Understanding Stormwater Policy Gaps:

A case study of two municipalities in Eastern Massachusetts

A thesis submitted by

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Abstract

For the northeast region of the United States, precipitation is projected to increase over time due to climate change and runoff from urbanization and impervious surfaces. EPA Phase II Small Community MS4 policy is a federal mandate that guides local community stormwater management strategies. Commonly cited permit challenges for MS4 permittees are aging infrastructure, increased capital costs, expanding regulations, and lack of technical resources. This study examined two communities in Massachusetts working under the jurisdiction of Phase II MS4 permits for stormwater management. The finding suggest that the municipalities' ability to address costs varied based on their needs and the available resources to comply successfully. Additionally, minimum control measures differed in their approach to meeting compliance and collaboration. The recommendations focused on implementing a stormwater utility fee to address costs, strengthening municipal stormwater partnerships with regional and watershed organizations, and implementing an "Adopt-A-Drain" program as a BMP for the communities.

Acknowledgments

In memory of Shelly Krimsky. I want to thank Professor Mary Davis and Scott Horsley for their support.

Thanks to my friends and family for their support!

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Abbreviations

BMP: Best Management Practices for [stormwater under Phase II MS4]

CSO: Combined Sewage Overflow

CWA: Clean Water Act

DPW: Department of Public Works

GI: Green Infrastructure

IDDE: Illicit Detection and Discharge Elimination

MCM: Minimum Control Measure

MS4: Municipal Separate Storm Sewer System permit

NPDES: National Pollutant Discharge Elimination System

PO_4: Phosphorus

SuAsCo: Sudbury-Assabet-Concord river watershed

SWMP: Stormwater Management Plan

TMDL: Total Maximum Daily Load

UA: NPDES Phase II designated **Urbanized Area and population density**

Chapter 1: Introduction

1.1 Introduction

Stormwater has been managed through stormwater drainage infrastructure systems to limit the nuisance of pollutants and potentially damaging flooding due to large volumes of runoff generated from urbanization (US EPA, 1999). Stormwater is still an issue as a non-point source pollutant in the waters of the United States (US EPA, n.d.). Per the United States Environmental Protection Agency (US EPA), municipalities must ensure that waterways are not further degraded by water pollution under the federal Phase II Municipal Separate Storm Sewer System (MS4) permit program. The Phase I and II MS4 program is 30 years old, and most MS4 communities have gone through multiple permit cycles (Taylor et al., 2021). Communities dealing with Phase II MS4 permits vary in stormwater management based on cost, permit compliance, and collaboration. In the northeast region of the United States, precipitation is projected to increase incrementally due to climate change and runoff from urbanization and impervious surfaces. This thesis will review the Phase II MS4 program in the northeast region, explicitly examining the stormwater policy of two eastern Massachusetts municipalities and evaluating the permit's challenges and benefits.

1.2 Stormwater

Stormwater runoff is from rain and snowmelt that flows over land or impervious surfaces (i.e., paved streets, parking lots, and buildings). Figure 1.1 shows the impact on the hydrological cycle for non-impervious versus impervious surfaces (EPA, n.d.). Stormwater runoff can pick up and deposit harmful pollutants (i.e., trash, pet waste, poorly managed grass clippings and yard wastes, leaf matter, residuals from pesticides/fertilizer, and sand/salt from winter treatment) into

nearby water bodies (i.e., lakes, stream, and groundwater) as non-point source pollution (US EPA, 2021; Moore, 2016). Other impacts of stormwater runoff include flooding, community health effects, streambank erosions that can lead to property damage, sedimentation, impact on groundwater recharge, and recreational opportunities (Penn State Extension, n.d; EPA, 1999). Stormwater has been managed using two types of sewer systems to convey stormwater runoff: separate storm sewers and combined sewers (US EPA, 1999). Separate storm sewer systems (MS4) and combined sewers (CSO) are two different sewer designs. MS4 has separate stormwater runoff and sewage drainage, whereas CSO combines both sewage and stormwater during storm events.

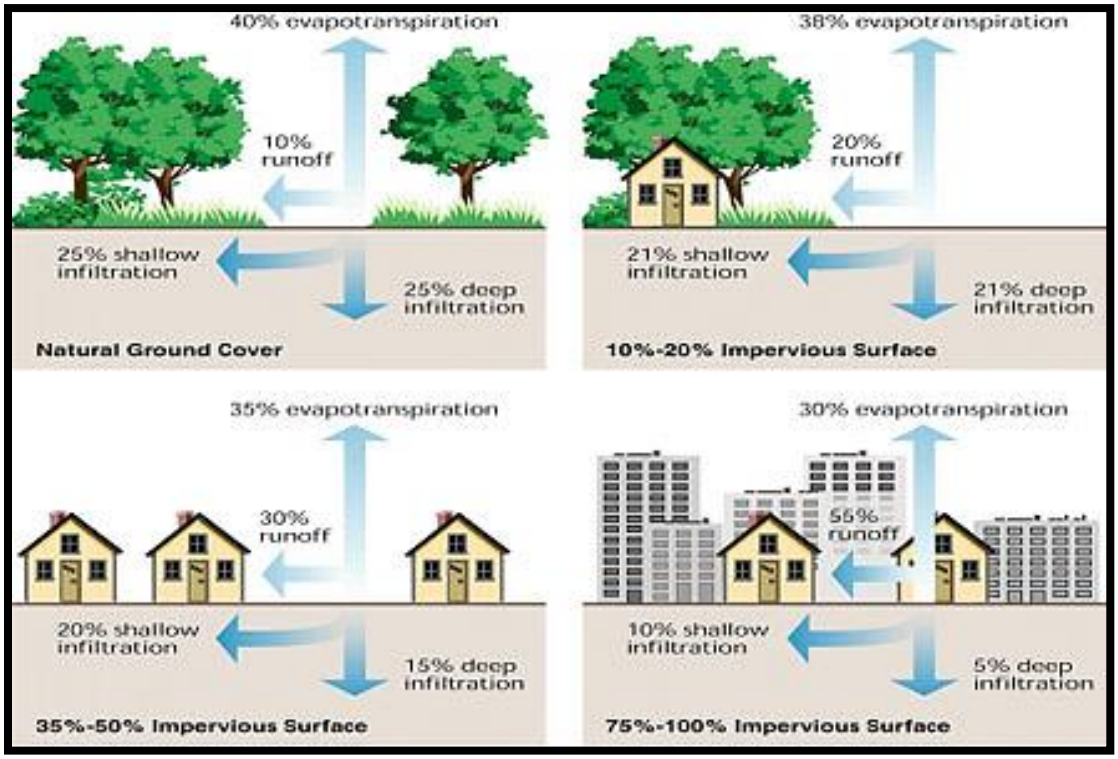

Figure 2.2: Impact on hydrological cycle for non-impervious surfaces vs. impervious surfaces (EPA, n.d.).

1.2.1 Stormwater: runoff impacts in urban areas

Stormwater is one of the most significant sources of water pollution in many waterways in the United States (Water Environment Federation, 2021). More recently, stormwater has accounted for 85% of non-point sources in waterways compared to 10% in 1970 (Water Environment Federation, 2015). Small and mid-sized cities with a population of less than 200,000 have accounted for 24% of urban populations and 35% of urban land areas, representing a significant contingent of urban systems in the United States (Hale, 2016). Urbanization impacts the hydrological processes through changes in land cover, the burial of streams, changes in lakes, re-plumbing of watersheds with stormwater infrastructure, and redesign/restoration of streams (Hale, 2016). The impact of urbanization and increased stormwater discharges includes increases in the number of full stage height and peak flow rates, sedimentation and transport, frequent flooding, streambed scouring and habitat degradation, shoreline erosion, stream bank widening, decreased baseflow, loss of fish population and aquatic species, aesthetic degradation, changes in the stream channel, and increased temperatures (US EPA, 1999).

Flooding is expected to become more frequent, increasing precipitation by 40% projected by 2070 to 2090 and high streamflow with instream erosion in the Northeast and Midwest regions (Dupigny-Giroux et al., 2018; Hayhoe et al., 2018). Projected changes in precipitation and seasonal temperatures would affect streamflow depending on watershed conditions and changes in streamflow during the summer months (Zamuda et al., 2018). Increased evaporation from warmer temperatures, changes in the timing and amount of streamflow from snow, and changes in the amount, timing, and type of precipitation, may also intensify droughts (Runkle et al., 2017).

The current pressure of stormwater and water infrastructure will worsen as urban populations grow to about 70% by 2050, with shifting precipitation patterns such as increased

droughts in some areas and intense and frequent storms in other regions (Water Environment Federation, 2021). Climate change has impacted the amount of rainfall, timing, and intensity combined with land development affecting the amount of stormwater runoff that needs to be managed (Asam et al., 2016). Impervious surfaces in cities and suburbs are expanding and exacerbating urban flooding, resulting in $9 billion in damages annually (ASCE, 2021). Cities, towns, and suburbs have developed over time to adapt to growing populations, which increased impervious surfaces that have led to the rise of stormwater runoff. Drainage systems have been placed with stormwater infrastructure and sewer systems, where the infrastructure is aging, poorly maintained, and undersized (Festing et al., 2015). For cities and towns to manage non-point source runoff from impervious surfaces, the EPA requires cities and towns to permit stormwater.

1.3 Stormwater permitting

Under the Clean Water Act (CWA), which prohibits the discharge of pollution into the United States' waterways, the National Pollutant Discharge Elimination System (NPDES) permit was established as a uniform, technology-based effluent limitation program applied to thousands of point sourced dischargers. The program was established to enforce individual discharges (Percival et al., 2018). Stormwater runoff has been worsened by human activities. It contains nitrogen and phosphorus pollutants, which in urban and suburban areas produce more runoff, in part, due to the high number of impervious surfaces (EPA, n.d.). The biggest issue with the NPDES permit involves non-point source pollution, which has evolved into the largest single source of water quality impairment in the country (Percival et al., 2018).

Over the past 30 years, the EPA has rolled out a national stormwater permit program (Phase I and Phase II) based on urbanized areas from the U.S. census (i.e., Phase I is required for

population size >100,000, and Phase II is required for population <100,000 across all states). There is an exception for two waiver options for the Phase II Small MS4. They consist of option 1, which includes <1,000 people within the urbanized area, a stormwater system not contributing to pollutant loading of an interconnected MS4, and within the limit for TMDL that addresses pollutants of concern; option 2 includes <10,000 people based upon population density. Waters of the US that receive discharges and meet the TMDL limit that addresses pollutants and future discharges from the small MS4 that do not have the potential to exceed water quality standards (US EPA, 2012). Figure 1.2 shows where Phase I and Phase II MS4s are located across the United States, which accounts for 80% of the population within the MS4 areas (US EPA, 2021).

