton Water department has been working with the Boxborough Water Resources Committee to create their own adapted solution. Rather than building both a well and a water treatment plant at the Harvard Sportsmen's Club, only the well would be built. Then, the water would be piped to the Littleton water treatment plant to be treated. The water main connections that would be built would be identical to those in the Harvard Sportsmen's Club, but with the addition of extending the water mains to the Boxborough Executive Center and to National Technical Service and without connections to Hill Road.

Based off Table 5, the following characteristics were identified as benefits to collaborating with Littleton:

- Improves water quality for consumption: As collaborating with Littleton would relocate a drinking water source away from wastewater and stormwater concerns, this option would improve drinking water quality.
- Adds system redundancy: If one well in the Littleton system dries up or becomes contaminated, there are other sources of water for backup.

- Removes need to operate individual Public Water Supply: The 18 Businesses would no longer have their own Public Water Supplies.
- Decreases cost for water over time: Even though the 18 Businesses would have to pay to have water delivered from Littleton, the operation, maintenance, and upgrade costs they are currently facing for their own drinking water systems would diminish.
- Leave water distribution to another entity: Through investigating the Littleton Water website and interviewing individuals from the department, it became clear that Littleton is not only in the water business, but they have been working for years to create an efficient and user-friendly process. The department is in charge of every aspect of their water system, from construction to water delivery to the customer, making it easy for them to monitor their system, create system guidelines, and bill customers. Since they are well versed in water distribution, collaborating with them would be a safe option as they have had the time to develop their water techniques. Since Littleton would be in charge of water distribution, the 18 Businesses would only be responsible for paying to have water delivered to their door.
- Mitigates road salt contamination: Drinking water wells would be removed from proximity to highways
- Mitigates salt contamination from salt storage facility: Drinking water wells would be removed from proximity to the salt storage facility.
- Mitigates salting of over impervious surfaces, like parking lots: Drinking water wells would be removed from proximity to other impervious surfaces.
- Reduces risk of toxins in water supply: Drinking water wells would be removed from proximity to wastewater discharge.
- Reduces wastewater facility standards and costs: The 18 Businesses would not need to upgrade their wastewater systems to further treat their wastewater to reduce the risk of wastewater contaminants appearing in drinking water.

4.2.3: Find a new water supplier

The final solution is to explore finding a new water supplier or water source. This is a very preliminary option that could have many different paths. One option could be for the 18 Businesses to form a water district or create an LLC. Another option could be for them to approach someone else to become a water supplier.

Based off Table 5, the following were deemed as benefits and concerns to this approach:

- Improves water quality for consumption: As finding another water supplier would relocate the drinking water source away from wastewater and stormwater concerns, this option would improve drinking water quality.
- Removes need to operate individual Public Water Supply: The 18 Businesses would no longer have their own Public Water Supplies.
- Create and manage a water distribution system: This option would leave water distribution management to Boxborough. If they were to pursue this option, the 18 Businesses would have to create a water distribution plan from scratch and learn how to bill customers, maintain systems, ensure smooth operations, and continuously check to

make sure their water is clean. In addition to creating this plan, finding a new water supplier could have a long timeline since the 18 Businesses would have to fully research this option. According to the Littleton Water Department, they believe that collaborating with them use their water treatment plant could take three to five years to build and implement. As they already have plans for construction and this option does not, completing the finding a new water supplier option could take upwards of ten years.

- Mitigates road salt contamination: Drinking water wells would be removed from proximity to highways
- Mitigates salt contamination from salt storage facility: Drinking water wells would be removed from proximity to the salt storage facility.
- Reduces risk of toxins in water supply: Drinking water wells would be removed from proximity to wastewater discharge.
- Reduces wastewater facility standards and costs: The 18 Businesses would not need to upgrade their wastewater systems to further treat their wastewater to reduce the risk of wastewater contaminants appearing in drinking water.

4.3: Assessed stakeholder perspectives on options and future steps, mainly through the end of project Focus Group

Name	Attended?
Harvard Ridge Condominiums	**y**
Brook Village Condominiums	**y**
Mass. Ave Gulf	**y**
LPCH Boxborough, LP	**y**
SYNQOR	**y**
Sentra Systems Inc.	**y**
WhiteWater	**y**
RCAP	**y**
Water Resources Committee	**y**
The Dartmouth Group	**y**
Marlborough Residents	**y**
Boxborough Residents	**y**
Codman Hill Condominiums	n
Boxborough Executive Center	n
1300 Mass. Ave	n
60&70 Codman Hill Road	n
Winstanley Enterprise	n
330 Codman Hill Road	n
Boxboro Green	n
Boxborough Regency	n
National Technical Systems	n
Bright Horizons Daycare	n
Paddock Estates	n
Cisco Systems, Inc.	n

Table 6: Stakeholder attendance at the focus group

On April 21, 2019, a Focus Group was held at Boxborough Town Hall to discuss with representatives from the 18 Businesses the current water issues in western Boxborough, possible options for helping mediate said issues, costs associated with the options, and thoughts for next steps. Table 6 details which businesses and living communities had representatives at the Focus Group. In total, about twenty stakeholders attended.

The meeting opened with an introduction of the team, an explanation of what an IQP is, and the project work that had been done over the past thirteen weeks. A presentation followed, which was divided into three sections: our understanding of the water issues in western Boxborough, the three most viable options, and possible next steps to continue to work on a common solution. We paused on each section to facilitate discussions with the attendees to get their opinions, thoughts, and ideas. A copy of the notes taken at the Focus Group can be found in Appendix D: Focus Group Discussion Summary

The Focus Group was a key outcome of this project as it not only gave us the chance to interact and directly hear from the businesses and living communities we were trying to help, but also allowed them to hear from one another. Four key findings were: collaborating with Littleton is the preferred option; the

Water Resources Committee is ready to continue work on collaborating with Littleton; the problem that western Boxborough is facing could potentially spread, making it a community wide problem; and the Boxborough stakeholders were concerned about wastewater permitting, regulations, and fees if they were to pursue a collaborative approach with a long timeline.

4.3.1: Collaborating with Littleton is the preferred option

During the Focus Group, the option that the attendees expressed the most interest in was Option 2, collaborating with Littleton to create a water system to serve the western portion of Boxborough.

The consensus was that Options 1 and 3 would not be viable options for the businesses and living communities in the future. Option 1 would not promote collaboration, making it more costly if they fixed each problem on their own. Also, the attendees recognized that if they were going to put money into something that they should put money into an upgrade that will best serve them in the future. Option 3 also did not have much support, and some businesses pointed out that many legal decisions would need to be made in order to start a new water district or LLC. In addition, the attendees agreed that option 3 would take the most time to complete as there currently are not any definite plans.

Businesses agreed that Option 2 would make the most sense to update their water systems as well as remediate several wastewater and storm water issues that they have been experiencing would be most beneficial. In addition, many of them already had a good relationship with Littleton as they receive electric services from the town, so they felt comfortable entering into another agreement with them.

Even though the overall cost is high, the cost could be divided amongst interested parties and the town could decide to help fund the project. Attendees also had interest in researching if the system could be expanded beyond western Boxborough, either into neighboring Harvard or to the rest of Boxborough. Unfortunately, Harvard would not be a viable option because the Littleton system does not have the capacity to serve both Boxborough and Harvard and there are not any businesses close enough to the town line to make an extended system worthwhile. However, expanding into more of Boxborough could be pursued since it would help to lower the overall cost of the solution.

4.3.2: The Water Resources Committee is ready to continue working towards collaborating with Littleton and will take the lead.

The Boxborough Water Resource Committee was a reliable and significant help throughout this project. They are knowledgeable about Boxborough, its water infrastructure, the 18 Businesses, and the needs of the town. They are well prepared to continue the conversation in working towards collaborating with Littleton to keep motivation high and work towards analyzing all of the many issues that will need to be dealt with if Littleton is pursued. Following the end of project Focus Group, they offered to meet with any stakeholders interested in further discussing collaborating with Littleton.

4.3.3: While the western portion of Boxborough has been hit the hardest with stormwater, wastewater, and drinking water issues, it could become a community-wide problem.

While many of the 18 Businesses are facing high drinking water sodium levels, some of them are below the MassDEP guideline. Others are not facing any water infrastructure issues and follow wastewater and drinking water standards. However, heightened water issues could not only spread to other businesses and living communities in western Boxborough, but also to the entire town. Sodium levels will continue to rise as more salt is spread on the highway and makes its way into aquifers, and other parts of town are already experiencing radon and perchlorate issues.

Currently, the western part of Boxborough is facing the most serious water problems, so efforts are only being focused there. During the end of project Focus Group, it was clear that some stakeholders were concerned about the possibility of water issues spreading, or the current issues in other parts of town worsening, thus also affecting their drinking water. Multiple stakeholders discussed broadening the focus of these efforts from just western Boxborough to the entire town. Right now, other sources of drinking water would need to be identified and built in order to have the capacity to serve the entire town. However, future projects or research could, and should, be conducted to explore expanding this system as it could benefit the entire town.

4.3.4: The Boxborough stakeholders are concerned about wastewater permitting if they pursue a collaborative option.

Other than the Do it Yourself option, Options 2 and 3 have a long timeline, and wastewater and stormwater issues will only continue to worsen. There is the chance that more money will need to be spent, by each business, to continue to keep their own drinking water clean. During the Focus Group, many of the attendees were concerned about wastewater permitting as many of their permits are up for renewal this year. They felt that if they had to pay to upgrade their wastewater systems in order to comply with permitting and also want to collaborate with Littleton, then they would be paying both for the Littleton system and any permitting-required upgrades while the system is being built. This is not economically feasible for those that attended and having to pay for both would not encourage them to pursue a collaborative solution.

After raising this concern to David Boyer from the MassDEP, it is our understanding that the 18 Businesses' wastewater permits, and associated upgrades, would be temporarily put on hold, perhaps up to a year and a half, if the businesses and living communities and WRC actively research possible solutions and create action plans. However, they would need to provide proof of progress to the MassDEP as the hold cannot be indefinite.

4.4: Developed a preliminary analysis of stakeholder costs for the Littleton Collaboration Option

A set of cost analysis spreadsheets were made to break down costs associated with collaborating with Littleton. The sheets do only include initial cost estimates and a cost breakdown of the option by stakeholder but provide a framework for future cost analysis work. While there were many different variables and estimates that were made, the cost analysis did ensure confidence within the businesses that attended the Focus Group. The full cost analysis sheets can be found in Appendix B.

4.4.1: There are lots of variable cost and considerations, so the Littleton cost analysis spreadsheet is only in its preliminary stages.

Currently, the cost analysis spreadsheet is only in its preliminary stages and was primarily used to break down the cost of Option 2 per business and living community. As mentioned in Chapter 3, gathering costs from engineers and other stakeholders was difficult as we were not paying them to do a cost analysis, and many of the representatives we spoke to about current water costs at the 18 Businesses deemed the information sensitive from sharing.

