

Assessment of Municipal Compliance of Central Massachusetts Municipalities with the 2013
MS4 Draft Permit and Development of a Compliance Tool

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

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December 15th 2013

ABSTRACT

Stormwater runoff poses a threat to the environment. This project's goal was to assist four Massachusetts municipalities with compliance with the 2013 New Hampshire (NH) Municipal Separate Storm Sewer System (MS4) draft permit, which regulates municipal stormwater discharges. In collaboration with the Massachusetts Department of Environmental Protection and Central Massachusetts Regional Stormwater Coalition (CMRSWC), we assessed: the subject towns' compliance with the 2003 MS4 permit; steps they must take to meet the 2013 NH MS4 draft permit requirements; and created a checklist and fact sheet to increase municipalities' understanding of and ability to comply with the 2013 NH MS4 draft permit. Although we focused on four towns, we hope our work benefits all 30 CMRSWC municipalities.

ACKNOWLEDGEMENTS

At the culmination of our project, we would like to thank the many people who took the time to work with us to make this project possible. First, we would like to thank our sponsor, the Massachusetts Department of Environmental Protection. Specifically, we would like to thank Andrea Briggs, Frederick Civian, Cheryl Poirier, and Stella Tamul for providing their vast knowledge on stormwater management and the Municipal Separate Storm Sewer System (MS4) permit. We would also like to extend our thanks to Ms. Briggs for her assistance in scheduling interviews with municipal employees.

Additionally, we would like to thank the municipal employees who took the time to answer our questions, provided us with invaluable information for our research, and provided feedback on our project deliverables. In particular, we are grateful to Bradford Stone of Shrewsbury, Patrick Navaroli and Thomas Wood of Leicester, Jeffrey Thompson of Upton, and Brian Szczurko of Grafton.

We would also like to thank Aubrey Strause of Verdant Water and Matthew St. Pierre of Tata and Howard. Both provided our team with insight about municipalities and their compliance with the MS4 permit and were always eager to answer our questions. Additionally, we would like to thank the Central Massachusetts Regional Stormwater Coalition (CMRSWC) for providing our team with the opportunity to network with employees from a variety of municipalities and present our findings. The CMRSWC also generously allowed our team to use their resources, such as a GPS unit, for which we are thankful.

More thanks are in order for Newton Tedder of the United States Environmental Protection Agency, who took the time to meet with our team in order to provide expert knowledge of the MS4 permit as well as valuable feedback on our project deliverables.

Finally, we would like to thank our project advisors, Professors Melissa Belz and Corey Dehner. Without their extensive guidance and advice, we would not have been able to accomplish as much as we did during our project.

EXECUTIVE SUMMARY

INTRODUCTION

In the United States, stormwater runoff is listed as the primary source of pollution for many bodies of water (EPA, 2002). Stormwater runoff is created from rainwater or melted snow when it flows across impervious surfaces. Impervious surfaces are manmade features that water cannot permeate, such as roads and parking lots (Weng, 2008). Stormwater runoff continues to flow across impervious surfaces until it enters a storm drain, which is a part of a Municipal Separate Storm Sewer System (MS4). The stormwater runoff then flows through the MS4's pipes until it reaches an outfall and discharges into a surface waterbody, untreated and unfiltered. As stormwater runoff flows over impervious surfaces, it picks up pollutants such as pesticides from agriculture and microbial pathogens from animal waste (EPA, 2012b). These pollutants adversely affect the health of humans, animals, and the environment. For example, microbial pathogens are the water pollutants most responsible for compromising human health worldwide (Lerner & Lerner, 2008b).

Because pollution from contaminated stormwater poses a threat to the environment, the United States Environmental Protection Agency (USEPA) has taken steps to reduce the amount of stormwater runoff entering surface waterbodies. In 1972, a series of amendments were added to the Federal Water Pollution Control Act of 1948, which became commonly known as the Clean Water Act (CWA) (Jeffrey, 2007). The 1972 amendments to the CWA created a national permitting system called the National Pollutant Discharge Elimination System (NPDES) in order to manage point source pollution. According to the CWA, point source pollution is defined as “any discernible, confined and discrete conveyance” (Clean Water Act, 1972). When stormwater drains into an MS4, it is eventually discharged from an outfall. This discharge is a “discrete conveyance,” making it a source of point-source pollution. Due to the fact that the USEPA defines this conveyance as a point-source pollutant, it is regulatable under the CWA.