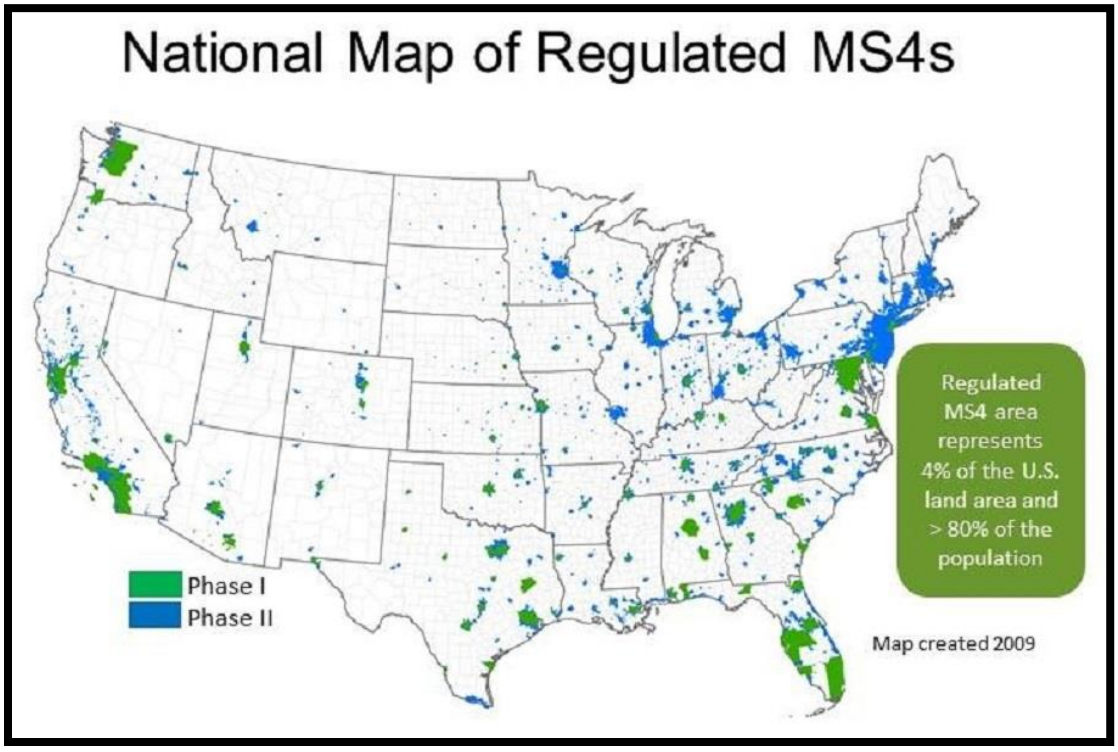

Figure 1.3: National map of regulated MS4s in the United States (US EPA, 2021).

1.3.1 Phase II MS4 final rule

The Phase II MS4 program applies to regulated small municipal MS4s within the designated Bureau of Census defined urbanized areas (UA). The UAs are based on the current decennial census. Once a small MS4 is selected, it cannot be removed from the program unless it leaves the designated U.A. (EPA, 2012). The Phase II program approach entails encouraging general permits and flexibility for regulated operators to determine which stormwater control to use. The process includes public education and participation efforts, facilitating and promoting watershed planning and applying on a watershed basis, and working towards a unified and comprehensive NPDES program with the Phase I program (EPA, 2005).

In 2014, during the next round of Phase II MS4 permit proposals from the EPA, there was criticism from states that EPA did not have the technical knowledge to regulate stormwater across the nation. Instead, critics argued that stormwater regulation is best made at the state and local levels due to differences in stormwater discharges (Copeland, 2015). As part of stormwater management under the MS4 permit program, municipalities require stormwater management practices through local ordinances, building codes, and development plans (ASCE, 2021). EPA is to provide incentives, technical assistance, and other approaches for cities to address stormwater and promote green infrastructure as a part of stormwater management (Copeland, 2015).

As states are federally required to implement the stormwater program, the mandate for states to enforce the program puts pressure on utilities and municipalities to implement the Phase II Small MS4 permit and ensure that waterways are not further impaired.

1.3.2 Phase II MS4 program and challenges

In 2018 and 2020, a national MS4 program assessment survey was completed to understand the MS4 program challenges, identify information and resource needs, and estimate

current funding levels and conditions in the MS4 sector. The Phase II MS4 permittees found the main challenges were aging infrastructure, funding/capital, increasing/expanding regulations, technical resources with funding/financing needs, assets management, and watershed-based planning (Taylor et al., 2021).

The Phase I and II MS4 programs provide two levels of control: technological and water quality-based limits (US EPA, n.d.). Municipalities must consider these needs as states are federally required to meet the Phase II MS4 permit requirement to reduce further water quality impairment through the permit and local stormwater measures.

For municipalities to handle aging infrastructure, water quality, and land development, a stormwater fee to fund the stormwater program can be used to manage costs (Taylor et al., 2021). Regulations, governance, and institutions shape the landscape around how stormwater management decisions are made to support stormwater approaches (Water Environment Federation, 2015). Communities must be compliant under Phase II MS4 permit with measurable goals such as public education and outreach, public participation and involvement, illicit discharge detection and elimination, construction site runoff control, post construction runoff control, and pollution prevention (WEF, 2015).

As states are required to implement the Phase II MS4 permit and delegate to cities and towns, some states remain under EPA jurisdiction, such as Massachusetts.

1.4 Region 1 Phase II Small MS4 Stormwater in Massachusetts

Stormwater is one of many challenges that communities in Massachusetts face due to numerous factors involved in meeting the stormwater permit goals. Much is at stake since stormwater in Massachusetts is the most significant contributor of pollution to impaired rivers, lakes, streams, ponds, and other water bodies (US EPA, 2020). The Phase II Small MS4 permit

was implemented in Massachusetts in 2017, but it took until 2018 through legal action to ensure that the permit was enacted. The revised permit requires municipalities to update and enhance their stormwater management plans, map stormwater systems, monitor outfall pipes, and undertake a cleanup to improve water quality and decrease public health risks from climate change (OARS, 2017).

EPA administers Phase II MS4 stormwater permits for four states, including Massachusetts. Stormwater permitting for Massachusetts and New Hampshire are under the enforcement of EPA Region 1. Other states in New England have authorization from EPA to enforce their stormwater programs and certify that they meet the EPA's goals and requirements for permits at the state level. Water quality measures for Phase II Small MS4 permitting have become more stringent, and municipalities and stormwater utilities must update or expand their stormwater systems, which strains their limited economic resources (ASCE, 2021). Figure 1.3 shows the Phase II Small MS4 program encompasses 264 communities in Massachusetts in EPA Region 1 (US EPA, 2016). Each community has different challenges in managing the stormwater program due to planning, funding, and community size.

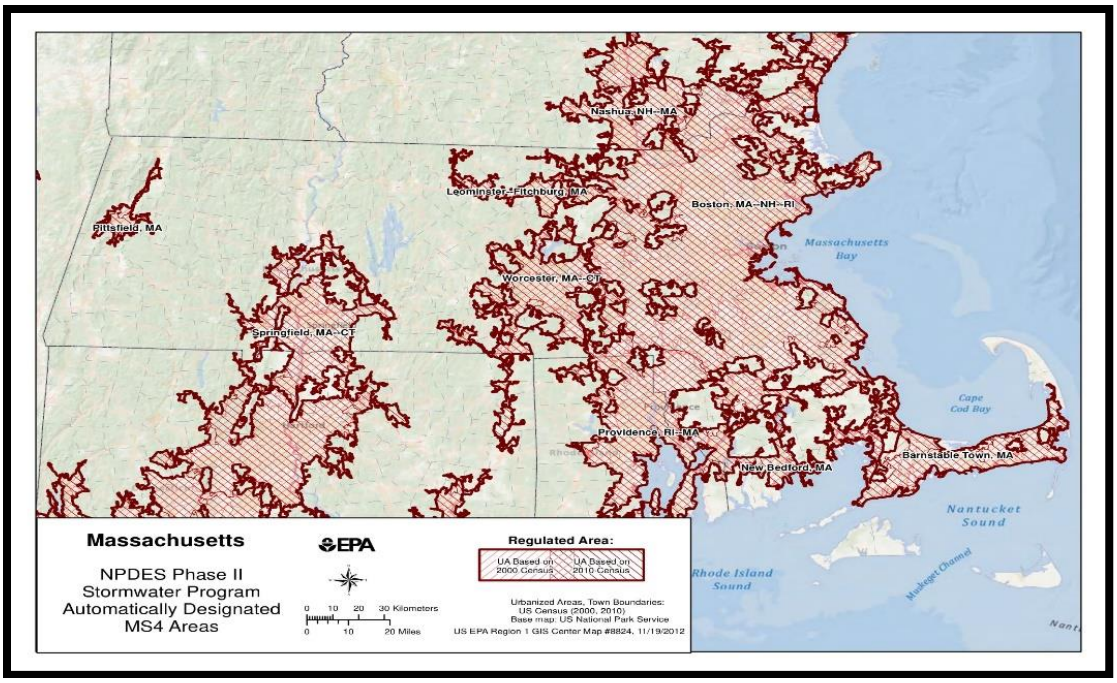

Figure 1.4: Map of regulated Phase II MS4s in Region 1, including C.T., RI, MA, and N.H. (US EPA, 2016).

1.5 Methods

This thesis will review the Phase II Small MS4 program in eastern Massachusetts, specifically examining the stormwater policy of two municipalities located northwest of Boston, Massachusetts. It will analyze the permits' challenges and benefits by exploring the stormwater programs and how these two municipalities implement stormwater policies. Each Phase II Small MS4 municipality has stormwater management plans or annual reports as part of the permit requirements. This thesis will focus on the following questions:

1. What are the gaps for the Phase II Small MS4 program from 2008 to 2016?
2. How are two communities in Massachusetts addressing the 2016 Phase II Small MS4 program?
    a. Total Maximum Daily Load (TMDL) parameters – phosphorus (PO_4) and pathogens

b. Outreach and education

c. Illicit discharge and detection elimination (IDDE)

3. What are the barriers to and benefits of implementing the permit?

The thesis is based on secondary sources such as scholarly journals and books and primary sources, including interviews of town staff from two municipalities (Town of Maynard and the City of Marlborough) and a private consultant. These municipalities are located within the SuAsCo (Sudbury, Assabet, and Concord rivers) watershed. Because the thesis will include interviews, a submission was made to the Tufts IRB as part of the human subjects' research requirement and was identified as exempt.

Chapter 2 will focus on urban stormwater management literature review, specifically on the past literature on Phase II Small MS4 permitting. Furthermore, it will discuss three focus areas (cost, compliance, and collaboration) that explain current Massachusetts's stormwater management policy. Chapter 3 will describe the qualitative methodology of the interviews and the data analysis of the interview transcripts. Chapter 4 will focus on the results of the interviews and data analysis of two Phase II Small MS4 municipalities. Chapter 5 will focus on the policy issues arising from the interviews, recommendations for the two municipalities, and the conclusion/limitations of the research.

Chapter 2: Literature Review

2.1 Introduction

Since implementing the MS4 permits, there has been criticism about how the EPA has managed the stormwater program regarding the evolving Phase II Small MS4 requirements in MS4 regulated communities. The basis for meeting stormwater goals under the Phase II Small MS4 program requires stormwater control measures that vary among states, with plans to manage erosion and sedimentation control, recharge/base flow, water quality, channel protection, and flooding events (National Research Council, 2009, 348). The Phase II Small MS4 requires six minimum control measures (MCM):

- public education and outreach
- public involvement and participation
- illicit discharge detection and elimination
- construction site runoff control
- post-construction stormwater management for development and redevelopment
- pollution prevention for municipal operations

This thesis explores how municipalities manage the Phase II Small MS4 to protect waterways, people's health, and impacts from impervious surfaces associated with urbanization.