Most of the sections in the cost analysis spreadsheet include current versions of cost breakdowns of the collaborating with Littleton option that have been discussed over the last ten years. After receiving information from different engineers, government agencies, and the local town committee, we were still only able to compile rough cost estimates. Many of the numbers, especially interest and contingency percentages, were the best guess we could make at the time. Rather than serving as a final cost of the price of collaborating with Littleton, this cost analysis serves more as collection of spreadsheets with all the information we collected as well as a breakdown of what each of the 18 Businesses could estimate to pay over thirty years to collaborate with Littleton. This was created to help the attendees at the end of project Focus Group rationalize the cost of the Littleton solution, as seeing a $7 million figure without a breakdown would be daunting.

4.4.2: It is difficult to compare cost analysis studies completed by different parties.

Throughout researching the different drinking water options, as well as talking with different stakeholders, we discovered that there was a lack of communication between the stakeholders involved in the project. For this reason, there are multiple tabs on the cost analysis spreadsheet with numbers from different studies, making them difficult to compare (for example, numbers from the CDM study are based off 2008 dollars and 2008 estimates, which are not accurate to current 2019 prices). Hopefully, this will make future cost analyses of the Littleton option easier as all the numbers are in a single location, rather than dispersed among different stakeholders.

4.4.3: Stakeholders nonetheless found value in the preliminary analysis which modeled a variety of key considerations and assumptions.

Once the Focus group was held, and the numbers for the Littleton solution was displayed, the attendees of the meeting were impressed with what we have calculated so far. Table 7 shows the cost analysis that was shown during the Focus Group.

Location	Gallons/mo	Littleton Water Rate ($/mo)	Littleton Rate + 20% ($/mo)	Construction and connection (C&C) ($)	C&C with 25% MassDOT funding ($)	C&C with DOT funds and 3% interest ($/mo for 30 years)	C&C w/ 3% + Littleton water adjustment price ($/mo for 30 years)	C&C w/ 3% + Littleton water adjustment price per unit ($/mo for 30 years)
1300 Mass. Ave	40,392	301	361	156,132	117,099	494	855	
330 Codman Hill Road	15,092	108	129	77,290	57,967	244	374	
60&70 Codman Hill Road	37,475	279	334	147,043	110,282	465	799	
Boxboro Green	949	12	15	10,522	7,891	33	48	
Boxborough Executive Center	9,702	70	84	60,493	45,370	191	276	
Boxborough Regency	375,795	2,860	3,432	1,201,338	901,003	3,799	7,231	
Bright Horizons Daycare	40,132	299	359	155,321	116,491	491	850	
Brook Village Condominiums	529,888	4,036	4,843	2,377,609	1,783,207	7,518	12,361	64
Cisco Systems, Inc.	172,250	1,307	1,568	605,764	454,323	1,915	3,484	
Codman Hill Condominiums	236,733	1,799	2,159	1,146,289	859,717	3,625	5,783	54
Harvard Ridge Condominiums	284,283	2,162	2,594	1,453,354	1,090,015	4,596	7,190	48
LPCH Boxborough, LP	34,567	256	308	137,979	103,484	436	744	
Mass. Ave Gulf	45,353	339	406	171,593	128,695	543	949	
National Technical Systems	100,560	760	912	343,632	257,724	1,087	1,998	
Sentra Systems Inc.	113,482	858	1,030	383,900	287,925	1,214	2,244	
SYNQOR	124,192	940	1,128	417,275	312,956	1,319	2,448	
Winstanley Enterprise	104,342	789	946	355,417	266,563	1,124	2,070	

Table 7: Cost analysis shown during Focus Group

1. Gallons/mo: Number of gallons of water each business uses monthly
2. Littleton water rate ($/mo): How much Littleton would charge each business or living community monthly for water usage based on current Littleton rates and the amount of water each of the 18-use monthly
3. Littleton rate+20% ($/mo): Additional 20% added onto the Littleton rate in the event Littleton charged Boxborough extra
4. Construction and connection: Total cost for construction and connection fees. Connection fees were calculated based on Littleton's current connection fees, which are determined by the pipe size of the connection (or for condos, charged per unit). These numbers were determined based on the amount of water each of the 18 uses, more water would result in a larger contribution.
5. C&C with 25% DOT funding: Construction and connection costs per businesses if the MassDOT pays for 25% of the project
6. C&C with 25% DOT funds and 3% interest ($/mo for 30 years): Construction and connection costs each business would pay each year for 30 years if the MassDOT contributes 25% funding and they receive a 3% interest rate.
7. C&C w/ 3% + Littleton water adjustment price ($/mo for 30 years): Same as C&C with 25% DOT funds and 3% interest ($/mo for 30 years) column, but with the addition of the Littleton rate+20% ($/mo) column
8. C&C w/ 3% + Littleton water adjustment price per unit ($/mo for 30 years): This column was made for condos in the event that they want to charge each unit for the construction and connection fees with a 3% interest rate and the Littleton water fees every month for 30 years.

There were some questions they still had about additional fees, but the Focus Group attendees felt more confident in choosing Option 2 as each business was still able to see a layout of what they would need to pay individually for this option.

4.4.4: Recommendations for the cost analysis

Since the cost analysis only contains very rough estimates, it is recommended that there needs to be further detailed research into each cost breakdown. Although Option 2 was deemed the best at the end of project Focus Group, once a plan is definitively chosen, it will be easier to create more detailed costs. Hiring engineers and lawyers will help to move this process along. RCAP solutions will also have a large role in finding funding options for the option that is pursued. The final recommendation for the cost analysis is making sure the spreadsheet is updated with any financial changes.

4.4.4.1: Contact engineers and/or engineering firms to get more exact quotes and prices.

In order to create the cost analysis for this project, outside sources were contacted. Some of these costs include prices of water mains, pump stations, and treatment plants. We also were able to gather costs for collaborating with Littleton; however, they were rough estimates for each general component of the water system. Since a solution hasn't been confirmed and we aren't experts in the field, it was difficult to gather more exact numbers. In the future, hiring a professional town engineer to get exact quotes and prices for the chosen solution would be very helpful for the stakeholders involved.

4.4.4.2: Talk to lawyers to get a better understanding of the legal fees that would be involved in creating a cross-municipal agreement.

As Option 2 was deemed the best option to pursue during the Focus Group, collaborating with Littleton would require creating an inter-municipal system and thus making cross-municipal agreements. This type of system would require many legal documents and contracts to ensure a fair system.

As we are not law experts or familiar with the legalities that would go into this system, we recommend contacting lawyers as soon as possible in the development process to understand the types of legal fees that would be involved in creating this system. Since legal fees were not considered in the cost analysis, these fees would only increase the price of Option 2.

4.4.4.3: Talk to RCAP solutions to determine more concrete sources of funding.

RCAP solutions is a nonprofit organization based out of Worcester, MA that runs several different programs to residents and small towns find funding options for implementing drinking water and wastewater systems.

RCAP solutions, and specifically Jim Starbard, have been working with the town of Boxborough to help find drinking water solutions for the 18 Businesses. We recommend continuing to keep RCAP involved in this process to determine more concrete sources of funding. Since they specialize in projects of this scale and specialize in engineering solutions, they will have the knowledge and tools to give ideas in order to find a solid source of funding.

4.4.4.4: Revise the cost analysis to reflect any future updates.

We were not able to do a complete cost analysis of each drinking water option for this project. As mentioned, most of the cost numbers in the report are rough estimates based off engineering bids, previous studies, or educated guesses and fail to reflect any future updates. The cost analysis focused on how costs could be distributed among stakeholders. When a definitive

solution is chosen and pursued, the cost analysis should be continuously updated and developed to reflect any future changes to keep the 18 Businesses informed of what current and future costs are.

Chapter 5: Recommendations and Conclusions

Based on outcomes and findings, a set of recommendations for the 18 Businesses and MassDEP and MassDOT were created.

1. The 18 Businesses should form a Working Group with the Water Resources Committee to pursue the Littleton Option.
2. The 18 Businesses should all apply soon to the Salt Remediation Program.
3. Find other towns that have a similar issue to Boxborough and use Boxborough as an example to encourage them to work together.

Finally, a brief set of conclusions is detailed in Section 5.4.

5.1: The 18 Businesses should form a Working Group with the Water Resources Committee to pursue the Littleton Option.

From multiple key informant interviews with various stakeholders, it quickly became clear that there was a lack of communication between stakeholders involved in this project. From this finding, we believe it would be beneficial for the 18 Businesses to meet and appoint liaisons to create a Working Group with the Water Resources Committee to continue work on the Littleton Option.

As shown in Table 8, Brook Village Condominiums, Boxborough Regency, Harvard Ridge Condominiums, and Codman Hill Condominiums use 63% of the total number of gallons of water (27,182,212) consumed every year by the 18 Businesses (Paddock Estates was not included in this calculation as their water system meets all MassDEP regulations). As they use the majority of the water at the Routes 495/111 intersection, having one person from each of these four entities would be ideal. In addition, having one person to represent the technology companies and one final individual to represent the remaining smaller companies such as business centers, the gas station, and daycare would be beneficial.

Location	% of Total Water Usage
Brook Village Condominiums	**23%**
Boxborough Regency	**17%**
Harvard Ridge Condominiums	**13%**
Codman Hill Condominiums	**10%**
Cisco Systems, Inc.	8%
Winstanley Enterprise	5%
SYNQOR	5%
Sentra Systems Inc.	5%
National Technical Systems	4%
Mass. Ave Gulf	2%
LPCH Boxborough, LP	2%
Bright Horizons Daycare	2%
60&70 Codman Hill Road	2%
1300 Mass. Ave	2%
330 Codman Hill Road	1%
Boxborough Executive Center	0%
Boxboro Green	0%

Table 8: Percent total water usage by business and living community

By creating a working group with the 18 Businesses and Water Resources Committee, it will be easier to schedule meeting times as there will be less schedules to coordinate. In addition, having fewer points of contact will also help ease communication. With less people to contact, response times will be quicker, and it will be easier to explain current issues and statuses to fewer people that are vastly involved and committed, rather than a large amount of involved but busy people. From working with them, the Water Resources Committee has the technical background and experience to continue to develop the collaborating with Littleton option while the liaisons will be able to communicate stakeholder needs, concerns, and opinions.

Along with creating a working group, we also recommend that the MassDEP and MassDOT appoint a communication contact for future project work. From interviews and meetings with the MassDEP, they are very busy. We know that some of the businesses and living communities, and hopefully more of the 18, are motivated to act and are ready to continue to work with the MassDEP to develop the Littleton solution, but they had many questions that we could not answer. During the Focus Group it seemed that attendees were frustrated with the current involvement of the MassDEP and MassDOT and were hoping for more guidance and assistance from them. Creating the Littleton system would be a massive, long project, so having an assigned

person to provide guidance to the working group will not only help with communication but help to keep motivation high.

5.2: The 18 Businesses should all apply soon to the Salt Remediation Program.

As mentioned in Chapter 4, the Salt Remediation Program is a MassDOT run program that helps provide remediation to well owners that are experiencing high drinking water sodium levels due to MassDOT operations. To apply, owners need to fill out a two-page application and provide accompanying drinking water sodium levels.