Following a mandate by Congress to the USEPA to do something about stormwater pollution, the MS4 permit was created under the NPDES program. Every municipality, defined as a city or town with corporate status and a local government, with an MS4 is required to obtain an MS4 permit in order to legally discharge stormwater into surface waterbodies. In order to meet the

requirements of the MS4 permit, each municipality must be in compliance with six minimum control measures. The six minimum control measures detail steps that municipalities must take in order to reduce their stormwater runoff pollution. The MS4 permit also requires that municipalities submit an annual stormwater report to the USEPA detailing the municipality's progress towards compliance with the MS4 permit (EPA, 2003). The most recent Massachusetts version of the MS4 permit was issued in 2003. However, a new draft permit for New Hampshire (NH) was released in 2013. A permit similar to the 2013 NH MS4 draft permit is expected to be issued for Massachusetts soon (78 FR 27964).

Although the MS4 permit serves the important purpose of mitigating the impact of the stormwater pollution entering America's surface waterbodies, complying with it can be a challenge for many municipalities. Since municipalities have limited budgets and other responsibilities to fund, procuring the funding for MS4 permit compliance can be difficult. In order to better manage stormwater runoff and improve their compliance with the MS4 permit, 30 municipalities in Central Massachusetts have joined together to form the Central Massachusetts Regional Stormwater Coalition (CMRSWC). These 30 municipalities are able to improve their own stormwater management by working with their neighbor municipalities since stormwater runoff crosses town boundaries. The CMRSWC received funding from the Massachusetts government in order to work towards better compliance with the MS4 permit (Central Massachusetts Regional Stormwater Coalition [CMRSWC], 2012b).

Due to the challenges presented to municipalities by the permit, the Massachusetts Department of Environmental Protection (MassDEP) has taken on the role of an educational liaison for Massachusetts municipalities trying to understand the MS4 permit requirements (Massachusetts Department of Environmental Protection, 2013b). Over the course of this seven-week term, we, three junior level Worcester Polytechnic Institute (WPI) students, collaborated with Central MassDEP in order to assist municipalities in the CMRSWC with MS4 compliance.

METHODOLOGY

In order to achieve our goal, we worked to fulfill the following objectives: (1) learn the specifications of the 2003 MS4 permit and 2013 NH MS4 draft permit; (2) assess the degree to

which the municipalities of Grafton, Leicester, Shrewsbury, and Upton meet the requirements of the 2003 MS4 permit and assess the steps they would have to take to meet the 2013 NH MS4 draft permit requirements; and (3) finally, in anticipation of a new Massachusetts MS4 permit, create a tool to assist municipalities with meeting the 2013 NH MS4 draft permit requirements.

During the initial stage of our project, we met Frederick Civian, MassDEP's Stormwater Coordinator, and Andrea Briggs, Deputy Regional Director for the Bureau of Administrative Services for MassDEP, who gave us professional advice and the expectations of this project. Then, we conducted document analysis on the 2003 MS4 permit, the 2013 NH MS4 draft permit, and the 2013 annual reports of the four municipalities in order to understand the permits' requirements and to gain insight on municipal compliance with both permits. While analyzing the municipalities' annual reports, we created a spreadsheet for each municipality in order to track which requirements of the 2003 MS4 permit they were in compliance with. However, after analyzing these documents and creating the spreadsheets we were left with many questions about the permits' wording and the state of the four municipalities' MS4 compliance.

After we collected data from the document analysis, our team conducted several interviews with MassDEP employees, municipal employees, and environmental consultants who helped municipalities map and file their 2013 annual reports. During the interviews, we asked which control measures these municipalities focus on the most, which control measures they have the greatest difficulty with, which municipal departments work on stormwater-related tasks, and for suggestions for a tool for assisting municipalities with meeting the requirements of the 2013 NH MS4 draft permit. By asking these questions, we learned information that helped MassDEP further understand municipalities' challenges with the MS4 permit.

In addition to conducting interviews, our team assisted the towns of Leicester and Upton with mapping catch basins and outfalls, which the 2013 NH MS4 draft permit requires. We utilized both a Leica CS25 GPS unit and an iPad during our fieldwork. Fieldwork gave us the opportunity to observe the state of the municipalities' MS4 systems and directly connect with the people who face the challenges of dealing with stormwater runoff. Additionally, it allowed us to gather information on the benefits and downsides of each mapping device.