The recent academic literature focuses on the Phase II Small MS4 program requirements for various municipalities in the United States. Most of the literature is based on how stormwater management has been implemented under the permit. The different studies offer insight into how various municipalities meet the permit goals through costs that fund the stormwater program, meeting compliance, and inter-municipal collaboration or use of private consultants. This chapter

aims to understand further how this permit is one of many environmental policy requirements for municipalities, such as stormwater management policy and planning. The literature briefly discusses green infrastructure but is not the focus of the review. There is a gap in understanding how some states, such as Massachusetts, have been impacted by stormwater permit requirements. The EPA Region 1 is authorized to issue National Pollutant Discharge Elimination System (NPDES) permits (i.e., Phase II Small MS4 permit) in Massachusetts.

2.2 Concerns with Phase II Small MS4 on state and local levels

2.2.1 Compliance for meeting Phase II Small MS4 goals

The main driver for local stormwater management is the NPDES permit program. Under the NPDES permit program, Phase II Small MS4 compliance includes Minimum Control Measures (MCM) and Best Management Practices (BMP), which vary among states and municipalities based on their ability to meet those goals.

Per the NPDES permit requirements for the Phase II Small MS4, forty-six states administer their Phase II Small MS4 permits under the program. At the same time, Massachusetts, New Hampshire, New Mexico, and Idaho do not have authorization from EPA to manage the permit process (Reis, 2017). In 2016, the Phase II Small MS4 remand rule was implemented, which required greater public participation in the permit process and greater regulatory oversight of the permit, including how states and municipalities will handle BMP for stormwater. These changes might impact municipalities differently depending on current stormwater management program efforts, socioeconomic characteristics, or water quality challenges.

As states vary across population size, demographics, socioeconomics, institutional capacity, and specific water quality issues, the Phase II Small MS4 language allows states to

administer them (McDonald et al., 2019). Compliance varies among states based on the BMP and how municipalities meet the six MCM goals to avoid violating the Clean Water Act. This allows states to manage costs, which is important because the implementation of the Phase II Small MS4 is widely variable amongst states and regions. The compliance costs are one aspect of the regulatory process to ensure that municipalities meet the goals but put added strain on managing stormwater permitting.

In addition to compliance goals, urban stormwater management has been single-purpose management for pollution control that does not support the current stormwater needs. With the progress of urban stormwater regulation, the stormwater program has been governed impartially and ineffectively (National Research Council, 2009). A 2016 study critiqued that the Clean Water Act can promote green infrastructure but is limited in incentivizing it (Subramanian, 2016). The study indicated that non-structural solutions like ordinances or education programs encourage landowners to use less fertilizer or reduce littering. In contrast, structuralized solutions such as construction projects and other measures reduce the impact of urban stormwater runoff. Stormwater compliance and costs to manage the Phase II Small MS4 permit compete with differing municipal permits and implementation costs.

2.2.2 Costs associated with Phase II MS4s

For municipalities to manage stormwater under the Phase II MS4 permit, there are associated costs to implement and enforce the permit. The costs to construct and support stormwater management have been significant barriers to implementing the permit, including resources for funding or not having a stormwater utility to pay the stormwater program activities and permit costs. The National Research Council (2009) criticized that state and local governments have struggled to fill the gap for EPA's federal program due to expenses from

stormwater discharge requirements that may increase residential taxes, hinder businesses, and place an added burden on regulatory staff. Many municipalities have faced increasing funding permit costs due to a lack of political support to fund the permit through tax revenues.

According to the National Research Council (2009), EPA's stormwater management program has been a liability rather than a benefit for municipalities to meet water quality goals to reduce the impact of stormwater on receiving waterways. Along with funding capital improvements, communities with stormwater infrastructure also need to fund routine operations and maintenance. Historically, under the CWA, funding was supplied for the research, design, and construction of wastewater plants. Still, the stormwater amendment did not supply funding resources to support the implementation of the requirements on the municipal permittees. In recent years, communities have faced additional costs to mitigate the program's environmental impacts (Allen, 2020).

National Research Council (2009) argued that the Federal financial support for state and local stormwater programs was limited based on the lack of support for funding costs of the Phase II Small MS4 permit, which municipalities that do not have funding might be incompliant to meet the stormwater permit requirements. Furthermore, stormwater quality management is often not considered a municipal service other than flood control or wastewater conveyance and treatment (National Research Council, 2009). Researchers found that when stormwater programs are funded through tax revenues, they compete with other municipal programs and funding obligations. Activities common to most municipal stormwater programs are funded through tax revenues such as property taxes and sales taxes (NRC, 2009, 440 and Allen, 2020). The gap in the investment in addressing problems of cleaning up stormwater has left states and municipalities in a disadvantaged spot in trying to get financial support.

A 2017 study looked at several states, including Idaho, Massachusetts, New Hampshire, and New Mexico, which do not have authorization from EPA to issue the NPDES permits, such as the Phase II MS4 permits. The study found that costs for states varied based on ways to fund stormwater permits, such as through stormwater utilities, municipal funds, or other funding options. For Idaho, $3.1 million would be covered by a general fund and fees, but for municipalities, stormwater utilities were not allowed, and instead, the fees were set up as a tax to cover the cost of compliance. New Hampshire faced high compliance costs with the lack of flexibility and ease in meeting water quality goals. Lastly, in Massachusetts, municipalities struggled to control the cost of services to residents and pay the costs through municipal funds instead of other funding options (Reis, 2017).

The study raised how the 2016 Phase II Small MS4 permit required increases in municipal funding while communities are already struggling to control the costs of services to residents. One of many funding schemes that municipalities can choose to pay for stormwater management projects is through stormwater utilities, a public funding mechanism set up by a governing body to finance stormwater infrastructure and services (Allen, 2020; NRC, 2009).

When developing a stormwater utility, communities operate in a reactive mode and may view stormwater management as a burden rather than an essential infrastructure for healthy communities (Allen, 2020; NRC, 2009). There is a lack of clarity of legal authority and concern over possible legal challenges and political and public opposition at state and local levels. Some states have implemented stormwater utilities for municipalities to manage costs under the stormwater permit.

A study done in 2020 found that funding stormwater programs via stormwater utilities varied for national, state, and local governments, as well as apparent legal authority, attitudes

from stakeholders, and regulatory pressure (Allen, 2020). Furthermore, Allen (2020) found that of the forty-three communities in Alabama, Arkansas, Idaho, Kansas, Minnesota, New Hampshire, Ohio, and Utah that were interviewed, 53% had already set up a stormwater utility, 19% had tried or considered setting up a utility, 7% were in the process of setting up a utility, and 21% had not considered setting up a utility. Stormwater utilities vary for other states, in which some have levied permit fees to offset the costs, which may cost up to $10,000, for implementation and enforcement of the stormwater program (National Research Council, 2009).

The findings of the various studies only show a general scope of the common challenges related to costs, but this raises a question: will support for funding improve as the stormwater permit evolves to meet future challenges under the NPDES and CWA? There is consensus among researchers that stormwater management costs for Phase II MS4 permits vary based on factors such as political backing, funding setup, and transparent legal authority. Allen (2019) noted that for various levels of stormwater management in terms of stormwater utilities, the varying factors affected how states and municipalities would implement the utility. Furthermore, Allen (2020) argues that increased federal regulation can push for the establishment of stormwater utilities. The National Research Council (2009) argues that the Federal government should provide more financial support to state and local efforts to regulate stormwater and for the EPA to reassess its allocation of funds within the NPDES program.

The literature suggests that costs will be an ongoing challenge for many municipalities managing the Phase II Small MS4 program. Stormwater management has varying factors explaining why and how costs may burden municipalities, such as having a stormwater utility and political backing to meet water quality goals for receiving waters. Allen (2020) argues that increased regulation at the national level is one of the drivers of establishing stormwater utilities.

Municipalities and communities are still reactive in developing a stormwater utility through stormwater fees or state funds if available. Managing costs can be unburdened through nongovernmental collaboration or inter-departmental collaboration to meet the Phase II Small MS4 program goals.

2.2.3 Collaboration to manage Phase II MS4 permits

Governance plays a role in implementing and collaborating to manage costs and stormwater compliance to meet the Phase II Small MS4 permit goals. According to Porse (2013), water governance describes the range of actors, institutions, and organizations contributing to water management.

The collaboration attributes for the Phase II Small MS4 permit include various aspects of collaboration in siloed vs. inter-municipal participation. Through collaboration or siloed participation, researchers found that stormwater governance varied. Dhakal (2016) studied five municipalities based on how they have adjusted their governance to address the gap between technology and governance, from technocratic to distributed and participatory governance. The study found that stormwater governance lacked collaboration between departments and stakeholders for the five municipalities around green infrastructure. There was also a gap in communication around the best practices to manage the stormwater program on a municipal level.

In a 2019 study, an assessment of Utah municipalities' use of private consultants and inter-municipal cooperation examined strategies to address stormwater responsibilities and how consultants or inter-municipal cooperation use varied with city characteristics (Armstrong, 2019). Armstrong (2019) found that 75% of Utah's MS4 regulated municipalities used private consultants for a part in the stormwater activity, 73% of municipalities often collaborated on

educating the public, and 69% on educating contractors or developers about stormwater ordinances.

Recent studies on stormwater collaboration (participatory vs. siloed) focused more on green infrastructure for stormwater governance than stormwater management 30 years ago. Among researchers, there was consensus that stormwater management still has gaps in governance for green infrastructure compared to gray infrastructure, including how municipalities can fund stormwater permits. Stormwater governance needs a regime change in perceptions and attitudes, technological interventions, goals and objectives, management hierarchy, and governance actors (Dhakal, 2016). Collaboration across political boundaries needs to be encouraged to address regional environmental issues such as water quality impairments across watershed boundaries. Additionally, public education activities create an essential connection for interaction between local government and the public (Armstrong et al., 2019).

Cousins (2017) looked at how differences in stakeholders addressing stormwater management costs, especially for green infrastructure in Chicago, Illinois, varied for collaborative or siloed governance, using institutional or scientific approaches in addressing the gap in stormwater management. Additionally, Cousins (2017) found that in addressing stormwater management costs, more involvement from stakeholders is needed to meet the goals for stormwater governance best. In a broader view of stormwater governance specific to green infrastructure, Porse (2013) evaluated how a comprehensive framework recognizes local nuances of urban development and contributes to the planning and managing of sustainable urban stormwater systems. Porse noted that cities with extensive infrastructure integrate green approaches that promote infiltration and improve institutional expertise on government decisions compared to cities with little infrastructure.

Furthermore, Porse (2013) argued that various municipal agencies in cities face high municipal borrowing costs and a lack of expertise and funding for traditional stormwater governance models compared to decentralized hybrid stormwater governance and infrastructure. Alternatively, Reick et al. (2021) found greater involvement between the community, such as private landowners, in receiving incentives and support to install and maintain BMPs on their property through the municipality, developing clear goals with the stormwater management program, such as maintenance, monitoring, and inspections. Even though green infrastructure is not the focus of this study, it is an important BMP implementation to manage stormwater runoff and address increasing changes in precipitation.