The 18 Businesses are facing a real problem with sodium contamination as all but two are above the MassDEP's health guideline of 20 mg/L of sodium in drinking water (Figure 8). The average sodium level at the Routes 495/111 intersection is 112 mg/L, which is also over the guideline. The MassDOT feels that it is partially responsible for these levels since they are responsible for salting Routes 495 and 111 during the winter and have a salt storage shed located nearby some of the businesses and living communities. However, they are confused as to why the more of the 18 Businesses have not applied to the program.

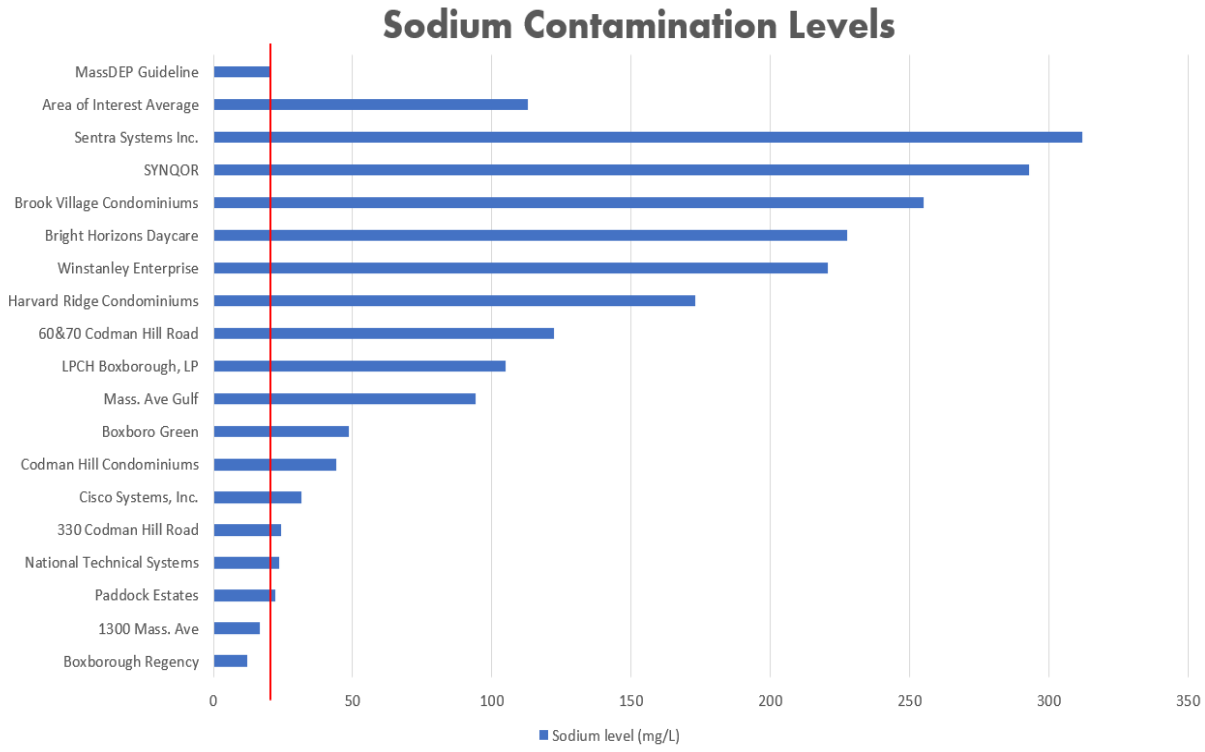

Figure 8: Average sodium levels in drinking water for the 18 Businesses in western Boxborough, excluding the Boxborough Executive Center, which has already qualified for the Salt Remediation Program.

Applying to the Salt Remediation Program was the first step proposed during the Focus Group. Based on discussion, it seemed that the 18 Businesses were more aware of the program than the MassDOT had previously thought. Quite a few of them, specifically the condominium

complexes, had looked at the application and had begun to fill it out. The problem was that, while the application is not difficult to understand, each public water supply applicant needs to provide the MassDOT with 10 years of salt level data. There was concern that not everyone had access to this information or had this information stored, which could either prevent them from applying or extend the application timeline while they try to find that information.

After speaking to Robert Bostwick from the MassDEP, he ensured that the 18 Businesses do have access to that information and if they need help finding it that they can contact him, providing a simple solution to this issue.

A picture of the public water supply owner flier we created was distributed at the Focus Group to encourage attendees to apply can be found in Appendix A. Below is a link to the application for public water suppliers:

https://www.mass.gov/files/documents/2018/08/10/PublicWaterSupplyDataForm.pdf

If more of the 18 Businesses apply to the Salt Remediation Program, it will raise awareness that many of the areas around Routes 495/111 are facing high salt levels. Hopefully, the created working group can assist the 18 Businesses in applying. Since this is a government funded program, the MassDOT must implement remediation techniques that are the most cost-effective. With more applications submitted, it could open the possibility for funding for a collaborative solution, such as the Littleton Option, as a collaborative solution would be more cost effective than providing remediation for individual businesses.

5.3: Find other towns that have a similar issue to Boxborough and use Boxborough as an example to encourage them to work together.

Many different small communities and towns across Massachusetts rely on their own well systems for drinking water and septic systems for sanitary needs. In addition, since Massachusetts receives large amounts of snow every year, roads are always going to need to be treated with an ice melt compound, such as salt. Unfortunately, since salt melts into stormwater, the risk of pollutants making their way into drinking wells will be a continuous concern.

Using Boxborough as an example of how to solve the issues that other towns are currently facing would be very useful to help other towns understand how to solve their current issues. If the process that Boxborough uses is well documented, it could be replicable in the future.

5.4: Conclusions

If nothing is done and conversation and collaboration fails to continue, then the 18 Businesses would choose the Do it Yourself option by default. Even though most of the 18 Businesses could maintain their water systems for the time being, water quality, especially sodium levels, are only expected to worsen over time. Currently, the Boxborough stakeholders that attended the Focus Group are motivated and want to collaborate and feel that collaborating with Littleton is the best option. The Water Resources Committee is ready to continue the conversation with the MassDEP, MassDOT, and Littleton to continue to work on developing a solution.

Bibliography

Beckley Sanitary Board. (2016, April 04). *What is stormwater?* Retrieved from http://beckleysanitaryboard.org/education/storm-water/stormwater-runoff/

Berkey. (2019, February 23). *Types of drinking water filtration systems reviews*. Retrieved from https://theberkey.com/blogs/water-filter/types-of-drinking-water-filtration-systems-reviews

Biology Dictionary Editors. (2017, August 06). *Biofilm - definition, function and structure.* Retrieved from https://biologydictionary.net/biofilm/

Bottled Water. (n.d.). Retrieved from https://www.bottledwater.org/types/tap-water

CDC. (2017). *Wastewater management*. Retrieved from https://www.cdc.gov/healthyplaces/healthtopics/wastewater_management.htm

CDC. (2018a). *Community Water Treatment*. Retrieved from https://www.cdc.gov/healthywater/drinking/public/water_treatment.html

CDC. (2018b) *Public water systems*. Retrieved from https://www.cdc.gov/healthywater/drinking/public/index.html

CDM. (2008, April 25). *Final report – water distribution system feasibility study town of Boxborough, Massachusetts* [PDF file].

Centralized Waste Treatment Effluent Guidelines. (2018, May 02). Retrieved from https://www.epa.gov/eg/centralized-waste-treatment-effluent-guidelines

EPA. (2015). *Information about public water systems.* Retrieved from https://www.epa.gov/dwreginfo/information-about-public-water-systems

Feehan, K., Franti, T., Holm, B., Holm, K., Rodie, S. Shelton, D. (2014). *Stormwater management: what stormwater management is and why it is important* (University of Nebraska-Lincoln Publicantion).

Fetterman, M., Friedman, D., Murphy, A., Meyer, J., & Vogel, R. (2015). *Boxborough housing production plan* (MassDEP Publication).

Goulds Water Technology. (2015, November 17). *Spring run-off: The difference between surface water and ground water*. Retrieved from http://residential.goulds.com/spring-run-off-the-difference-between-surface-water-and-ground-water/

Guidelines for Public Water Systems. (n.d.). Retrieved from https://www.mass.gov/service-details/guidelines-for-public-water-systems

Hancock, N. (2016, December 27). *Ground water*. Retrieved from https://www.safewater.org/fact-sheets-1/2017/1/23/groundwater

Koshland Science Museum. (2007, September 01). *Safe drinking water is essential*. Retrieved from https://www.koshland-science-museum.org/water/html/en/Treatment/Centralized-Treatment-vs-Point-of-Use-Treatment.html

Krueger, R. (1994). *Focus groups : a practical guide for applied research* (2nd ed.). Thousand Oaks, Calif: Sage Publications.

Littleton electric light & water departments. (2016). Retrieved from https://www.lelwd.com/water-department/

Local Services and Facilities. (2015, May 1). Retrieved February 10, 2019, from http://www.boxborough-ma.gov/sites/boxboroughma/files/file/file/local_services_and_facilities_150501_clean.pdf

MAPC. (2016, January). *Recommendations & implementation plan.* Retrieved from http://www.boxborough-ma.gov/sites/boxboroughma/files/file/file/boxborough2030_recommendations_and_implementation_plan_january2016.pdf.

Marczank, M. and Sewell, M. (2019, February 17). *Using Focus Groups for evaluation.* Retrieved from https://cals.arizona.edu/sfcs/cyfernet/cyfar/focus.htm.

Marshall, K., & Marshall, K. (2018, November 28). *What is an industrial water treatment system and how does it work?*. Retrieved from https://www.samcotech.com/what-is-an-industrial-water-treatment-system-process/

MassDEP. (2005). *The occurrence and sources of perchlorate in massachusetts.* Boston, MA: MassDEP.

MassDEP. (2016, March 11). *310 CMR 22: The massachusetts drinking water regulations.* Retrieved from https://www.mass.gov/regulations/310-CMR-22-the-massachusetts-drinking-water-regulations

MassDEP. (2019a). *Industrial wastewater program*. Retrieved from https://www.mass.gov/service-details/industrial-wastewater-program

MassDEP. (2019b, February 17). *Fact sheet: Water management act - registration and permitting*. Retrieved from https://www.mass.gov/service-details/fact-sheet-water-management-act-registration-and-permitting

MassDEP. (2019c, February 17). *Water management act program*. Retrieved from https://www.mass.gov/water-management-act-program

MassDEP. (2017, June). *Sodium in drinking water fact sheet*. Retrieved from https://www.mass.gov/files/documents/2017/06/zj/sodium-drinking-water-faq.pdf

MassDOT. (2019, April 4). *MassDOT highway salt remediation program.* Retrieved from https://www.mass.gov/massdot-highway-salt-remediation-program

Mass Live. (2015, May 3). *Boxborough executive office center*. Retrieved from https://businessfinder.masslive.com/boxborough-executive-office-center-boxborough-ma.html

Municipal Water Use. (2005). Retrieved from https://www.encyclopedia.com/environment/encyclopedias-almanacs-transcripts-and-maps/municipal-water-use

Nmarowitz. (2018, November 05). *Water filtration systems- boxborough, mass*. Retrieved from http://h2ocare.com/water-filtration-boxborough

NTS. (2019). *Testing, inspection & certification services*. Retrieved from https://www.nts.com/

NYWEA. (2013, January). *Wastewater management handbook for local representatives.* Retrieved from http://efc.syr.edu/wp-content/uploads/2015/03/Chapter1-web.pdf.