Using the knowledge gained from our previous methods, we created a checklist and fact sheet of the 2013 NH MS4 draft permit requirements. The checklist and fact sheet provide an easy way for municipal employees to track their town's compliance with the 2013 MS4 draft permit. We hope that the checklist and fact sheet will allow municipal employees to save time, while still ensuring permit compliance. As a result, municipal employees will be able to reduce their municipalities' stormwater pollution and have additional time to meet their other important responsibilities to the town. In addition to providing us with the information necessary to create a fact sheet and checklist, our methodology also led us to several findings.

FINDINGS

During the course of this project, we worked with the towns of Grafton, Leicester, Shrewsbury, and Upton in order to learn about the challenges municipalities face with MS4 permit compliance. We discovered several findings, the most significant of which are: (1) both permits have unclear wording; (2) many municipalities lack a dedicated source of funding, sufficient manpower, and enough time to implement the current permit and draft permit requirements; (3) the 2013 NH MS4 draft permit's additional requirements will make municipal compliance difficult; and (4) regionalization of stormwater management provides benefits to municipalities.

Unclear Wording in the 2003 MS4 Permit and 2013 NH MS4 Draft Permit

Both the permit and draft permit have some vaguely worded requirements. For instance, we determined that the wording of the Public Education requirement of the 2003 MS4 permit caused confusion about whether education regarding the dangers of illegal dumping counted as education directed at industrial groups. Other sections of both the permit and draft permit require permittees to "consider" the implementation of certain stormwater practices or stormwater management plans. According to Newton Tedder, a Physical Scientist of the USEPA, the vague wording of the 2003 MS4 permit was intended to encourage municipalities to begin working on stormwater management without overwhelming municipal employees with requirements (N. Tedder, December 3, 2013). He informed us that sections of the 2013 NH MS4 draft permit were also written in an intentionally-vague manner in order to give municipalities flexibility with permit compliance. However, many municipal employees are confused with both permits'

vaguely-worded requirements, which leads to problems with the implementation of certain control measures.

Lack of Funding, Manpower, and Time

The biggest challenges that municipalities face with MS4 permit compliance are lack of funding, manpower, and time for implementation. For example, many municipalities struggle with the mapping requirement of the IDDE control measure. This is because municipalities may contain upwards of 350 outfalls and 5,000 catch basins. Since municipalities have limited funding, they often cannot hire the additional staff that they would need in order to map all of their stormwater structures in enough time to satisfy the requirements of the 2013 NH MS4 draft permit.



Figure 1: Mapping of an outfall in Upton on November 22, 2013

As seen in Figure 1, we mapped an outfall in Upton. The process of mapping outfalls was very time consuming. First, we needed to find an outfall by looking into catch basins and determining which direction the stormwater was flowing. We also tried looking for pipes in the catch basins to determine the direction in which the outfall was located. After determining the approximate direction of the outfall's location, we walked in that direction and searched for the outfall. In

Upton, our team worked with Aubrey Strause, a professional engineer and the owner of Verdant Water, over the course of roughly six hours. During that time, we mapped three outfalls and approximately 30 catch basins. Based on this speed, our team estimates that if a municipality has 5,000 catch basins, municipal employees or environmental consultants would need to work for approximately 1,000 hours in order to map all of the municipality's catch basins.

Table 1: A comparative table of municipal data. See Appendix C for a larger version of the municipalities' impervious surface maps.

	Grafton	Leicester	Shrewsbury	Upton
Population at the 2010 census	17,765	10,970	35,608	7,542
Area (sq. miles)	23.33	24.64	21.73	21.8
Type	Semi-rural	Rural	Suburban	Suburban
Department in charge of stormwater	- DPW - Conservation Commission	- Highway Department - Sewer Department	- Engineering Department - Highway Department	- DPW - Conservation Commission
Number of people available to work on stormwater management	10 DPW employees (1 engineer and 1 worker at a time)	2 employees from Highway Department (1 superintendent, 1 worker)	3 employees from Engineering Department	5 DPW employees including 1 supervisor and 4 workers
Number of Outfalls	~ 350	89	~ 520	72
Number of Catch Basins	~ 2,500	~ 2,500	~ 5,600	Unknown
Area of Impervious Surfaces (sq. miles)	2.48 (10.64%)	1.41 (5.73%)	4.02 (18.48%)	1.42 (6.5%)
Map of Impervious Surfaces and Watershed	<p>Legend</p> <ul style="list-style-type: none"> Subbasins Groundwater Contributing Areas (GWCA) Impervious Area MS4 Urban Area MA Towns Water Bodies 			