2.3 Conclusion

This chapter looks at how the Phase II Small MS4 permit is one of the many environmental policy requirements for municipalities to manage. Municipalities face the burden of cost, compliance, and collaboration to meet the permit goals and TMDLs. As municipalities work towards meeting their stormwater goals, they must address reducing the further impact on water quality in waterways as part of regulating stormwater under the Phase II Small MS4 permit.

Moreover, not all states, such as Massachusetts, have authority from EPA to implement NPDES permits but implement the Phase II Small MS4 through EPA. For costs, some municipalities might want to implement a stormwater utility but face political pushback. Based on implementing the Phase II Small MS4 permit, the success of each municipality depends on the current stormwater management program efforts, and water quality challenges. Lastly, collaboration between municipalities and groups is key to managing resources and implementing the required MCMs. The next chapter will discuss the methods used in the study.

Chapter 3: Methods

3.1 Introduction

This chapter describes the methods used in this study, which examines the stormwater policy of municipalities in eastern Massachusetts and evaluates the challenges and benefits of the permit, such as cost, compliance, and collaboration. The methods I used included a description of the municipalities' stormwater programs, semi-structured data collection interviews, and data analysis to understand the gaps in the Small MS4 Phase II permits.

The following questions for this study are:

1. What are the gaps in the Phase II Small MS4 program from 2008 to 2016?
2. How are communities in Massachusetts addressing the 2016 Phase II Small MS4 program?
    a. Parameters of the maximum daily total load (TMDL): phosphorus and pathogens
    b. Outreach and education
    c. Illicit discharge and detection elimination (IDDE)
3. What are the barriers and benefits of implementing the permit?

The following subsections in this chapter will discuss how the study was carried out. This analysis will include the research design that outlines how the qualitative case study was used, the participants in the study, the data collection techniques that were used, the procedure that was used to collect data through interviews, data analysis methods used to analyze interviews, ethical consideration throughout the study, and limitations/assumptions in the study.

3.2 Methodology

3.2.1 Background

Due to the considerable number of municipalities required under the Phase II Small MS4 permits across Massachusetts, I focused the study on two municipalities (Marlborough and Maynard) in eastern Massachusetts within the Greater Boston region (Figure 3.2.3). The two municipalities vary in demographics, such as population size, land area, and household income (Table 3.2.1). These municipalities were selected based on their location within the Sudbury, Assabet, and Concord River watershed and demographics. Furthermore, the SuAsCo watershed drains into the Merrimack River, one of the impaired rivers listed under section 303(d) of the Clean Water Act.

Table 3.2.1: Demographics from the 2019 U.S. Census for municipalities: Town of Maynard and City of Marlborough, Massachusetts (U.S. Census Bureau, 2019).

MUNICIPALITY	AREA (MI^2)	POPULATION SIZE	MEDIAN HOUSING INCOME (ANNUAL)	WHITE ALONE, NOT HISPANIC OR LATINO (%)
MARLBOROUGH	20.87	41,793	$80,943	69.2 %
MAYNARD	5.21	11,336	$105,254	91.9 %

3.2.2 Methods

Understanding how municipalities implement the Phase II Small MS4 permit, semi-structured interviews were used to identify the gaps in Phase II Small MS4 permits focused on cost, compliance, and collaboration in the study. The qualitative method, semi-structured interview, was used for this study to identify stormwater managers in the designated Phase II

MS4 areas. This choice of methodology was based on previous studies (Allen, 2020; Armstrong et al., 2019; and McDonald et al., 2019) that focused on the MS4 stormwater program using a similar methodology. The focus of the questions in this study was derived from the six Minimum Control Measures (MCM) required in the Phase II Small MS4 permit.

1. **Public education and outreach**
2. Public involvement and participation
3. **Illicit discharge detection and elimination**
4. Construction site runoff control
5. Post-construction stormwater management for development and redevelopment
6. Pollution prevention/good housekeeping for municipal operations

- **Water quality/TMDL**

Three participants were interviewed for this study based on their availability (Table 3.2.3). The municipalities selected for this study are the City of Marlborough and the Town of Maynard, selected from the 264 Massachusetts communities based on the Phase II MS4 requirement for urbanized areas population size of 100,000 or less (Figure 3.2.2).

Table 3.2.2: Participants who were interviewed for the study

MUNICIPALITY	INTERVIEWEE'S ROLE
MARLBOROUGH	Anonymous, Town Employee
MAYNARD	Justin DeMarco, Director of DPW
	Sarah Nalven, VHB Consultant

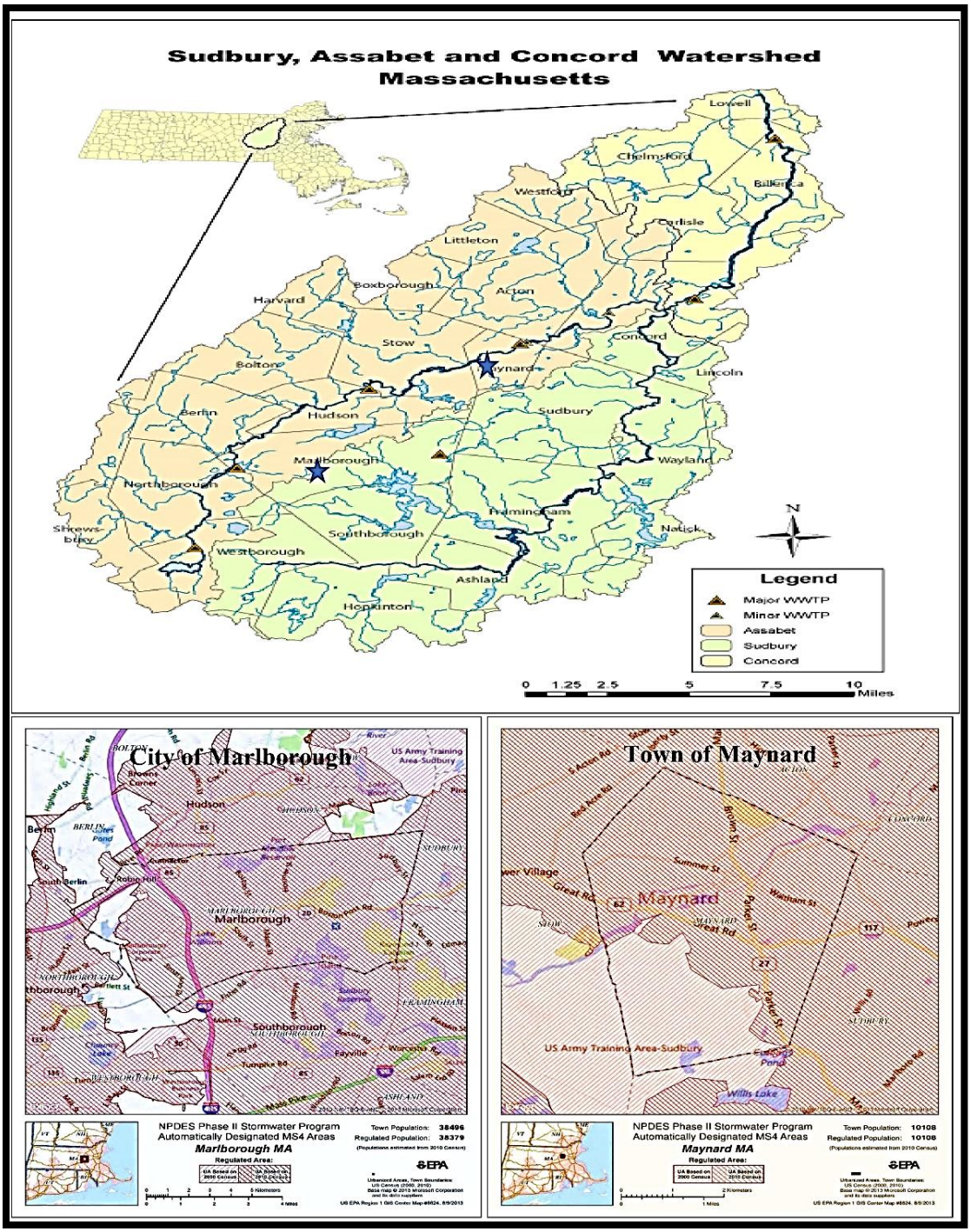

Figure 3.2.2: Map of the Sudbury-Assabet-Concord (SuAsCo) and NPDES Phase II Stormwater Program Designated MS4 area maps for the Town of Maynard and the City of Marlborough in Massachusetts (OARS, n.d.; US EPA, 2016).

3.2.3 Qualitative data collection and analysis

A non-random sampling procedure used in the study was called "purposive sampling," where individuals are representative based on meeting specific criteria for the study (Bui, 2014, 143). For this study, participants were selected based on the criteria that defined who was included in the study, namely those with a working knowledge of the Phase II Small MS4 stormwater permit and municipal planning policies.

Participants in the study were municipal staff, the Department of Public Works (DPW) for the City of Marlborough, and the DPW director and private consultant (water resources consultant) for the Town of Maynard, Massachusetts. They were identified as managing the Phase II Small MS4 permits through publicly available information under EPA Regulated MS4 communities in Massachusetts. The participants were contacted by email and phone; three were interviewed between November 2021 to March 2022 for an allotted time of 60 minutes. The interviews were conducted via Zoom to collect data on the experience of municipal personnel with their knowledge and experience working with the permit. Based on the sample size for this study, I originally wanted to interview ten participants but only focused on three due to time constraints.

Of the initial 10 participants I contacted, a few responded and were available, and others I did not hear back from after a couple of times of reaching out. The three participants I interviewed for this study represented a small sample size of municipalities within the SuAsCo watershed, with a DPW department managed by a DPW director or an engineer. Compared to the Boston area, the participants varied based on capital and human resources and who managed the stormwater permit, which fell under DPW jurisdiction either by a DPW director, engineer, or in collaboration with a private consultant.

The data in this study were collected using a semi-structured interview to gain perspective on the pre-selected questions. I used Zoom interviews with the consent of participants who agreed to be recorded and quoted directly. An interview guide (see below) was used in the interview process. A transcript of the Zoom interviews was used for further analysis. After the interviews, the recording was transcribed and coded. I then created themes from the coding notes. Additional notes were collected as follow-up questions, and the responses were included in the data analysis.

3.2.4 Interview questions guide

1. What are the regulatory gaps for the 2008 Phase II Small MS4 program (focused on 2008 to 2016)?
    - If yes, what has been missing or issues such as cost, compliance, or collaboration?
    - If not, what was successful throughout the 2008 permit?

2. How is the municipality addressing the 2016 Phase II Small MS4 permit?

a. Total Maximum Daily Load (TMDL) parameters – phosphorus and pathogens.

<u>Phosphorus</u>

- How has the Assabet (Total) Phosphorus TMDL helped address stormwater runoff to meet permit goals under the current permit?
    - In what ways have you not or hoped to improve?
- Are there incentives that have been taken to reduce further phosphorus loading in waterways from stormwater runoff to meet the goals under the permit?
    - If yes, what are the incentives? How have they helped to achieve the goals?
    - If not, what incentives to help the municipality meet the goals?

<u>Pathogens:</u>

- What are the municipality's goals to ensure that pathogens are reduced from MS4 and waterways?
- Are there challenges and benefits to implementing a TMDL in pathogens for waterways and land use?