Population Characteristics. (March 2015). Retrieved from http://www.boxborough-ma.gov/boxborough-2015/pages/population-characteristics

Pure Aqua. (2019, Feburary 23). *Industrial ultrafiltration UF systems*. Retrieved from https://www.pureaqua.com/industrial-ultrafiltration-uf-systems/

Radjenovic, J., Petrovic, M., & Barceló, D. (2006). Analysis of pharmaceuticals in wastewater and removal using a membrane bioreactor. *Analytical and bioanalytical chemistry, 387*(4), 1365-77.

Rathnayaka, K., Malano, H., & Arora, M. (2016, December 15). Assessment of Sustainability of Urban Water Supply and Demand Management Options: A Comprehensive Approach. Retrieved from https://www.mdpi.com/2073-4441/8/12/595/htm

Simms, J. (2006). *Local board of health guide to on-site wastewater treatment systems* (National Association of Local Boards of Health Publication).

Stormwater Partners of SW Washington. (2019, April). Retrieved from https://www.stormwaterpartners.com/facilities-catch-basin

Thermo Electron Corporation. (2003). *Total organic carbon (TOC) in wastewater*. Retrieved from http://www.apolloinstruments.fr/AutoFiles/doc/5012_AN_EN-03002_TOC_in_Wastewater[1].pdf

Towncharts.com. (2016, December 15). *Boxborough town, massachusetts demographics data.* Retrieved from https://www.towncharts.com/Massachusetts/Demographics/Boxborough-town-MA-Demographics-data.html.

Town of Boxborough. (2015a, March). *Boxborough2030.* Retrieved from: http://www.boxborough-ma.gov/boxborough2030

Town of Boxborough. (2015b, March). *Future land use map.* Retrieved from: http://www.boxborough-ma.gov/recommendations/pages/future-land-use-map

Town of Boxborough. (2015c, March). *Utilities in town*. Retrieved from: http://www.boxborough-ma.gov/boxborough-2015/pages/utilities-in-town

Town of Boxborough. (2015d, March). *Water resources*. Retrieved from: http://www.boxborough-ma.gov/boxborough-2015/pages/water-resources

Town of Boxborough. (2015e, February 24). *Water resources committee*. Retrieved from: http://www.boxborough-ma.gov/water-resources-committee

Town of Chelmsford, Massachusetts. (2019, March 1). *Water districts*. Retrieved from: https://www.townofchelmsford.us/467/Water-Districts

University of Illinois Extension. (2019, February 17). *Key informant interviews*. Retrieved from http://ppa.aces.uiuc.edu/KeyInform.htm.

UNL Water. (2019, February 17). *Wastewater - what is it*? Retrieved from https://water.unl.edu/article/wastewater/wastewater-what-it

USDA. (2019, April 4). *Water management.* Retrieved from https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/water/manage/

US EPA, O. (2015). *Small wastewater systems research*. Retrieved from https://www.epa.gov/water-research/small-wastewater-systems-research-0

US EPA, O. A. (1986, June 20). *President signs safe drinking water act amendments*. Retrieved from president-signs-safe-drinking-water-act-amendments.html

US EPA, O. A. (2013). *Summary of the safe drinking water act*. Retrieved from https://www.epa.gov/laws-regulations/summary-safe-drinking-water-act

US EPA, O. W. (2015). *Learn about small wastewater systems*. Retrieved from https://www.epa.gov/small-and-rural-wastewater-systems/learn-about-small-wastewater-systems

Water Monitoring. (2015, March). Retrieved from https://www.boxborough-ma.gov/boxborough-2015/pages/water-monitoring

Water Treatment Solutions. (2019, February). Retrieved from https://www.lenntech.com/library/coagulation-floculation/coagulation-flocculation.htm

Appendix A: Public Outreach Materials

This appendix includes links and copies of the public outreach materials that were created for this project. These public outreach materials are meant to serve as framework for future focus groups, meetings, and research on the Littleton option. The presentation can be shown at town meetings if the town were to vote on funding options or possible courses of action, while the flier can be distributed to further businesses and residents in Boxborough.

Focus Group Presentation

Below is a link to our project website with the Focus Group presentation that was shown to Boxborough stakeholders during Week 6.

https://wp.wpi.edu/wroc/collaborative-solutions-to-improve-drinking-water-quality-in-boxborough-ma/

Salt Remediation Program Fliers

To encourage the 18 Businesses to apply for the Salt Remediation Program, a flier detailing the application timeline for the problem for public water supplies was created and given to each of the Focus Group attendees (along with a printed application). A flier for private well applications was also created to give to the Town of Boxborough in the event that they would like to either distribute it to residents or make it available to residents. Pictures of the fliers can be found below.

Figure 9: Salt Remediation Program flier for private well owners

Figure 10: Salt Remediation Program flier for public water supplies

Appendix B: Cost Analysis Worksheets

The second major deliverable for this project was a set of cost analysis worksheets that details collected costs for the various drinking water options that were researched. As Chapter 3 discussed, a complete cost analysis was not able to be created due to difficulties obtaining information and lack of expertise in associated areas. These cost analysis worksheets focus on costs associated with collaborating with Littleton. Most importantly, the sheets are meant to serve as a tool and framework for future work done on the Littleton option. New numbers can be plugged into the excel formulas and the study where each of the costs we used can be tracked.

Below is the link to our project website which has the cost analysis spreadsheet:

https://wp.wpi.edu/wroc/collaborative-solutions-to-improve-drinking-water-quality-in-boxborough-ma/

Sheet 1: *Notes and Abbreviations*. Includes a table of contents with the name of each sheet, its number, and a brief description of the sheet. Also has an abbreviation chart with abbreviations used throughout the spreadsheets and their meanings.

Sheet 2: *Littleton 2019 Monthly Cost.* This spreadsheet shows the cost of the 2019 Littleton solution, with costs broken down and distributed amongst the 18 Businesses (excluding Paddock Estates). The first three columns break down the number of gallons of water each business or living community uses annually, monthly, and daily. The next column gives the population (or number of units for the condos) of each business. The next column, water price/mo, estimates how much each of the 18 Businesses would pay every month for the amount of water they use if they were charged the current Littleton rate. The next two columns give the monthly water prices with a 5% and 20% adjustment if Littleton were to charge extra to bring water down to Boxborough. The Littleton Connection fees column estimates how much each of the 18 Businesses would pay to connect to Littleton's system based on Littleton's current connection fees. Condos are charged on a per unit basis. The remaining businesses are charged based on the pipe size of the connection. After speaking with a Littleton engineer, it was estimated that most of the businesses, other than Cisco, would require a 2" pipe or less. The construction fees were taken from Sheet 3 and distributed amongst the 18 Businesses based on the amount of water they use. If they use more water, then they would pay more towards construction costs. The next column, construction and connection, adds the two fees together. The C&C with 25% MassDOT funding shows how much each business or living community would pay for construction and connection costs if the MassDOT provides 25% funding towards the project. The C&C Payment per year over 30 years shows how much each of the businesses would need to pay annually for construction and connection fees, with the next column showing the same information but adjusted to a 25% MassDOT contribution. The next column shows how much they would have to pay monthly for 30 years for C&C, with the next column showing the same monthly costs with a 25% MassDOT contribution. The next column, C&C with DOT funds and 3% interest shows the cost each of the 18 would need to pay per month for 30 years for C&C with 25% DOT contribution and a 3% interest. The next column adds this monthly cost to the monthly cost for water with a 20% Littleton adjustment. The monthly C&C w/ 3% + Littleton water adjustment price per population (or unit) is geared more towards the condos if the condos would like to

charge each individual unit the cost for this project over the next 30 years. The second to last column, average monthly water cost per person (or unit) shows how much each single population or unit would have to pay monthly for just water. The final column, % water usage of total, shows how much of the total water usage in the area each of the 18 use.

Sheet 3: *Littleton's 2019 Solution.* Since the 2008 study was published, Littleton has recently been working with the Boxborough Water Resources Committee to create their own adapted version of Alternative #2. Rather than build a water treatment plant in Boxborough, the water from the Harvard Sportsmen's Club would be treated at the Littleton Water Treatment Plant instead. This spreadsheet gives the estimated costs of this plan.

Sheet 4: *WRC Cost Allocations*. This sheet was created by the Boxborough Water Resources Committee and sections off each major area in western Boxborough that could potentially have piping running from Littleton. Recorded is the distance from a specific area (such as Beaver Brook Road) to Littleton, the unit cost per foot, and total cost it would be to run the piping. It then broke down each residential and community area, stating the number of public water systems it holds and the population. This is useful as it provides an estimate of how much the piping would cost to run it up to the town of Littleton if the 2b solution was chosen.

Sheet 5: *WRC Demand Projections.* This spreadsheet breaks down each of the 18 businesses and living communities' population, the residential water use (gallon per day), and, for some, the commercial square footage of the entire property. This helped with monthly rate calculations to determine how much water would possibly cost if they were charged Littleton's rates.

Sheet 6: *WRC Future Phase Plans.* This information was also received from the Boxborough Water Resources Committee. The planning and designing process is discussed along with the implementation process of the 2019 Littleton option for the next 10 years. This is only a rough outline of possible planning. This is also based off if a solution is picked within the next year and the project starts within the near future.

Sheet 7: *CDM 2008 HSC Solution.* Costs taken from the 2008 CDM feasibility study done in Boxborough to assess different drinking water solutions to help solve water issues in western Boxborough. While the sheet includes the costs for both phases of each alternative, alternative #2, collaborating with Littleton to drill a new well at the Harvard Sportsmen's Club (HSC), build a water treatment plant at the site, and connect the new well to the Littleton Water system in order to supply Littleton with a new water source and give Boxborough access to Littleton's system, was deemed the best option. The first table sets give the estimates of project costs for all three alternatives while the second gives the approach to implementation of alternative 2.

Sheet 8: *RCAP Asset Assessments*. These values were obtained from RCAP Solutions. The sheet gives a breakdown of the type of piping material that is generally used for drinking water projects, like Littleton's system. Material such as ductile iron, cast iron, and copper were ranked on their condition and longevity if maintained. Also included in this sheet are the typical costs of piping and the valve sizes. The durability, length, price, size, and age of pipes all play a role in this project because as knowing what material to work with is important for cost.

Sheet 9: *Additional Fees.* This sheet details other fees that should be considered for future work that we were unable to consider in this cost analysis. Other than planning and implementation, there are betterment, contingency, and legal fees that need to be taken in consideration. These fees are extra consideration for room for extra and could cover extra costs if parts of the project did not go as planned.