Additional Requirements of the 2013 NH MS4 Draft Permit

As previously stated, the 2013 NH MS4 draft permit requires municipalities to map additional stormwater structures, such as catch basins. We anticipate that many municipalities will have difficulty fulfilling this requirement as a result of the previous challenges discussed with funding, manpower, and time. Additional requirements within the IDDE section of the permit mandates municipalities to complete water quality sampling of outfalls during both dry and wet weather. Water quality sampling, especially during wet weather, requires multiple individuals to be mobilized simultaneously, and as mentioned above, many municipalities have upwards of 350 outfalls (B. Stone, November 12, 2013).

Additionally, we anticipate that municipalities will face challenges with the Public Education control measure of the 2013 NH MS4 draft permit. Section 2.3.2.1.c of the 2013 NH MS4 draft permit requires municipalities to send at least two messages to each of four target audiences during the permit term of five years. Additionally, municipalities must space the messages sent to each audience by one year. Since the 2003 MS4 permit requires municipalities only to address residential and industrial groups, this control measure has gained many additional requirements (78 FR 27964; EPA, 2003).

Utility of Regionalization

Municipalities that work together in order to meet the requirements of both the 2003 MS4 permit and 2013 NH MS4 draft permit can better overcome the various challenges that the permits present. For instance, the CMRSWC has proved to benefit the four towns we worked with and has also benefitted the other 26 member communities as we saw firsthand during the CMRSWC's meetings and workshops. The CMRSWC has annual training workshops, and on November 20 our team attended this year's training workshop. During the workshop, municipal employees were taught how to use the CMRSWC's Leica GPS unit in order to perform mapping. Municipal employees were also taught how to perform water quality testing. Since the skill sets of municipal employees attending to stormwater tasks in each municipality is varied, this training provides a way for municipal employees to learn about methods to meet the requirements of the MS4 permit that may be unfamiliar to them. Overall, the use of shared resources and the collaborative effort towards meeting the requirements of both the 2003 MS4 permit and 2013

NH MS4 draft permit has proved to be a valuable asset to the 30 participating Central Massachusetts municipalities in the CMRSWC.

RECOMMENDATIONS

After accomplishing the tasks set forth in our methodology and discovering the findings partially detailed in the section above, we developed a set of recommendations for the USEPA, MassDEP, future researchers, and Central Massachusetts municipalities. We believe that through these recommendations, municipalities will be better able to mitigate the impacts of stormwater runoff, leading to cleaner, more usable surface waterbodies. Additionally, we believe that these recommendations will allow municipal employees to save time meeting the MS4 permit requirements and allow more time to focus on their other responsibilities. Some of our key recommendations are detailed below. These recommendations are those that we believe will make the most significant impact on stormwater management and MS4 compliance across Central Massachusetts.

Future Researchers: Research the Logistics of Creating a Stormwater Utility

We recommend that future researchers research the logistics of creating a stormwater utility, which is a utility established in order to provide a consistent source of funding for stormwater management. Creating a stormwater utility would provide a municipality with a dedicated and consistent source of funding. However, the process of creating a stormwater utility is complicated and can be difficult to accomplish due to political reasons. The cost of the stormwater utility falls on a municipality's residents, and no politician wants to propose a new tax. Due to the difficulties in creating a stormwater utility, we also recommend that future researchers research alternate dedicated and consistent sources of funding for stormwater management.

USEPA: Encourage Regionalization of Stormwater Management

Through our project, we have witnessed the enormous benefits that regionalization of stormwater management can have to member municipalities. It allows them to share resources that each municipality might not own, such as GPS units or water quality sampling kits. It also allows municipal employees to receive training that they would not otherwise have access to, such as

training on how to use the aforementioned GPS units and water quality sampling kits and presentations on IDDE. Additionally, regionalization allows municipal employees to build relationships with employees from other municipalities, leading to the potential of future collaboration.

Despite the benefits that result from regionalization, there are also drawbacks. It is very difficult to organize a large group, especially when its members come from as vastly different backgrounds as the members of the CMRSWC. Because of this, municipalities considering regionalization will need dedicated leadership in order to make the group work together efficiently. Due to the variation in background of the municipal employees, training cannot be tailored to one specific audience. Some municipal employees from engineering department may have extensive knowledge on topics such as water quality sampling while other department such as DPW may have none. As a result, training on water quality sampling can be immensely beneficial to some members from DPW, but a waste of time for others from engineering department.