- Are there incentives that have been taken to reduce the loading into waterways from stormwater runoff?
    - If yes, what are the incentives? How have they helped to meet the permit goals?
    - If not, do you think the incentives will help the municipality meet the goals? What would they be?

b. Outreach and education
    - In addition to the stormwater management plan, what challenges have residents/businesses/developers faced in stormwater education and outreach?
    - Has the stormwater outreach and education program helped residents/businesses understand the purpose of the stormwater permit and how stormwater impacts local waterways?
    - Are there incentives the Town has put in place for residents/businesses to reduce stormwater runoff?
        - If yes, what incentives are in place, and how has the community received them?
        - If no, do you plan or would like to implement stormwater reduction incentives, and what would that be?

c. Illicit discharge and detection elimination (IDDE)
    - Are there commonly found sources of illicit discharges found within MS4 by identifying IDDEs?
    - What are the challenges and benefits of doing IDDE under the permit?
    - In what ways has this work helped the community to understand stormwater?

3. What are the barriers and benefits of implementing the permit?
    a. Do you foresee barriers or benefits for the next round of permitting to meet the goals in terms of compliance?
    b. Are there current barriers to permit costs for this round of permitting?
        - What do you anticipate for future costs to meet permit goals?
            - What about future land use development, climate change (drought and flooding), and green and gray infrastructure?

c. How has the permit been delegated in terms of inter-municipal collaboration?
    - Has there been a success with inter-municipal collaboration?
        - If yes, what was done?
        - If not, what do you hope to improve to ensure collaboration between groups?

3.3 Ethical Consideration

Procedures were followed to secure permission to conduct the study through the Tufts Institutional Review Board (IRB) and to ensure that participants were protected from any potential harm. The consent of the participants was gained at the beginning of the Zoom interview using the written consent document. Participants received a copy of the consent form when asked if they were interested in participating in the interview. This was done so they understood the steps I would take to ensure that I complied with the IRB's requirements for informed consent.

The amount of time devoted to the consent discussion was between 5 and 10 minutes, as needed, for any questions if they arose. Steps were taken to ensure the participants' understanding of their rights. They were asked whether they consented to be interviewed and to the recording of the interview and whether they agreed to be quoted directly or preferred to be paraphrased. After reading the consent script, participants' consent was documented via the participants' options. Steps taken to minimize the possibility of coercion or undue influence were verbally stated. To monitor ongoing consent throughout the interview, I let the participant know that they could verbally state that they were not comfortable answering the question, or they could request that the Zoom recording be stopped at any time during the interview.

3.4 Conclusion

There were many limitations in using the qualitative case study design. The purposive sampling was drawn from a sample of municipalities in eastern Massachusetts and may not

represent other Massachusetts municipalities. The small sample size could have been expanded to reduce sampling bias and increase the validity of the data collected. Another limitation was the availability of the participants to be interviewed. The next chapter will discuss the results of the interviews with the municipalities.

Chapter 4: Results

4.1 Introduction

This chapter focuses on two municipalities as case studies: the Town of Maynard and the City of Marlborough, Massachusetts, for the Phase II MS4 permit. The chapter will discuss the findings of the municipalities and the interview results.

4.2 Case Studies

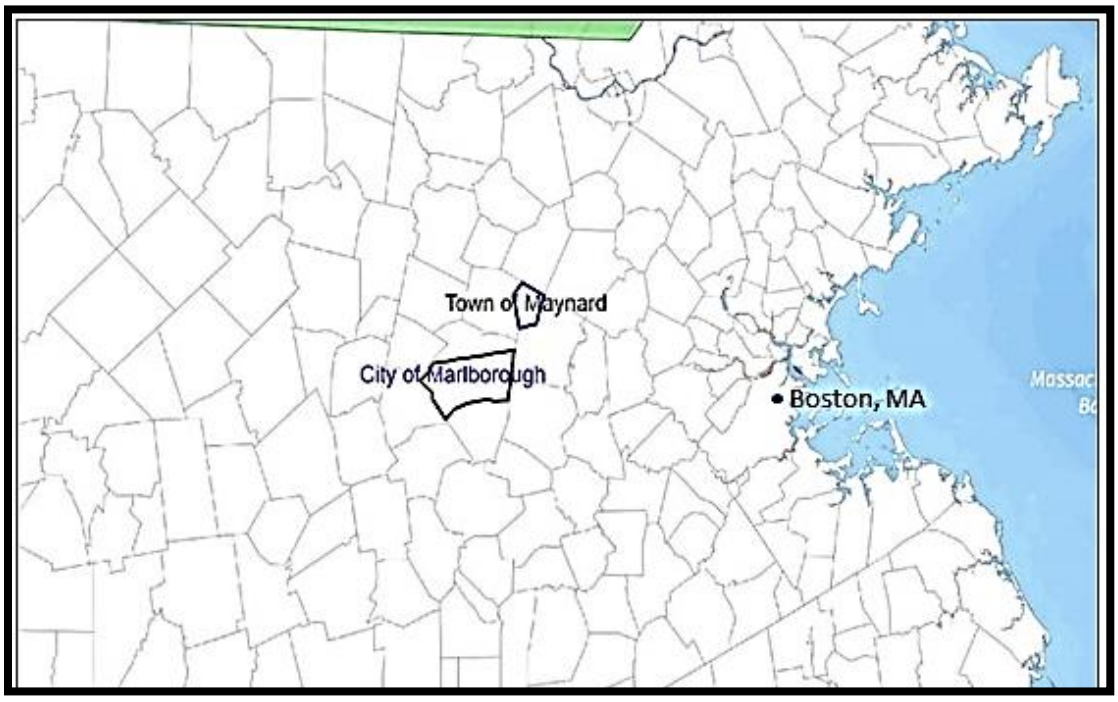

Figure 4.1: Locations of the Town of Maynard and the City of Marlborough, Massachusetts.

Between November 2021 and February 2022, I interviewed two municipal employees and one private consultant from the Town of Maynard and the City of Marlborough. For this study, the sample was selected based on their experience with the Phase II MS4 permit and their willingness to participate. The interview questions are provided in Chapter 3. The questions

explored how the permit has been managed for the municipalities to meet the compliance requirements and how it has or has not been successful for the stormwater managers and the municipalities. An analysis of the interviews yielded from the municipalities revealed findings within the areas of the research questions.

The Town of Maynard and the City of Marlborough is located within the Assabet, Sudbury, and Concord River (SuAsCo) watershed. The Assabet River watershed is 177 square miles in area, with the river being thirty-one miles in length and classified as a Class B waterway for surface water quality (OARS, n.d.).

4.2.1 Town of Maynard

The Town of Maynard is a small suburb located in Middlesex County, twenty-five miles west of Boston, Massachusetts (U.S. Census Bureau, 2019). The surface water sources of the Town of Maynard drain into the Assabet River, part of the SuAsCo river watershed. The Assabet River Wildlife Refuge contributes to the total land area, with 70.4 acres of surface water and 307 acres of vegetated wetlands (Town Maynard Master Plan, 2020).

Maynard faces several threats, including chronic flooding due to the surface waters in some areas in the surrounding community, development and population growth putting a strain on the current infrastructure, including the drainage system, and impairment of water bodies and waterways failing to meet the Class B waterway requirements. These threats have been addressed through public education by the Phase II MS4 program (Town of Maynard Master Plan, 2020). The Town has an aging sewer and stormwater drainage infrastructure, which requires proactive planning, maintenance, and upgrades to help the community (Town of Maynard Master Plan, 2020).

4.2.1.1 Stormwater Management Plan

The Town of Maynard is one of Massachusetts's 264 Phase II MS4 communities required to comply with the permit. The stormwater management plan was written in 2019 by the Planning Department. The plan explains the Town's activities and measures to meet the permit requirements.

The stormwater management plan focuses on the six minimum control measures (MCM) (Appendix 1) and water quality/total maximum daily load (TMDL) per the Phase II MS4 permit. The six minimum control measures are goals for the Town to comply with the stormwater permit. Maynard's goals include public and education outreach, illicit discharge and detection elimination, public involvement, preconstruction, post-construction, and operation and management. Specifically, Maynard has impaired waterbodies, including the Assabet River that flows through the town, such as phosphorus (PO_4) and bacterial (*E-coli*) contamination.

4.2.1.2 Results

4.2.1.2.1 Gaps in the permit -- costs

Costs were a significant aspect of the Phase II MS4 permit for the Town of Maynard. Municipalities like Maynard have worked with small budgets and regulations such as Phase II MS4, which has a significant impact. The challenges related to the stormwater permit that Maynard has dealt with are the gaps in funding and resources to best manage the permit to meet the requirements. The Director of Public Works (DPW), Mr. DeMarco, who is working with the stormwater permit, noted less support for the Town to manage the permit. The larger picture was that there was no funding mechanism for the regulatory gap, representing an unfunded mandate.

Stormwater permit consultant, Ms. Nalven, discussed how the permit is complex and complicated for municipalities and consultants to meet the requirements for the permit goals.

Maynard has struggled to acquire funding and move on to actionable items, including meeting the yearly items. For example, the permit is vast and extensive, and the requirements put a lot of strain on Maynard to manage the permit and comply accordingly, which is one of the biggest hurdles at the local level. Furthermore, to comply with meeting the goals, according to Mr. DeMarco, Massachusetts does not have a funding mechanism to address compliance aspects such as TMDLs.

The Phase II MS4 permit has required municipalities to act quickly, but it takes time to meet the requirements. MA DEP and EPA overlap in regulations in terms of stormwater, such as the Massachusetts Wetland Protection Act state regulation. Another aspect of the gaps in the stormwater permit was that staffing professionals such as Ms. Nalven must ensure that the permit is appropriately interpreted or risk inefficiently interpreting something in the permit and wasting public funds. As it is comprehensive, the permit has smaller gaps, such as the time it takes to determine what needs to be done to fulfill the permit requirements, including minimum control measures.

4.2.1.2.2 Minimum Control Measures aspects

Phosphorus TMDL

The Assabet River's phosphorus TMDL for Maynard is an exception to the Massachusetts MS4 general permit, such that the Assabet River drains into the Merrimack River, which is impaired for nutrient loading. According to Mr. DeMarco and Ms. Nalven, the phosphorus TMDL does not look at why or how phosphorus can be managed holistically to deal with phosphorus reduction. In her work, Ms. Nalven mentioned an example that Minnesota has a more comprehensive phosphorus TMDL that has funding and resources to look more closely at why and where phosphorus is occurring and how to manage it compared to Massachusetts.

Mr. DeMarco mentioned that phosphorus TMDL is a challenge; to allocate how phosphorus can be managed better for the Assabet, such as having more resources that could be used to study or improve the wastewater treatment plant in Maynard that discharges into the Assabet. For example, over ten wastewater treatment facilities discharge into the Assabet, and stormwater is only a small part of reducing phosphorus in the Assabet River.

As the permit progresses, the call for actionable measures significantly increases investment costs. An example is that phosphorus control plans are currently in place to remove phosphorus but do not get credit for phosphorus removal. This creates a challenge in what needs to be done on the municipal level, creating barriers to money and resources, including funding for public education and outreach.

Public Education and Outreach

According to Mr. DeMarco and Ms. Nalven, there is a gap in how Maynard can meet the goals of public education and outreach for the stormwater permit. Maynard is a small municipality and lacks the resources to manage the permit requirements, such as public education and outreach. Ms. Nalven's role helps the Town of Maynard move forward and meet the stormwater goals. Mr. DeMarco mentioned a disconnect where the permit should have a template education plan. For example, Maynard's education piece takes time and is not the same for all municipalities.