Appendix C: Interview Summaries

MassDEP/MassDOT Initial Interview

Interviewer: Katie Vasconcelos

Interviewee(s): Marielle Stone, Laurene Poland, and Dr. Eric Hinlein

Note-Takers: Mike McGoff, Spencer Vinson, and Jake Wisniewski

Location: Phone

Time: 10am

Questions	Notes
1. Why are you involved in this project?	The drinking water problem needs to be solved before it gets worse and spreads to the whole town.
2. What is the motivation for this project?	The Boxborough town officials aren't very motivated to complete this project and haven't provided much support or interest to fixing their system. They still don't see this issue as a problem that can end up becoming very apparent. The MassDEP hopes that the town will become motivated by the fact that their own community is facing challenges. The overall motivation would be protecting public health and environmental safety. Portions of the town's drinking water is still being impacted with salt and there is no room to locate a drinking water supply on individual properties. There are also multiple aging infrastructure facilities that need tooe updated because they are facing sodium chloride issues, thus leading to more health risks.
3. What challenges might we face?	Each business will have their own opinion and different input. There may be some stakeholders willing to contribute a larger sum of money than others. Some may not want to contribute at all because they feel like they use less water than another company or living residency. There also has always been a lack of communication between each business, therefore nobody knows what the potential next step would be.
4. What challenges have you encountered so far?	Money is a huge driving factor for this project. The solution needs to be cost-

	effective, especially if the town won't be able to provide any financial resources. Finding open land to try and put a new water source has been difficult because of all the overlapping zones that are already corroding other individual water systems.
5. What major environmental and health concerns exist at our area of interest?	None that they know of or have encountered so far. The biggest concern is the salt runoff that is coming from highways after it snows and is mixing in with the drinking water.
6. Do you have any specific objectives for us?	Creating a cost analysis for the government agencies and any stakeholders that want to see a breakdown of the solution we end up coming up with. Also included in this cost analysis would be price comparisons from 2008 versus now versus 2028. Another goal should be compiling estimates for drinking water systems. Making sure the businesses understand that the solution that ends up being picked is a good deal for them would be part of our public outreach job.
7. What are you hoping to be the end goal for this project?	Finding a cost-effective and cost-efficient solution for residents and businesses to agree on.
8. Do you have any resources or documents for us to help with our preliminary research?	They have old maps throughout the years. Their appointed GIS mapping specialist was able to help print out more updated maps that can be used for the Focus Group and this final report. Also, they provided us with some 2017 ASR reports of each business. This helped us track the gallon intake of each business and living residency.

Interviews with the Boxborough Water Resources Committee

Interviewer(s): Mike McGoff and Jake Wisniewski

Interviewee(s): Leslie Fox and Bryon Clemence

Note-Takers: Spencer Vinson and Katie Vasconcelos

Date: March 18, 2019

Time: 10 am

Place: Boxborough Town Hall

Questions	Notes
1. What is your role as a part of the Boxborough Water Resources Committee?	Mr. Fox and Mr. Clemence conduct water research for the Town of Boxborough. The current western Boxborough water issues were first brought to their attention in June of 2018 when the MassDEP asked if the Town of Boxborough wanted to be a part of the current conversations. The WRC and the MassDEP has met with the 18 Businesses in September, December, and January to talk about the current water issues. The MassDEP also recommended that the WRC contact RCAP Solutions to help them solve the problem.
2. What kind of research has the WRC done regarding drinking water, wastewater, and stormwater in Boxborough?	A prior WRC had looked at groundwater problems in western Boxborough. The gas station in Boxborough had a leak of MBTE that quickly dissolved into water and a large effort was made to resolve the issue. The MBTE issue has since gone away. There was also a temporary perchlorate issue that was attributed to blasting in western Boxborough and sodium has been an ongoing concern.
3. Are you familiar with the water system issues at the Routes 495/111 intersection? If so, have you met with any of the businesses and living communities in the area to discuss it and potential solutions?	They have met with some and currently most are leaning towards a different source of drinking water.
4. Are there any possible solutions to water problems that have been discussed that could be helpful for our project?	A feasibility study could be helpful, but the costs would be the most helpful, especially costs for working alone versus working with Littleton. Negotiations with the Harvard Sportsmen's Club would need to be done before pursuing a solution with them, and another test well would need to be drilled to ensure that the water at the club is still sustainable.
5. Is connecting to a satellite water source other than Littleton a possibility?	Working with Cisco could be a possible option. This would involve a two-phase approach. Phase I would be hooking up with Cisco's water system to use their water to service Boxborough. Phase II would be building a new well, tapping into Littleton's water system, and use the new well's water to provide water to the areas that were serviced

	by Cisco in Phase I, and extend the service areas beyond.
6. How can we get stakeholders to begin to move in the same direction?	There seems to be a lot of gaps between what stakeholders do an do not know, so it is important to fill in the gaps.
7. Are there any other towns similar to Boxborough that have recently had to implement a new water system?	Charlton and Acton have both implemented or explored implementing new water systems recently. Charlton recently implemented a municipal water system, which would be an ideal solution for Boxborough, but Boxborough currently does not have the capability to run their own system. Acton looked into hooking up to the Massachusetts Water Resources Authority water system and wrote a report on why it was not feasible.
8. Are there any other resources that could be helpful for this project?	The Boxborough Town Hall website has a GIS mapping software that details land values for Boxborough that could be helpful for the cost analysis.

Interviewer(s): Katie Vasconcelos

Interviewee(s): Leslie Fox and Bryon Clemence

Note-Takers: Spencer Vinson and Katie Vasconcelos

Date: March 29, 2019

Time: 10 am

Place: Boxborough Town Hall

Questions	Notes
1. Would you say the 2008 CDM Study or the current Littleton Plan would be more feasible to implement at this time?	The current Littleton plan is less expensive than the CDM plan, so it could be more feasible. The current Littleton plan involves using Littleton's water treatment plant rather than building a water treatment plant at the Harvard Sportsmen's Club.
2. Do you happen to have any potential costs you can give us to help make a cost analysis for your plan?	Littleton has given the WRC some potential costs for their plan. The WRC would like to look into extending the current plan, and costs, to National Technical Services and to the Boxborough Executive Center. The cost analysis plan should also include engineering costs as well as a contingency factor that needs to get added in, which will increase the price. The WRC and Littleton also do not

	know what under the top layer of dirt, so they could be digging into soil or rock; they do not know yet. Littleton will also charge a "per unit" connection fees to each of the condos, so it will be more expensive. However, there is the possibility that betterment fees could pay for this project.
3. In the 2008 plan, the CDM broke down three alternatives. Which do you think is the best to pursue?	Alternative two is the closet to the current Littleton plan, but phase 2 should be eliminated since they will not be constructing more storage tanks.
Other Notes	Some of the land that could be acquired for a new well could be under conservation and it is very difficult to get land under conservation.

Interview with the Littleton Water Department

Interviewer(s): Spencer Vinson and Jake Wisniewski

Interviewee(s): Corey Godfrey and colleagues

Date: March 19, 2019

Time: 9am

Place: Littleton Water Department (39 Ayer Road, Littleton, MA)

Question	Notes
1. What is your area of expertise?	Mr. Godfrey is an environmental engineer that works for the Littleton Water Department and has had communication with the MassDEP. Littleton is very familiar with the 2008 CDM study and are willing to work with Boxborough to create a shared system. Currently, Littleton Water has about 3,300 connections and pumps about 350 million gallons of water every year. This month, they have pumped about 20 million gallons and generally pump about a million gallons every day.
2. Could you give us some more background on the Littleton-Boxborough solution that is currently being pursued?	Currently, Boxborough has two pressure zones, high and low. The low-pressure zone would work with the proposed system. Boxborough would provide Littleton with a new water source. Littleton would connect the water source to their treatment plant, give Boxborough access to Littleton's water storage tanks, and deliver water to Boxborough. The first step would be to talk to the Harvard Sportmen's Club to ask about building a well since the well would be large and would need time to develop. While this option is expensive, if Cisco could be convinced to join the effort, a lot of money could be saved since Littleton does not know where the money would come from. Hooking up to Littleton's system could also supply Boxborough with fire protection resources, which would lower insurance rates.
3. What is our involvement in this project?	Littleton started to get involved about a month and a half ago after speaking to the MassDEP.

4. Where do you currently stand on the Littleton Solution with Boxborough? What steps are currently being taken?	Nothing seems to be pursued actively, but Littleton hopes that Boxborough will act on this problem in the near future.
5. Who from the town of Boxborough have you interacted with in regards to this project?	Littleton has spoken with the MassDOT and MassDEP.
6. What have you found is the best way to interact with all the stakeholders in Boxborough?	Littleton hasn't really interacted with any of the businesses or stakeholders in Boxborough.
7. How long would installing pipes from Littleton take? What is the timeline like for this solution?	To build piping, it could take a year to a year and a half. The process as a whole could take about three to five years. Cost has become a big problem since implementing such as system in Boxborough back in 2008 would have been less expensive than it is now, and if Boxborough continues to push off this expansion, the price will only increase. For the current Littleton/Boxborough solution, with Boxborough using Littleton's Water Treatment Plant, it would cost about $6 million.
8. Who else is connected to the Littleton water source?	Currently, there are emergency connections with Westford and Acton. Other than that, there are only connections in Littleton.
9. Do you have any health/environmental concerns that might conflict with this project that we should be concerned with?	None

Interview with the MassDOT

Interviewer(s): Katie Vasconcelos

Interviewee(s): Laurene Poland

Note-Takers: Mike McGoff, Spencer Vinson, Jake Wisniewski

Other Attendees: Scott Jiusto

Date: March 20, 2019

Time: 11am

Place: Phone Interview

Questions	Notes
1. What companies in Boxborough currently take advantage of the Salt Remediation Program	The Boxborough Executive Center has been approved for the Salt Remediation Program and the MassDOT is currently helping them find remediation options. In order to qualify for the program, the MassDOT needs to determine if the location has high salt levels due to the MassDOT's operations. To do so, their water is sampled for a year to monitor any changes. This data helps determine how the MassDOT can best assist someone that qualifies for the program. For the Executive Center, the MassDOT took a holistic approach by switching from sodium chloride to calcium chloride to treat snow in that area and putting extensions on the nearby salt shed to help sweep salt back into the facility as it is being used. However, these remediation techniques won't immediately solve the problem. To help with immediate changes, the MassDOT is looking into implementing a Reverse Osmosis System at the Executive Center that will also help take care of lead and copper in the water. Since the MassDOT uses taxpayer money, all of their remediations must be as cost-effective as possible.
2. Do you have a cost analysis of the salt remediation program? If so, would we be able to have access to it?	Currently, there is not a cost analysis available, but one is in progress. However, treating a business center is much different than a condo and the costs aren't really scalable. For reference, to install an RO system into a 3-bedroom home, it costs about $25,000. Condos would need a massive

	system that isn't really practical. RO systems also leave behind salty brine, and that brings the question of where that brine should be dumped.
3. Where are the storm drains of concern located?	The MassDOT has a preliminary map marking storm drain locations, but it isn't finalized.
4. Have you met with any of the 18 Businesses we will be speaking to? What was their attitudes towards this project?	Other than the Boxborough Executive Center, only the Brook Village Condos is in the process of applying and being tested.
5. Between drinking water, wastewater, and stormwater, which aspect do you think would be most beneficial to address first?	A new source of drinking water would be the best option since the salt and wastewater issues would go away once a drinking water source is relocated. Connecting to Littleton would be the best option, but currently, Littleton doesn't have enough water to service western Boxborough. If more people were to buy into the Littleton system, then it would cost less, but extending the system past 495 would be costly. Locating a new drinking water source in Boxborough to create a water district is an option, but would take an extremely long time.
6. What funding for this type of project would be available from the DOT?	The MassDOT is not fully responsible for the high salt levels in Boxborough. There could be some funding from the MassDOT, but Boxborough does have a lot of impervious surfaces that they salt and is not under the MassDOT's service.