Municipalities that have sufficient resources, such as staff and stormwater knowledge, may not benefit from regionalization. However, through our research we learned that even municipalities with significant stormwater knowledge and staff still face challenges with meeting the MS4 permit requirements. Therefore, for many municipalities, regionalization will provide a chance at compliance with the MS4 permit that they would not otherwise have. If more municipalities facing challenges with MS4 permit compliance follow the CMRSWC's example, they will also experience benefits with meeting the requirements of the MS4 permit.

Municipalities and MassDEP: Pilot the 2013 NH MS4 Draft Permit Checklist and Fact Sheet

Our team recommends that MassDEP test the utility of the checklist and fact sheet that our team created for tracking compliance with the 2013 NH MS4 draft permit. Since the 2013 NH MS4 draft permit is 60 pages long, it is time consuming for people to complete reading the permit and it is difficult to remember every requirement. Municipalities can use the checklist as a tool to quickly track what they have done and not done. When they are looking for an explanation of a certain requirement on the checklist, then they can use fact sheet to clarify the requirement. The

fact sheet condensed the requirements of 2013 NH MS4 draft permit into approximately 20 pages. If MassDEP finds that the checklist and fact sheet will benefit municipalities, we highly recommend that the 30 municipalities of the CMRSWC pilot the checklist and give suggestions about further adjustments. If the municipalities also find the checklist and fact sheet helpful, we recommend that MassDEP make the checklist and fact sheet available to all Massachusetts municipalities.

CONCLUSION

Although municipalities in Massachusetts still face challenges meeting the requirements of the 2003 MS4 permit and 2013 NH MS4 draft permit, the checklist and fact sheet we created in this project will assist municipalities with compliance with the upcoming MS4 permit. By working collaboratively with MassDEP and four Central Massachusetts municipalities, we saw firsthand how municipalities have difficulty meeting the permit's requirements for a variety of reasons. However, we saw that municipalities are very enthusiastic about reducing the impacts of stormwater runoff. We hope that the tools we created and data that we uncovered will allow the four municipalities we worked with to make the progress they desire towards complying with the 2013 NH MS4 draft permit. We also hope that the additional 26 municipalities of the CMRSWC can benefit from our research and deliverables. Further, we hope that our recommendations will extend to other municipalities in Massachusetts and other states in order to reduce stormwater runoff and lead to cleaner surface waterbodies across the country.

AUTHORSHIP

Our team took a collaborative approach towards writing our final report. Originally, each team member was responsible for each section and/or subsection of a chapter, but throughout the iterative process of revision, each team member contributed their writing and editing skills towards each part of the final report. We all took on the roles of drafting, writing, editing, and formatting this report into its current state.

There are some sections of the final report which were written primarily by one author, then edited by the other two members of the team. These sections follow in the table below.

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Table of Contents

ABSTRACT..... i

ACKNOWLEDGEMENTS..... ii

EXECUTIVE SUMMARY iii

AUTHORSHIP xiv

ACRONYMS xxii

1.0 INTRODUCTION 1

2.0 BACKGROUND 3

2.1 STORMWATER..... 3

 2.1.1 The Hydrologic Cycle 5

 2.1.2 How does Stormwater Runoff Begin? 6

 2.1.3 Water Pollutants and their Impact..... 7

 Suspended Solids..... 7

 Phosphorus..... 8

 Microbial Pathogens 8

 Heavy Metals 9

 Oil, Grease, and Other Automotive Fluids 9

 Toxic Organic Compounds..... 10

 Trash 10

 2.1.4 Stormwater Situation in Massachusetts..... 11

2.2 REDUCING THE IMPACTS OF STORMWATER..... 12

 2.2.1 Mitigation at a Residential Level 12

 Solid Waste Disposal..... 13

 Toxic Chemical Usage..... 14

 2.2.2 Mandated Mitigation 14

Clean Water Act	14
NPDES.....	15
MS4 Permits	16
Best Management Practices.....	17
2.2.3 Obstacles with Mandated Mitigation	18
Noncompliance.....	18
Financial Limitations.....	19
Stormwater Utility Fees.....	19
Grants.....	20
2.3 ASSISTANCE WITH MS4 PERMIT COMPLIANCE	20
2.3.1 The Community Innovation Challenge Grant	21
2.3.2 MassDEP’s Role.....	22
2.3.3 Stormwater Engineering Consulting Firms	22
2.3.4 Volunteer Groups	23
2.4 SUMMARY.....	24
3.0 METHODOLOGY	25
3.1 OBJECTIVES	25
3.1.1 Determining MS4 Specifications	25
Document Analysis.....	26
Interviews	26
3.1.2 Assessing Municipality Compliance.....	27
Document Analysis.....	27
Interviews	28
Participant Observation	29
Data Analysis.....	30