The education material that Maynard uses is called Think Blue. Think Blue is a tool that municipalities can use to pool money within the various departments to help with education plans. Maynard DPW and the Planning department use the Think Blue Stormwater program educational materials to develop their education and public outreach campaign for residents. The Town of Maynard uses Facebook to post information about stormwater education. Ms. Nalven

mentioned that the educational material is broad. She also mentioned that working templates make it easier for municipalities such as Maynard to educate the Town residents, such as protecting the waterways from runoff.

Mr. DeMarco and Ms. Nalven noted that residents need to understand certain aspects of stormwater pollution, such as not blowing leaves into the Assabet River or how dog waste impacts the river. For example, stormwater leeches phosphorus out of the leaves, percolates through the soil, and does not go directly into the river. Furthermore, understanding how leaves have phosphorus or pet waste with *E-coli* impacts the health of the Assabet River. Education needs to be centralized rather than having communities do the education plan independently. For example, Ms. Nalven noted that there are not enough resources committed to education. Still, if communities pooled money and resources, it might help advance their collective education and public outreach permit goals.

Mr. DeMarco mentioned that education should be in the Phase II MS4 permit, not as a best management practice. Not every community has to develop an education plan, which is considered a waste of resources, rather than having a firm that can develop a 90% developed template that can be used. Communities can fill in the gaps based on their assets and needs. Currently, communities such as the Town of Maynard have been developing their education plans in a silo, based on the subjective viewpoint of the permit without clarification from regulators such as EPA and MA DEP. Having a consulting firm develop an education plan template and MA DEP adopt it later rather than deal with it upfront would reduce the local funds needed for an educational plan. It could be used for implementation purposes of removal or mitigation, such as catch basin cleaning and sewer replacement repair. This would help the Town of Maynard teach what is needed for stormwater in the community. Furthermore, it would help

communities understand the negative impacts of illicit discharge and detection elimination (IDDE).

Illicit Discharge and Detection Elimination

Maynard has done comprehensive work on the outfalls of stormwater. The Town of Maynard has spent a lot of time and funds screening all of the Town's outfalls during dry weather in the last couple of years. Dry weather screening has allowed the Town to identify where the sewer is potentially connected and contributing to *E.coli* and illicit sewage to sewage overflow. According to Mr. DeMarco, there are many outfalls and not enough staffing to examine all the work that has been done. The Town of Maynard has outfalls that are 40 years old, and comprehensive screening of all the outfalls requires money and more resources.

According to Mr. DeMarco, many small communities in Massachusetts have sewer and water districts at the municipality scale. Sometimes, sewer and water districts are independent of the municipality and might not fall under the municipality's authority. For example, Maynard's sewer and water districts are managed under the DPW umbrella. Mr. DeMarco noted that this forces DPW to look at treatment and Phase II MS4, which has no funding in place. They must deal with both using a holistic approach, which will help eliminate infiltration and identify areas of concern for stormwater.

The resources required to meet the permit requirements could be used elsewhere, putting a strain on what the Town can do. For example, for illicit discharge and detection elimination in Maynard, when it rains, wet weather screening is challenging because detecting *E.coli* in a sample is required to differentiate fecal matter from dog or goose waste from sewage overflow into the stormwater sewers. Part of the screening includes factoring in vulnerability in the system.

According to Mr. DeMarco and Ms. Nalven, phosphorus TMDL, IDDE, and *E. Coli* could use more resources to look at this impairment holistically rather than in the weeds. With a look at illicit discharge and detection elimination, the Town of Maynard has done comprehensive work on the outfalls of stormwater. The permit helps keep things moving along to manage water quality, but there is much room for improvement.

4.2.1.2.3 Future challenges for stormwater management

Municipalities need additional funding to support water quality obligations to the community. State and federal funding do not cover stormwater infrastructure, which would provide the means for local initiatives to make large-scale improvements such as green infrastructure. Mr. DeMarco mentioned that the American Rescue Act is the first actual means of addressing stormwater infrastructure projects.

According to Mr. DeMarco, retrofitting Maynard's stormwater system to handle predicted stormwater totals would cost more than $5 million. With the increased failure of stormwater infrastructure when faced with large-scale rain events, the Town's infrastructure has not adapted to keep up. The Town of Maynard has little to no success with inter-municipal collaboration. Each community has different areas of concern based on geographic location and infrastructure. Regionalization in terms of collaboration in Massachusetts is weak compared to other states, which has been an issue due to insufficient public funding to provide public services.

4.2.3 City of Marlborough

The City of Marlborough is located in Middlesex County, twenty-seven miles west of Boston, Massachusetts. Marlborough has a mix of large surface impoundments used for drinking water, recreation, and open space opportunities (Marlborough Open Space Plan, 2009). Marlborough is within the headwaters of the Assabet River, which has experienced flooding.

The Stormwater Management Ordinance was adopted to help manage stormwater runoff and erosion/sedimentation to surface water bodies (i.e., ponds, streams, and rivers). The surface water bodies drain into the Assabet River and Sudbury Rivers, part of the Sudbury, Assabet, and Concord rivers (SuAsCo) watershed. More than seven impaired waterways and over four hundred outflows into the receiving water segments with phosphorus are noted as one of the impairments to the waterways within the City (NOI, 2018 and the City of Marlborough IDDE Plan, 2019).

4.2.3.1 Stormwater Plan

The City of Marlborough is one of Massachusetts's 264 Phase II MS4 communities required to comply with the permit. Marlborough's stormwater management plan focuses on the six minimum control measures and water quality/TMDL per the Phase II MS4 permit (Appendix 2). The six minimum control measures are goals for the City of Marlborough to comply with the stormwater permit. Marlborough's goals include public and education outreach, illicit discharge and detection elimination, public involvement, preconstruction, post-construction, and housekeeping. The City of Marlborough's illicit discharge and detection elimination plan was developed in 2019 in collaboration with the Central Massachusetts Stormwater Coalition and the Department of Public Works. The interviews focus on two MCMs (public education and outreach and IDDE) and water quality/TMDL.

4.2.3.2 Results

4.2.3.2.1 Gaps in the permit -- costs and meeting compliance

Costs were a significant aspect of the Phase II MS4 permit for the City of Marlborough. According to the third interviewee, who wished to remain anonymous, there was much more included in this permit than the previous permit, and there were many additions to this current

permitting process. For compliance, the City of Marlborough already had some of the things required for this permit. The department has a GIS system with all the drainages mapped, which gets updated whenever a discrepancy or something new is found.

According to the city employee interviewed, the City of Marlborough has had a stormwater ordinance already in place since 2009. The ordinance was implemented as part of the previous permit to ensure the DPW was prepared for the new permitting process. Marlborough is now part of the Central Massachusetts Stormwater Coalition, which has been helpful in this permitting process for public and educational outreach, illicit discharge and detection elimination, minimum control measures, and water quality/TMDL requirements.

4.2.3.2.2 Minimum Control Measures aspects

Phosphorus and Pathogen TMDL

This research identified several challenges with phosphorus TMDL and pathogens in Marlborough. There are still many septic systems within the City, and many outfalls flow into the Assabet River. Recently, the City has reimplemented changes to the stormwater requiring residents and businesses to connect to the city sewer and eliminate the septic system within the City. According to the city employee, this policy change would help keep pathogens out of the city's aging water system. Furthermore, as another action to reduce phosphorus and pathogens, street sweeping has been conducted daily from Memorial Day until Labor Day to reduce additional impairment in the stormwater system. Phosphorus and pathogens TMDL is part of public education and outreach activities.

Public Education and Outreach

The City of Marlborough has faced challenges in public education and outreach. The challenge that the city employee mentioned in my interview was that the department was having

trouble measuring the effectiveness of outreach. An example of this was that the City has done a lot of mailings of stormwater education outreach materials as a form of education and public outreach and is aware of how many mailings have gone out to residents.

Marlborough has struggled to measure the effectiveness of the mailing as part of public education and outreach. For example, the City wants to provide more engaging outreach with the residents and developers in commercial properties as part of public education and outreach to let them know the importance of stormwater management. Having the Department of Public Works be more involved with the outreach would include assessing what is missing in residents' knowledge about stormwater. This includes the illicit discharge and detection elimination work in stormwater management.

Illicit Discharge and Detection Elimination

One of the challenges for Marlborough catchment investigations is the lengthy process. According to the city employee, as they go through the investigations, they can locate those illicit discharges and get them out of the City's waterways. The most common illicit discharge was pet waste in the catch basins, which is a challenging point source to determine where it originated within the catchment basins. For example, finding dog waste bags in the catch basins has been common when doing outfall inventories. According to the city employee, there have not been additional illicit discharges.

There has been a challenge in educating residents about separate sanitary and stormwater sewers. An example is that during the outfall inspections near residents' properties, some residents do not realize that sanitary and stormwater sewers are separate or what catch basins are collecting. This is an added challenge in managing illicit discharge and how residents perceive Marlborough's ongoing stormwater management work.

4.2.3.2.3 Looking ahead

The city employee noted that as the current Phase II MS4 permit is comprehensive, the following permit will build off this current permit. Costs are one of many future aspects of the permit that the City has to consider. For example, Marlborough has nearly five hundred outfalls; almost a third are not flowing, making it more challenging to identify which areas to work on and representing an added cost in the outfall investigations. The department will have to conduct catchment investigations, adding to wet weather inspections. The department has been trying to do most of the work for the permit in-house and has not had to hire any consultants to help with the permitting. Additionally, other costs, such as retrofitting any BMPs, that will need to be done in the future, will be costly.

4.3 Conclusion

Both municipalities face similar and different challenges as part of implementing the Phase II MS4 permit. Both hope the new permits will build upon previous permits and address communities' needs. Common themes in the interviews were the needed resources for the municipality to implement the permit and, as the permit is comprehensive and encompassing, a gap in costs and focus on IDDE. The next chapter will discuss the findings, policy analysis for both municipalities, and study limitations.

Chapter 5: Discussion and Conclusion

5.1 Introduction

Communities dealing with Phase II MS4 permits vary in stormwater management based on cost, permit compliance, and collaboration. As seen in the literature review and introduction, municipalities in Massachusetts face varying challenges in managing stormwater permits due to planning, funding, or community size. The findings provide insight into how stormwater management under Phase II Small MS4 permits varies based on the availability of resources to fund and manage the stormwater permit process. The following discussion highlights the challenges of stormwater management related to the stormwater policy in Massachusetts.

5.2 Discussion

The results show varying municipal needs regarding water quality based on water quality impairments, such as phosphorus and pathogens. Costs relating to the Phase II Small MS4 permit were similar for both municipalities; the Town of Maynard has experienced challenges in allocating resources to manage stormwater. Both municipalities had challenges in managing public outreach and education and IDDE as part of the minimum control measures. Implications for Massachusetts in part of the interviews suggest that the cost of and availability of resources for stormwater management were variable for each municipality.

5.2.1 Challenges in costs

Each municipality faced challenges in costs as stormwater management varied based on resources to fund the permit. As the 2016 Phase II Small MS4 permit requirements changed, the municipalities' ability to address costs and compliance varied based on their needs and the available resources to comply successfully.