Interview with RCAP Solutions

Interviewer(s): Katie Vasconcelos

Interviewee(s): James Starbard (RCAP Massachusetts State Lead), Laurie Stevens (RCAP New England Technical Compliance Specialist), and Laurene Poland

Note-Takers: Spencer Vinson and Katie Vasconcelos

Other Attendees: Mike McGoff and Jake Wisniewski

Date: April 1, 2019

Time: 9:40am

Place: WPI Campus Center Chairman's Conference Room

Questions	Notes
1. What is RCAP Solutions?	RCAP is a nationwide, government funding non-profit that helps small water and wastewater systems plan and get financing for new project. They help systems with 10,000 people or less.
2. What is your role at RCAP?	Mr. Starbard and Ms. Stevens have worked with the MassDOT as well as with the Littleton Water Department on the water problems currently going on in Boxborough.
3. Are there any Boxborough water solutions that have already been discussed?	One possible option is for the businesses and living communities in western Boxborough to apply for the MassDOT's salt remediation program. Mr. Starbard sent them applications, instructions for applying, and an offer to help them apply, but he didn't receive any responses and the MassDOT did not receive any additional applications. Although RO systems are a popular method for remediation, using it for the condos is not a feasible option as they have so many units. RCAP has been in contact with Littleton about looking to drill a well at the Harvard Sportsmen's Club and running a water main up to the Littleton Water Treatment Plant. However, they have not heard anything further from Littleton since an initial discussion.
4. What would you suggest the WPI team look at when creating a cost analysis plan?	Long- and short-term solutions could be beneficial to look at since Boxborough was scared about the cost of the CDM solution in 2008.

5. What sources of funding exist for this type of project?	Types of funding do exist for communities with less than 10,000 people. Western Boxborough has the option to apply for funding individually, as a unit, or the Town as a whole could apply (one large loan or many small loans). The state revolving fund and clean water fund could be possible options. For the clean water fund, applications are submitted once a year in August and the winner of the money is announced on Earth Day. However, the application is very competitive and it takes a long time to find out if you did nor did not win. Bank loans could be another option, or writing the project as a state budget line. The MassDOT could provide some funding, but an amount cannot be determined until the MassDOT determines how much they contributed to the problem.
6. How might betterment fees play a role in the cost of this project?	Betterment fees are assessed in property values. If a public water line is run through someone's property, the property value will increase. The fees could help pay for the project but if the MassDOT pays for the project, there will not be any betterment fees since the MassDOT paid for the infrastructure.
7. Which of the 18 Businesses do you recommend we reach out to?	The WPI team should contact all 18 Businesses that are involved. RCAP had a meeting with them in December and felt that attendance was good and that they all wanted to collaborated.
Other Notes	Since the 2008 CDM study has been conducted, some of the locations that were pursued as a possible water source have been sold, so Boxborough should consider securing more land for future water needs. In addition, if Boxborough does not do anything about these issues, then parts of their Master Plan may not be able to be accomplished. The Zone Is and IWPAs in western Boxborough are so heavily populated that nothing else can really be built on the land. Littleton, since they have public water, has experienced massive growth over the past few years.

Interview with Wayland Town Engineer

Interviewer(s): Spencer Vinson & Jake Wisniewski

Interviewee(s): Paul Brinkman (Wayland's town engineer)

Note-Takers: Spencer Vinson & Jake Wisniewski

Date: April 11th, 2019

Time: 11:00am

Place: WPI Gordon Library (phone interview)

Questions	Notes
1. What does your job for the public works entail?	Brinkman used to be a consultant for companies to help get them close estimates on what they would need if they were to create a water system. What he does is he starts at a high number for his customers, and as he receives more detail about the project... the price goes down.
2. A rough cost estimate for a storage tank?	For a 50,000 gallon tank plus the pumps and chemical treatments, it would be around $3,000,000. Just if the tank was in the ground with running pumps.
3. A rough cost estimate for interconnections?	This depends on the durability of the road the piping is being placed under and we would have to include the cost that covers restoring the roads once the piping is installed. This estimate would be around $200-$250 per foot. However, Paul did inform us that there should be a plan for fire flow. The bigger the pipe, the more expensive it will be.
4. Do you have any sort of estimates for operating a treatment plant?	If Boxborough were to build a treatment plan t from scratch, it would be around $5,000,000 plus the cost of a septic tank. If each business roughly used around 50,000-75,000 thousand gallons per day, that would come out to $200,000 per year.
5. Are there any other alternative ways to transport the water other than running piping up to Littleton?	Finding a singular groundwater source would be around $1,000,000 and is considered cheaper than running piping.

Appendix D: Focus Group Discussion Summary

Date of Focus Group: April 18th, 2019, 6-8 pm

Location of Focus Group: Boxborough Town Hall

Number of participants/names/who attended: 17 participants from Harvard Ridge Condominiums, Brook Village Condominiums, LPCH Boxborough, SYNQOR, Sentra Systems, Jumbo Capital Management, Mass. Ave. Gulf, WhiteWater, RCAP Solutions, the Boxborough Water Resources Committee, the Dartmouth Group, and residents from Marlborough and Boxborough.

Moderator Name: Katie Vasconcelos

Assistant Moderator Name: Jake Wisniewski

Note-Takers: Spencer Vinson and Mike McGoff

Note taking template, adapted from Kreuger *Focus groups : a practical guide for applied research*:

Question 1: Is this also your understanding of the water issues western Boxborough is facing? Does anyone have anything to add?

Key Points/Notes	Follow-Up questions
• WPI group had a solid understanding of the DEP regulations and what is currently going on in western Boxborough. • Representative from Harvard Ridge believes that the salt shed is the bigger problem since the salt levels of businesses and living communities around the salt (especially south) are higher than those further away. • Boxborough engineering representative believes it is a combination of both because businesses that are relatively far from the salt shed are seeing increasing salt levels.	• What direction does water from the MassDOT salt shed? • Which is the main cause of high sodium levels? The MassDOT salt shed or the salt that is spread on the highways?

Question 2: What concerns do you have about the current water issues or your own water systems?

Key Points/Notes	Follow-Up Questions
• Harvard Ridge does not have anywhere else they can drill a new well, so they are hoping to find a solution that can relocate a well farther away from their property since they also are experiencing higher sodium levels.	• Are there other types of road treatments for snow, such as calcium chloride?

• Mike: There are other treatments, but many of them still involve using chloride. • Les Fox: Boxborough had used a combination of salt and sand on their roads but recently switched to just salt. Sand was clogging storm drains. Currently, they are using the same amount of salt they used when it was mixed with sand and it was just as effective. • Some of the Boxborough Stakeholders do not have any problems with their water systems and have relatively low sodium levels, but this could eventually become a town-wide problem. These water issues could be thought of on a community level. • Other people reported that other pollutants are affecting water quality in other areas of Boxborough. One type of other pollutant mentioned was radon.	

Question 3: How do you feel about the outlook of where these water problems could project over the next ten years?

Key Points/Notes	Follow-Up Questions
• Concerned that Mass. Ave will start to experience higher sodium levels. • The DOT has already said that reverse osmosis is not a viable option for condos. Condos use too much water for the system to handle purifying water for drinking through RO, so a different remediation solution would have to be pursued. • The cost to implement a RO system into a 3-bedroom home is about $25,000, so implementing these systems is very expensive. • Brook Village engineering representative does not think that the salt issue will get any better even if salt were to be eliminated. The salt has made its way into aquifers and deep into rocks and it would take a very long time for that salt to clear out. If reverse osmosis where to be used, it still leaves behind a salty brine, and the question of where do you put that salty brine.	• What is the possibility of implementing Reverse Osmosis systems? • Would removing the MassDOT salt shed help solve the high salt issues?

• Harvard Ridge Representative has already spoken to the MassDOT about removing the salt shed and they are resistant to do so as it would cost $5 million to remove it.	

Question 4: How do you feel about the three options we just presented? Why does option (blank) sound more or less appealing?

Key Points/Notes	Follow-Up Questions
• Brook Village engineering representative believes that option 1, do it yourself, just isn't an option. Wastewater and stormwater issues will only continue to worsen, and more money will need to be spent to continue to keep water clean. Believed that option 2, Collaborating with Littleton, would be the best option to pursue. • There are not very many businesses or living communities near the town line and the Littleton system may not have the capacity to expand into Harvard. • Bryon Clemence believes that pursuing the Littleton option could take ten years. • Many of the Boxborough stakeholders were concerned about permitting as, if they decide to collaborate with Littleton and create a new drinking water source that would help their wastewater and stormwater issues, they feel they would be paying double to fund the Littleton system and pay to do any permitting upgrades while the system is being built. • Les Fox: Back in 2008, when CDM Smith conducted a water study in Boxborough, the Town was concerned about the high cost and, at the time, did not want to fund any further studies. This problem hasn't been revisited on a town level since then so it would need to be presented again. • Bryon Clemence does not think that the Harvard Sportsmen's Club well could have the capacity to serve the entire town.	• Would anyone on the Harvard/Boxborough border be interested in sharing the Littleton solution? • What does the timeline look like for collaborating with Littleton? • If the Boxborough stakeholders pursue the Littleton option, what would happen to permitting from the DEP side? Would they still enforce needing to update their systems? • Is the Town of Boxborough interested in pursuing or funding any of these options? • Could the Littleton option eventually create collaboration with the entire town? Is there the possibility of it serving the entire town? • Could connections from the Littleton water system be made to the condos' existing pump houses? Reusing the existing water lines could help reduce the cost.

Currently, Littleton is only looking at servicing western Boxborough. • Creating a longer list of participants for the Littleton Solution would help make this a cheaper option for each involved stakeholder. • General consensus was that Collaborating with Littleton is the best option as it moves the drinking water source away from high salt levels and would leave water management to Littleton. • Many of the Boxborough stakeholders also feel that the MassDOT has a lot of accountability for the high salt levels they are experiencing even though there are other impervious surfaces in the area. • If the drinking water source were to be relocated, other water concerns in Boxborough, like radon and perchlorate, would also diminish. • Littleton is planning to charge a connection fee to each individual condo unit.	

Question 5: What are your thoughts and concerns about working together to pool resources and pursue a collaborative solution to this problem?

Key Points/Notes	Follow-Up Questions
• Boxborough already has a good relationship with Littleton as they provide Boxborough with electric services. • Collaborating with Littleton would bring many different people into the solution so it could be a long timeline. The Town of Boxborough would need to be involved in this solution since they have to assess betterment fees, land acquirement, legalities, etc. • MassDOT could provide some funding if there in an increase of applications to the Salt Remediation Program.	• What type of funding could be available for the Littleton Solution?

Question 6: What do you think of these next steps?

Key Points/Notes	Follow-Up Questions
• Applying for the Salt Remediation Program is a viable option.	• What are some next steps from the MassDEP?

• Drilling more test wells would need to be pursued soon to see if the HSC is still a viable option. • Also need to start considering and looking into how the Littleton Solution could be funded. • The Littleton Solution should also be brought to the Town to see if there is any interested.	

Question 7: How do you feel about the urgency of the problem after seeing our presentation? Do you feel about the same before or more motivated to act now?

Key Points/Notes	Follow-Up Questions
• The Boxborough stakeholders are interested in finding a collaborative solution and want to continue the conversation. • Option 2 still seems like the easiest, most viable option. • Les Fox invited those that attended to meet again the week after the presentation to continue the discussion.	

Question 8: Do you have any final questions or comments for us?

Key Points/Notes	Follow-Up Questions
• Follow-up with the MassDEP on wastewater permitting and regulations. • The WPI group made option 2 sound like a very attractive option for the Boxborough stakeholders.	

Appendix E: Maps from the MassDEP

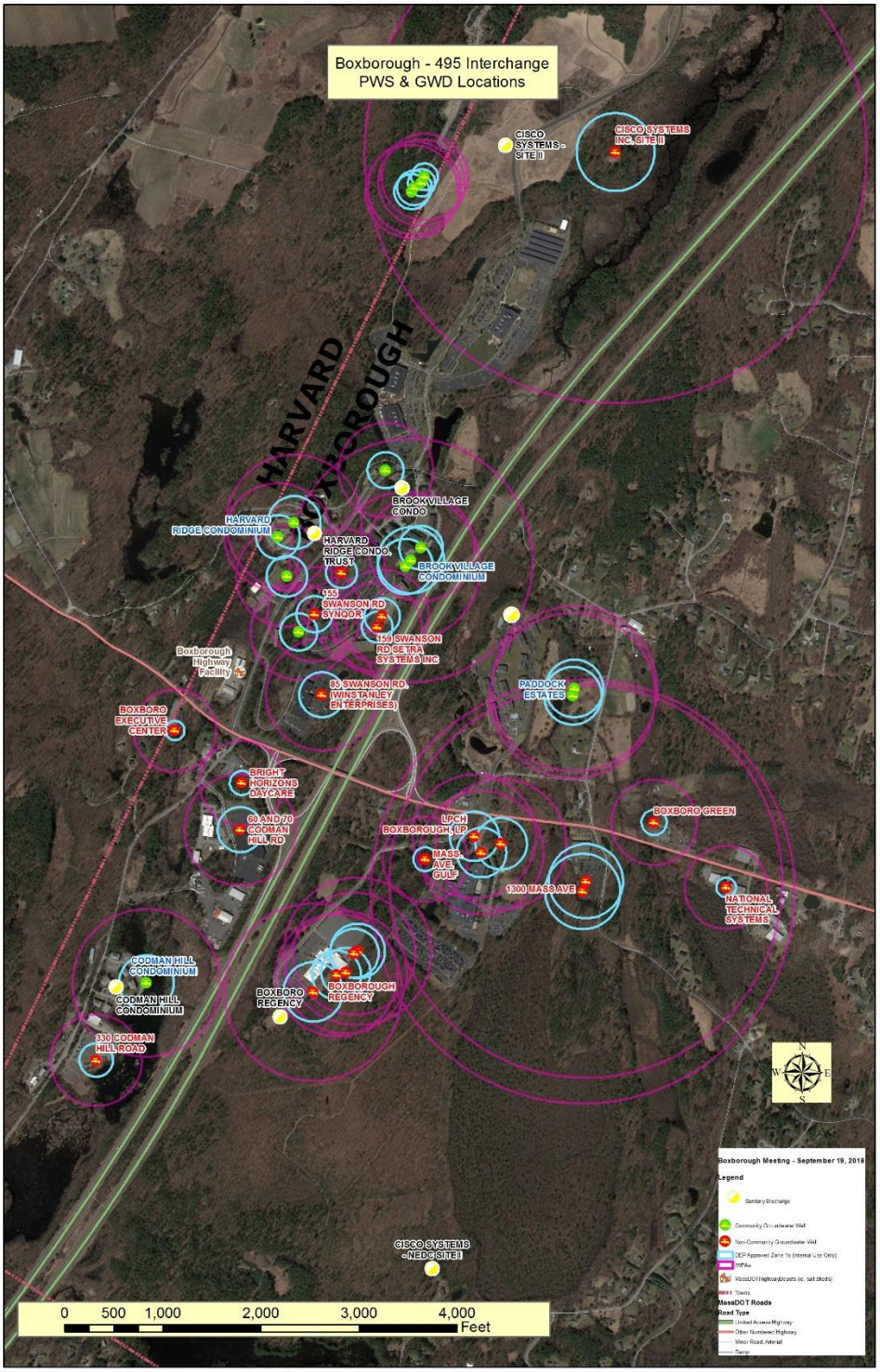

Figure 11: Map from MassDEP labeling the 18 Businesses' locations as well as well heads and sewage systems.