Common challenges for the Phase II MS4 permittees include aging infrastructure, funding, expanding regulations, and technical resources (Taylor et al., 2021). Stormwater management costs have been significant for both municipalities, especially Maynard. The challenges that the Town of Maynard faced for stormwater management include water quality issues such as phosphorus, impervious surfaces from development impact and population growth, and aging stormwater infrastructure, thus creating an additional burden on the municipality. Additionally, the stormwater management challenges faced by the City of Marlborough were impaired water quality and numerous outfalls that drain into the waterways, which added costs for the municipality to address under the permit.

As both municipalities varied in population density, the Town of Maynard and City of Marlborough had challenges with funding regarding how they manage the permit, which was limited by a lack of staffing or technical resources. For Maynard, small municipalities may have smaller maintenance departments and often have challenges funding ongoing maintenance, monitoring, and inspection programs due to not having a department or employee solely tasked with managing stormwater (Rieck et al., 2021). Moreover, municipalities in Massachusetts struggled to control the cost of services to residents and pay the costs through municipal funds instead of other funding options (Reis, 2017).

Additional to the gaps in the costs to manage stormwater, other aspects of addressing costs from the study stemmed from the burden placed on the municipalities to fund the permit, but not on the residents who own private property where stormwater runs off from their property. A lack of direct funding burdens effective stormwater programs and limits the ability to rely only on current taxes and fees (Rieck et al., 2021). Though the study did not look at stormwater utility, the findings suggest that the additional challenge to address costs might need to come

from residents rather than the state or EPA. As these challenges in costs persist, the results suggest that the burden falls more on the municipalities than on the states and EPA, as they are required to ensure that the waterways within the municipal boundaries are not further degraded. These challenges, as seen for both municipalities, exemplify how municipalities across Massachusetts manage stormwater.

5.2.2 Meeting stormwater compliance and collaboration

As part of the more considerable stormwater policy in Massachusetts, stormwater minimum control measures vary based on municipal resources and time. The significant aspects of the minimum control measures for the Phase II Small MS4 permit for the municipalities differed in their approach to stormwater management (i.e., inter-municipal, private consultant, or regional stormwater collaboration) in meeting compliance and collaboration.

Based on the study's findings, a varying focus on meeting the permit's minimum control measures, including water quality. The Town of Maynard's burden was managing and meeting the phosphorus TMDL in the Assabet River, which included having a phosphorus control plan. This was different for the City of Marlborough, which only looked at pathogens focused on wastewater and managing their existing stormwater systems related to the IDDE and outfalls to reduce their impact on the waterways. Furthermore, the findings show that each municipality's stormwater manager's focus was to ensure that the waterways were not further impaired by stormwater runoff from water quality impairment.

However, both municipalities face challenges in managing their public outreach and education aspects of their stormwater permit obligations. This includes the cost, time, and resources required to educate residents about the importance of stormwater management and waterways protection. Both of these municipalities have been educating to encourage residents to

change their behaviors (i.e., reducing leaf litter or dog poop in the waterway) to minimize water quality degradation for the waterbodies. This includes IDDE work relating to the behaviors of residents around stormwater, such as inspecting nearby residential properties and educating residents.

Focusing on the permit requirements, minimum control measures vary on what is required, including differences in their approach to public outreach or IDDE based on financial or staffing resource constraints. The findings suggest that meeting the requirements for IDDE has common challenges in this aspect, including that the process and work for inspection take significant resources, staffing, or time. This is in contrast to municipalities that do not inspect stormwater outfalls, who are more likely to not have a municipal maintenance program for managing stormwater or training employees on stormwater pollution prevention (McDonald et al., 2019).

The study's findings suggest that to comply with the Phase II Small MS4 permit, the approach in stormwater management using a private consultant, in-house work, or a regional collaboration varies based on what they have for resources and what is needed to meet the stormwater permit goals. Similar to Massachusetts, municipalities located in southeastern Wisconsin either prepared their stormwater management plan or had a consultant work on it (McDonald et al., 2019). Moreover, cities in Utah use a private consultant for any stormwater activity, ranging from using private consultants for conducting stormwater inspections, monitoring water quality, or regularly relying on private consultants for any stormwater activities (Armstrong et al., 2019). The findings showed that the Town of Maynard and the City of Marlborough managed their permits based on what they had for resources.

Other than using a consultant solely for specific needs for the stormwater permit, a stormwater collaboration between small municipalities can reduce costs by working together to develop shared training programs, templates for ordinances and annual reports, public education materials, programs, and group purchasing/maintenance contracts (Rieck et al., 2021). Though the study did not discuss watershed collaboration as a way to address the minimum control measures, this is in contrast to collaboration across political boundaries that need to be encouraged to address regional environmental issues such as water quality impairments across watershed boundaries (Dhakal, 2016). The results highlight significant differences in how these two municipalities manage their stormwater. The minimum control measures for public outreach and education and IDDE are important to stormwater management. The stormwater permit places the burden back on the municipalities to meet the requirements.

5.3 Limitations

As part of this study, some limitations arose in implementing the qualitative case study design. The purposive sampling was drawn from a sample of municipalities in eastern Massachusetts and might not best represent other Massachusetts municipalities. The small sample size could have been expanded to reduce sample bias and increase the validity of the data collected. Due to time constraints for this study, the participants' availability varied, and it was difficult to recruit more stakeholders for my interviews.

I did not get to talk with other agencies, such as the Massachusetts Department of Protection, EPA Region 1, the Massachusetts Regional Planning Council (MAGIC stormwater collaborative), or the SuAsCo watershed association. The permit review was comprehensive and only allowed me to explore a few critical aspects of the six minimum control measures: water quality, public education and outreach, and IDDE. This study did not look at green infrastructure

(GI); however, stormwater management is heading in the direction of GI to adapt and mitigate the projected increase in rainfall for municipalities in Massachusetts in response to the growing impact of climate change.

5.4 Recommendations

These municipalities are examples of how stormwater management varies based on costs, compliance, and collaboration. Furthermore, varied perceptions exist between the municipality and residents on how vital stormwater is, especially for IDDE and water quality. The following recommendations are suggested to the municipalities in the study and for other stakeholders in Massachusetts. The recommendations are based on the discussion of the interviews that were conducted and from the literature review. The recommendations are suggestions that the municipalities can utilize based on the challenges of their work with stormwater management, especially with the Phase II Small MS4 permit. Massachusetts does not have delegation of the NPDES permit as MA DEP is jointly working with EPA Region 1; these factors play into how municipalities can better meet the Phase II MS4 permit goals. The following recommendations focus on costs, collaboration, and compliance in addressing the stormwater permit and challenges.

Recommendation 1: Adopt a stormwater utility fee to fund stormwater maintenance and operations

As costs for stormwater management increase under the CWA, the Phase II Small MS4, as a federal mandate, provides funding to states and municipalities. The stormwater permit is very complex and comprehensive. For Massachusetts, the top-down policy does not provide a lot of flexibility to municipalities to best manage their goals but places accountability on them to

ensure that waterways are not further degraded from runoff. Furthermore, land-use policies support the protection of waterways using economic, social, and environmental means.

Massachusetts has different funding schemes that are available but limited. Municipalities such as the Town of Maynard and the City of Marlborough might consider implementing a stormwater utility fee that could help them reduce the cost burden to the municipality as stormwater is more localized in terms of water quality and TMDL requirements. Furthermore, municipalities implementing such a fee may face pushback on costs, site location, or human resource requirements to support green infrastructure projects.

Creative funding approaches to encourage private landowner implementation of stormwater management include grants, new taxes, stormwater utilities that can charge fees for services, and other market-based mechanisms (Reick et al., 2021). As seen for the Town of Maynard, the municipality has had trouble getting funding to cover the costs of the stormwater permit requirements, which puts a significant cost burden on the municipality. Furthermore, the municipality cannot retrofit green infrastructure due to costs and available land area.

A stormwater utility is a public funding mechanism, similar to other utilities such as electric and water, to finance stormwater infrastructure and services, including typical stormwater utility fees (Allen, 2020). The following shows the stormwater utilities by fee type (Allen, 2020):

- equivalent residential units (ERU)
- a fixed-rate, tier system
- resident equivalence factor
- two-level system (residential/commercial)
- fee per parcel, water meter
- by water usage
- the existence of a stormwater utility

- fee per square foot impervious area

The Town of Maynard and the City of Marlborough could implement a stormwater utility to ensure a source of funds for stormwater maintenance and infrastructure. This can be used as a model for other municipalities in Massachusetts, including within the SuAsCo watershed and others who might not already have a stormwater utility fee set up as a tool to fund stormwater management. Stormwater fees allow everyone contributing to a stormwater utility to pay for the available services. They are more flexible and responsive, allowing property owners to adopt a BMP to control runoff (Vicari et al., 2016). As of 2020, 22 stormwater utility fees have been implemented for many municipalities in Massachusetts with different stormwater utility options.

Massachusetts has legislation to enable municipalities to implement a stormwater utility (MGL Chapter 83, section 16 and MGL Chapter 40, section 1A) (Pioneer Valley Planning Commission. N.d.) The legal challenges for implementing a stormwater fee usually fall under the language of the utility as a fee or a tax. Municipalities must seek voter or legislative approval for such a fee (Hammer et al., 2018; Buchheister et al., 2016).

An example of a stormwater utility in Massachusetts is the City of Chicopee. The City implemented a Rain Smart Rewards ordinance that offers up to a 50% reduction to implement BMPs for property owners (Pioneer Valley Planning Commission. N.d.). Another example is the Town of Ashland. The Town implemented a stormwater enterprise fund set up as a fair share based on the amount of stormwater produced from the residential properties. The process faced a lot of pushback, but there was buy-in from the stakeholders, and educating the residents helped pass the stormwater enterprise fund (EPA Region 1, 2019).

The benefits of the stormwater utility are that it allows equitable means to pay for the fee, such as tax-exempt properties are required to pay. The fee creates funding that can be used to

meet grant/bond requirements and can provide an incentive for low-income residents if a credit or reduction is offered (Pioneer Valley Planning Commission. N.d.). It is also easier for municipalities to implement than other types of funding. Public education and outreach are crucial to ensure buy-in from the community, especially collaborating with stakeholders such as consultants, EPA Region 1, MA DEP, and the Massachusetts Planning Council. The collaboration would benefit from working with the residents who would be paying the fee to help them understand how this would benefit them in the long run.

Recommendation 2: Strengthen municipal stormwater partnerships with regional and watershed organizations

Non-point source pollution, such as phosphorus, is a significant pollutant in stormwater water quality due to urbanization and an increase in impervious surfaces, along with the intensity of the precipitation due to climate change. Both municipalities are located within the lower basin of the SuAsCo watershed, which then drains into the Merrimack River, part of the larger Merrimack River watershed of Massachusetts and New Hampshire.

In the State of Massachusetts, there is an established Statewide Stormwater Coalition that includes regional stormwater coalitions such as the Central Massachusetts Regional Stormwater Coalition, Connecticut River Stormwater Collaborative, Southeast Regional Stormwater Coalition, and Northern Middlesex Stormwater Collaborative. There is no defined stormwater coalition for municipalities in the SuAsCo watershed. However, the City of Marlborough is part of the Central Massachusetts Regional Stormwater Coalition, and the Town of Maynard is not part of one. Maynard is part of the larger Massachusetts Metropolitan Planning Council, specifically the Minutemen Advisory Group on Interlocal Coordination (MAGIC). The MAPC has stormwater tools that are available for use. An example of a watershed-level regional

stormwater collaborative is Massachusetts's Neponset River Watershed Association and the Charles River Watershed Association.