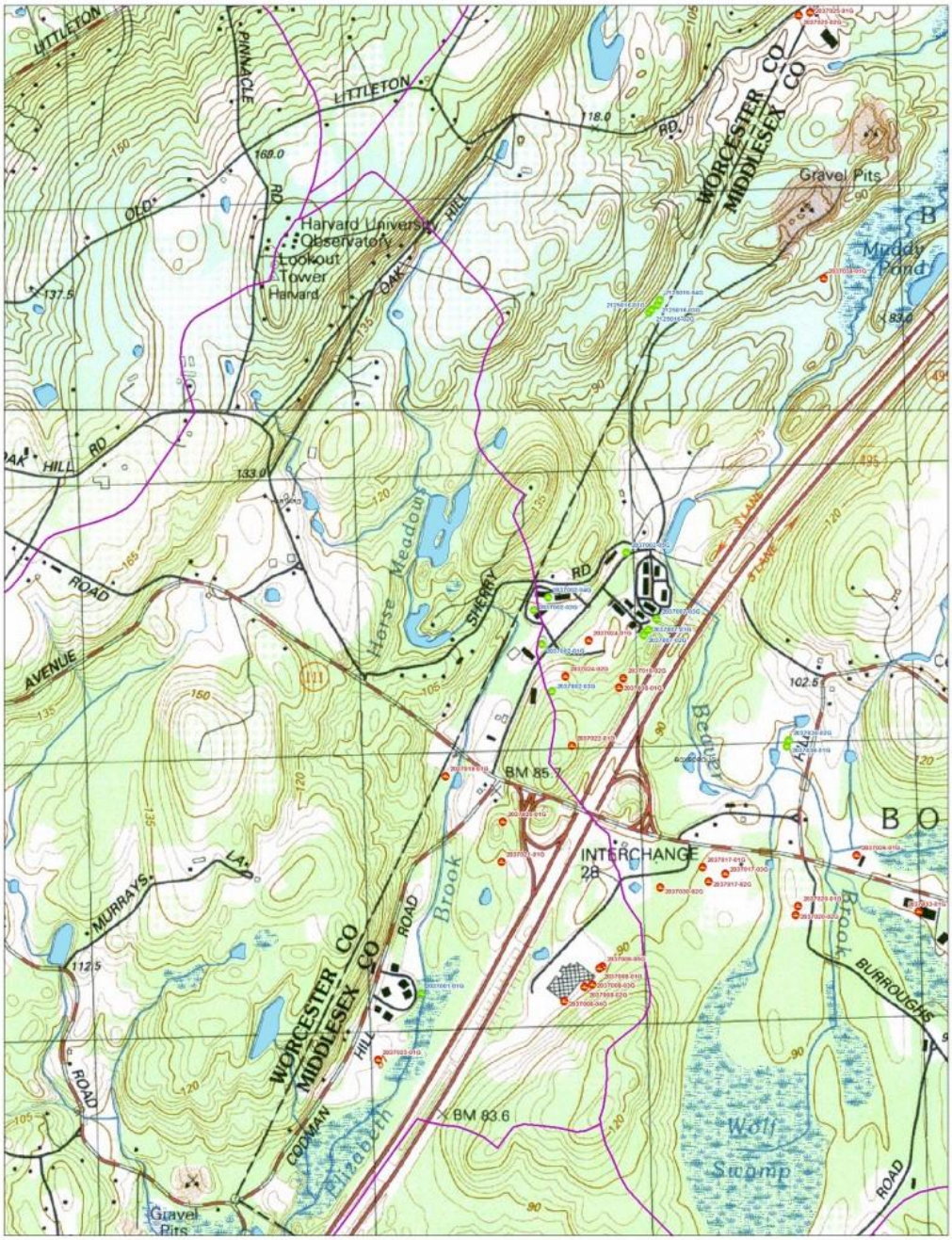

Figure 12: Topography map of western Boxborough with public water supply wells

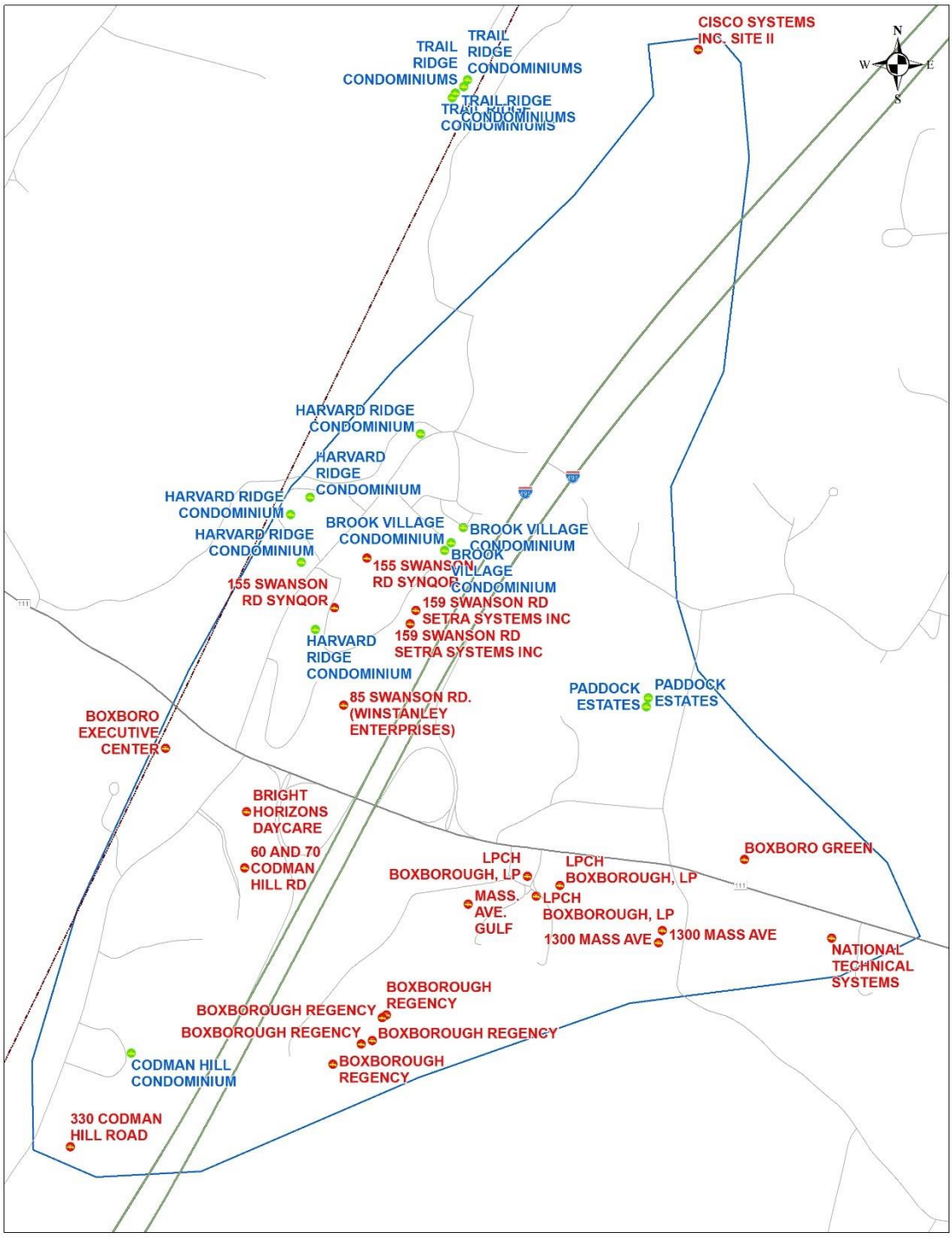

Figure 13: Area of interest with public water supplies, business, and living community names

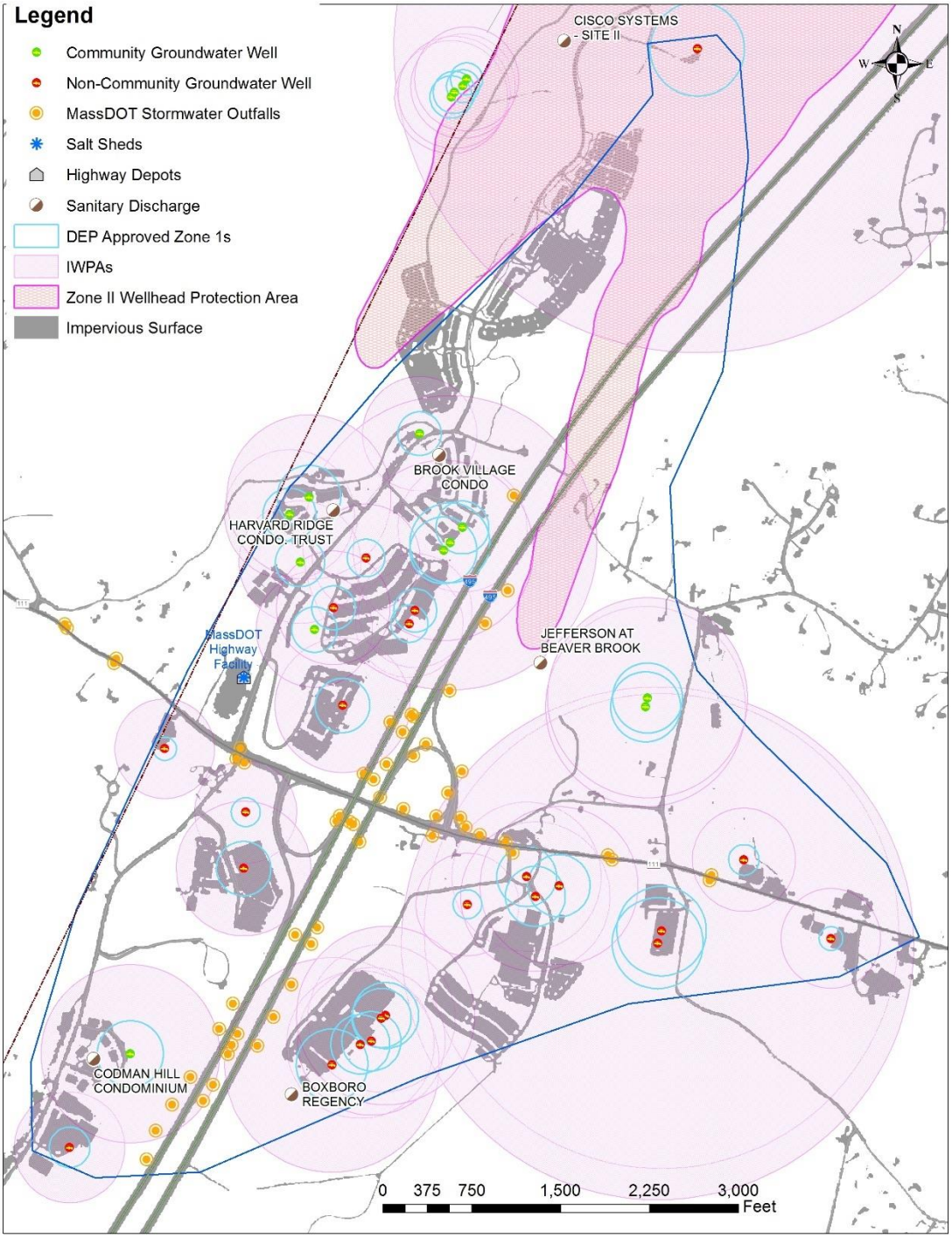

Figure 14: Map of Boxborough with wells, sanitary discharge, stormwater outfalls, salt storage facility, and impervious surfaces

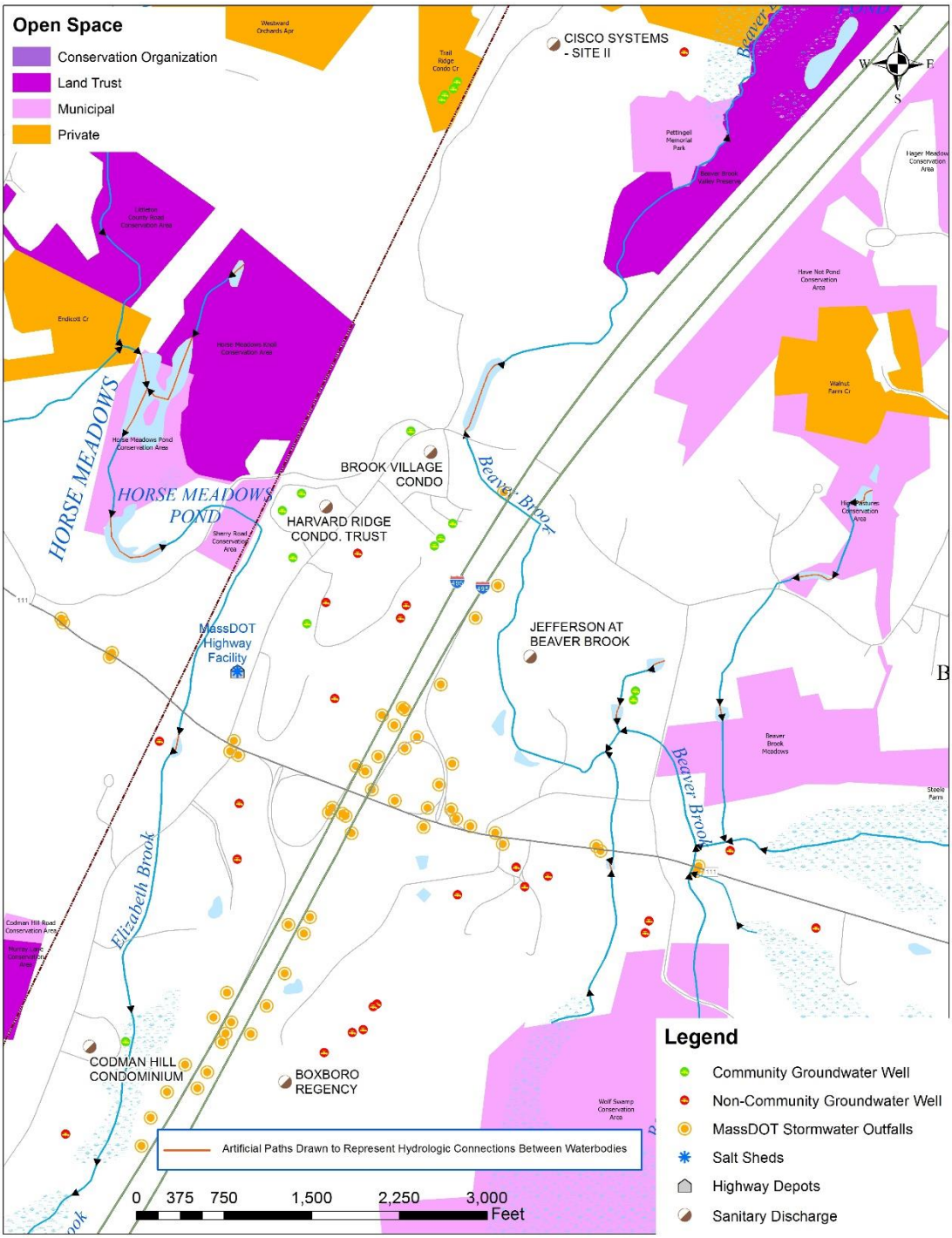

Figure 15: Map of western Boxborough with direction of water flow marked with arrows

Appendix F: Table of the 18 Businesses' Information

https://wpi0.sharepoint.com/:x:/s/gr-wroc19commwater/EeoCdm0TK8JJgO2oHz36AIAB8FZnZqOUlw9AhBJg20t65Q?e=THhCfq

Appendix G: Informed Stakeholder Consent Statement

Hello,
We are the Boxborough Community Water IQP team from Worcester Polytechnic Institute. We are currently working with the MassDEP and the MassDOT to develop a more functional and cost-effective water system solution to support local businesses near the intersections of Routes 495 and 111 in the Town of Boxborough, MA. We would like to hear
your thoughts about water issues in the area and some options we've identified that might help local businesses in Boxborough.

With your permission, we might include information you provide in our report that will be published online. However, your identity will be kept confidential and anything from this meeting used in our report will not state your name or identifying characteristics, unless you explicitly grant us permission to do so.

This meeting is completely voluntary. You may decide not to participate at any time and any information you provide will not be used in our report. You have the right not to answer any question you are not comfortable with, and you may withdraw responses at any time.

You will be provided with a copy of this statement so that you are aware of your rights and have access to our contact information if you have any questions after today.

If you have questions or concerns about our conversation, feel free to contact us using the information below:

Mike McGoff
mdmcgoff@wpi.edu

Katie Vasconcelos
kmvasconcelos@wpi.edu