To further ensure that stormwater quality goals are being met, such as phosphorus and pathogens TMDL, it is critical to consider stormwater on a watershed scale. Collaborative water quality monitoring programs operating on a watershed level can effectively identify and address water quality issues more efficiently than local or individual efforts (Tran et al., 2019). According to Tran et al. (2019), the reasons why municipalities might want to join a watershed level collaboration include:

- Coordination of response to increasing future regulatory pressures
- Shared regional concerns or problems
- Reduced costs through economies of scale and reduced duplication of work that have already been done
- Improve chances for funding of awards directed towards more significant projects

An example of a stormwater collaboration/partnership regionally within a watershed association is the Neponset River watershed, where they have a regional partnership that focuses on stormwater and collaborates on meeting permit goals such as financing, creation of permit documents, school programs, stormwater bylaws, and production of regional public outreach. The Neponset River watershed works in collaboration with the Massachusetts Planning Council. Another example is the Central Massachusetts Regional Stormwater Coalition which works with 31 communities to help meet the Phase II Small MS4 permit goals and shared resources.

Region 1 EPA, in conjunction with MA DEP, could help municipalities encourage regional or watershed level collaboration that could benefit municipalities in meeting their permit goals. Collaboration that could include private and inter-municipal involvement would help stormwater managers to work together to address the issues. This could help provide funding to

do the work or hire private consulting companies to help municipalities meet the minimum control measures and the Phase II Small MS4 permit requirements.

Collaboration between municipalities, watershed associations, and regional agencies can help meet the Phase II Small MS4 permit goals and address stormwater quality issues to ensure waterways are not further degraded. This is an additional resource for municipalities, in addition to private consultants who help with the stormwater management process.

Recommendation 3: Implement the Adopt-a-Drain program

Public outreach, education, and IDDE are part of Phase II Small MS4 goals; engaging with residents is essential to ensure ongoing stewardship. Implementing community science and engaging with the municipalities and stakeholders help with low-cost monitoring programs with community science, GIS, interdepartmental collaboration with other local governments, or higher education (Rieck et al., 2021).

As seen for the Town of Maynard and the City of Marlborough, public education and outreach and IDDE were common challenges for both. With monitoring, private landowners and volunteers can have the opportunity to boost buy-in to the maintenance of BMPs. Regarding stormwater, this could encourage residents to change their behavior. Municipalities can implement the "Adopt-A-Drain" program utilized by other cities and towns (i.e., Massachusetts, Minnesota, Oregon, Vermont, and New Jersey) for stormwater management.

The "Adopt-A-Drain" program is a national clean water program. The program asks stakeholders (i.e., businesses, neighborhood groups, and individual residents) to adopt or manage stormwater drains in their communities by pledging to clear out leaves and other debris from a stormwater drain and report issues to those who manage the program (i.e., department of public works) (Saywitz et al., 2021).

Utilizing the program engages residents to keep neighborhoods clean and protect waterways within communities, thus helping implement changing behaviors to reduce runoff and localized flooding (Adopt-a-drain, n.d.). Furthermore, ensuring that the program is equitable includes a variety of participants based on neighborhood variables such as race, ethnicity, homeownership, and socioeconomic status (Saywitz et al., 2021). Benefits of implementing the program include (Adopt-a-drain, n.d.):

- Improve water quality by reducing pollution runoff and localized flooding
- Meet the Phase II Small MS4 permit requirements (i.e., pollution prevention and public education and outreach)
- Direct action through the Adopt-a-Drain web app and track data for pollution prevention metrics

Statewide examples of the program adopted in Massachusetts are the City of Medford, which implemented the program in 2021, and the Town of Seekonk, which implemented it in 2011. The City of Medford planning department established its Adopt-A-Drain program as part of its stormwater management and to reduce localized flooding (City of Medford, MA. n.d.). The City is located within the Mystic River watershed, which has impaired waterways and drains into the Mystic River and lakes. The planning department has a website for Medford which allows residents and other volunteers to adopt a drain. The Town of Seekonk's program is a partnership between the Town and residents to keep storm drains cleared on a timely basis to reduce flooding during heavy rain events and report any pollutants (Seekonk, MA., n.d.). For residents to participate, there is a paper application that residents and others who want to adopt a drain submit to the Department of Public Works.

Implementing an "Adopt-A-Drain" program could help municipalities, the Town of Maynard and the City of Marlborough, incentivize their residents, businesses, and neighborhood

groups to be more involved with their community's stormwater management. It represents a creative solution to reduce costs in addressing stormwater BMPs for the municipalities and to meet Phase II Small MS4 goals.

5.4 Conclusion

The stormwater permit is a comprehensive federal mandate to ensure that waterways are not being impaired by stormwater runoff pollution like phosphorus and pathogens. The study aimed to examine the Phase II Small MS4 permit regarding the stormwater policy for municipalities in Massachusetts. It focused on how the policy impacts municipalities in terms of cost, compliance, and collaboration. Stormwater management related to Massachusetts's stormwater policy varied based on the municipalities' resources and time. The two municipalities differed in their stormwater management approaches, including doing the work in-house versus collaboration with or a regional stormwater coalition. The municipalities also differed in some of the challenges they faced meeting the six minimum control measures such as public outreach and education, IDDE, and water quality/TMDL.

The larger context of the findings shows how different municipalities manage the stormwater permit based on their time and resources while ensuring compliance with the permit. As noted in the study, the top-down policy is challenging for municipalities but ultimately ensures that waterways are protected as stormwater management evolves to adapt and mitigate the projected increase in rainfall expected with climate change. Though the study size was small, the findings provided insight into how the stormwater managers dealt with the permit and how the permit could be better utilized to meet the needs of protecting waterways and reducing stormwater runoff.

Future studies could extend this research to explore additional watershed areas in Massachusetts that have managed the Phase II Small MS4 permit and addressed similar challenges related to costs, permit compliance, and collaboration. Stormwater does not follow political boundaries, so it follows that stormwater policy is best determined on a watershed level. Planning and policy play a role in how water quality can be protected and further address stormwater management.

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Appendix

Appendix 1: Town of Maynard SWMP

1. **Public Education and Outreach:** The focus of the Town of Maynard on public outreach and education for possible pollutants that would impact the town's waterways were trash, sediment, dog waste, fertilizer, leaf litter, and grass clippings. The focus of the MCM was on residents, businesses, and developers over five years. The BMPs the Town entailed were stormwater management website, *Think Blue MA* advertising campaign, stormwater display and handouts at town meetings, stormwater and LID fact sheets outreach to Maynard Business Alliance, septic system maintenance fact sheet, dog owner education, spring, summer, and fall messages for dog waste, grass clippings, and leaf litter management (Maynard Town of Maynard Stormwater Management Program, 2019).

2. **Public Participation:** The focus of the Town of Maynard's public participation was to engage the public in reviewing and implementing the SWMP. The Town's BMPs entailed public review of the SMMP, Assabet River cleanups, Little League cleanups, and household hazardous waste (Maynard City Stormwater Management Program, 2019).

3. **Illicit Discharge Detection and Elimination (IDDE):** The focus of IDDE for the Town of Maynard was to find and eliminate illicit sources of non-stormwater discharges to its MS4 and prevent any illicit discharges. The Town's BMPs entailed illicit discharge bylaw, written IDDE program, sanitary sewer overflow inventory, stormwater sewer system mapping, employee training, dry weather outfall, catchment investigation, wet weather screening, and ongoing screening (Town of Maynard Stormwater Management Program, 2019).

4. **Management of Construction Site Runoff:** The focus of the Town of Maynard on the management of construction site runoff was to minimize or eliminate erosion and maintain sediment on the site to ensure that sediment is not transported in stormwater discharged to the U.S. water of the U.S. through the Town MS4. The Town's BMPs involved a stormwater management bylaw, site inspection and enforcement procedures, and site plan review (Maynard Town Stormwater Management Program, 2019).

5. **Management of Post Construction Site Runoff:** The focus of Maynard's management of post construction site runoff was to reduce the stormwater discharge of stormwater pollutants to its MS4 and to receive water bodies through retaining or treating stormwater runoff after construction on new or redeveloped sites. The Town's BMPs entailed post construction stormwater management bylaw, as-built plans, target properties to reduce impervious areas, green infrastructure, and street design and parking lot guidelines (Town of Maynard Stormwater Management Program, 2019).

6. **Good Housekeeping in Municipal Operations:** The focus of Good Housekeeping in municipal operations was to prevent or reduce runoff from the Town's facilities and operations. The Town's BMPs involved facilities inventory, written MS4 O&M operations, SWPPP of the DPW yard, catch basin inspection and cleaning, winter road

maintenance, and stormwater treatment facility inspections (Town of Maynard Stormwater Management Program, 2019).

7. **TMDLs and Water Quality Impairments:** Per the MS4 permit, additional requirements for MS4s discharge to waters subject to TMDLs and specific water quality limited waters. The receiving water bodies were identified as impaired or required in TMDLs: impairment: bacteria/pathogens and TMDL: PHOSPHORUS TMDL. BMPs to reduce impairment and meet TMDL include meeting the required 6 MCM to reduce further PHOSPHORUS loading into the Assabet River.

Appendix 2: City of Marlborough SWMP

1. **Public Education and Outreach: prevention of** stormwater pollution, letters about annual reporting on stormwater, stormwater permits for each project, proper maintenance (salt, materials, sweeping), preconstruction meetings, and proper erosion controls (City of Marlborough Phase II MS4 NOI. 2019).

2. **Public Involvement and Participation**: SWMP review and collection of household hazardous waste/used oil (City of Marlborough Phase II MS4 NOI. 2019).

3. **Illicit Discharge Detection and Elimination (IDDE):** Develop an SSO inventory, create a map and update IDDE program completion, create a written IDDE program, train employees on IDDE implementation, implement catchment basin investigations, conduct outfall screenings and investigations, and conduct dry and wet weather screening (City of Marlborough Phase II MS4 NOI. 2019).

4. **Construction site stormwater runoff control:** Complete written inspections and enforcement procedures, review of the site plan, erosion and sediment control, and waste control (City of Marlborough Phase II MS4 NOI. 2019).

5. **Post-construction stormwater management in new development and redevelopment**: As built plans for on-site stormwater control, target properties to reduce impervious areas, green infrastructure street design, and parking lot guidelines (City of Marlborough Phase II MS4 NOI. 2019).

6. **Municipal Good Housekeeping and Pollution Prevention:** Infrastructure and Operations and Management procedures, inventory of all permittee owned parks and open spaces, buildings and facilities and vehicles, and equipment, stormwater pollution prevention plan, catch basin cleaning, street sweeping program, and road salt use optimization program (City of Marlborough Phase II MS4 NOI. 2019).

7. **TMDLs and Water Quality Impairments:** Per the MS4 permit, additional requirements for MS4s discharge to waters subject to TMDLs and specific water quality limited waters. The City of Marlborough receives water bodies impaired or required to TMDLs – fecal coliform, TSS and turbidity, and TMDL: PHOSPHORUS TMDL (City of Marlborough Phase II MS4 NOI. 2019) 2019).