3.1.3	Creating Tools to Assist Municipalities with Compliance.....	31
	Document Analysis.....	31
	Interviews	32
3.2	OBSTACLES.....	33
3.3	CONCLUSION.....	33
4.0	FINDINGS AND DISCUSSION.....	35
4.1	INTRODUCTION	35
4.2	CASE STUDIES OF FOUR MUNICIPALITIES	35
	Grafton, Massachusetts	35
	Focus on Public Education	36
	Challenges with Outfall Mapping.....	37
	Challenges with the Upcoming MS4 Permit	37
	Lack of Manpower.....	38
	Issues with the Implementation of a Stormwater Utility.....	38
	Utility of Regionalization	39
	Leicester, Massachusetts	40
	A High Level of Knowledge is Needed in Order to Map Leicester’s Catch Basins	41
	The Leica CS-25 GPS Unit is Unreliable.....	42
	The Leicester Highway Department is Understaffed for its Scope of Responsibilities	42
	Benefits of Regionalization	43
	Funding.....	44
	Unclear Wording	44
	Shrewsbury, Massachusetts.....	44
	Shrewsbury’s Compliance with the MS4 Permit	45
	Challenges with Meeting the IDDE Requirements of the 2013 NH MS4 Draft Permit	46

Challenges with Meeting the Public Education Requirements of the 2013 NH MS4 Draft Permit.....	47
Lack of Manpower, Funding, and Time	47
Inefficient Storage of Documents	49
The 2013 NH MS4 Draft Permit Fact Sheet from the USEPA is Complex	49
Upton, Massachusetts.....	49
Difficulty of the IDDE Control Measure in Both Permits.....	50
Experience Using Mapping Devices	51
4.3 COMPARATIVE QUALITATIVE DATA ANALYSIS	53
Unclear Wording in the 2003 MS4 Permit.....	53
IDDE: The Greatest Challenge of the 2003 MS4 Permit.....	54
Lack of Funding	54
Lack of Manpower	56
Time Constraints	58
Knowledge of Stormwater Management/Training.....	60
Unclear Wording of 2013 MS4 Draft Permit.....	61
Difficulty of the IDDE Control Measure in Upcoming MS4 Permit.....	62
Difficulty of Public Education Control Measure in Upcoming MS4 Permit.....	62
Utility of Regionalization.....	63
Use of Environmental Consultants.....	64
Experience Using Mapping Devices	65
5.0 RECOMMENDATIONS	67
Recommendations to the USEPA:	67
Encourage Regionalization of Stormwater Management.....	67
Develop a Method for Assessing Educational Messages' Effectiveness	68

Create a More Condensed Fact Sheet for the Upcoming MS4 Permit	68
Provide Funding for Meeting the Requirements of the Upcoming Permit.....	69
Provide Training on the Upcoming Permit Requirements	69
Recommendation for Municipalities:.....	69
Develop a Schedule for Implementation of Public Education	69
Order of Completion of IDDE Mapping Requirements	70
Recommendations to the CMRSWC and MassDEP:.....	70
Pilot the 2013 NH MS4 Draft Permit Checklist and Fact Sheet	70
Recommendation to Future Researchers:.....	71
Research the Logistics of Creating a Stormwater Utility	71
6.0 CONCLUSION.....	73
WORKS CITED	74
APPENDICES	83
APPENDIX A: INTERVIEW QUESTIONS	83
APPENDIX B: SPREADSHEET OF MUNICIPAL COMPLIANCE WITH THE 2003 MS4 PERMIT	87
APPENDIX C: MAPS OF IMPERVIOUS AREA IN GRAFTON, LEICESTER, SHREWSBURY, AND UPTON, MASSACHUSETTS	91
APPENDIX D: CHECKLIST OF THE 2013 NH MS4 DRAFT PERMIT REQUIREMENTS..	95
APPENDIX E: FACT SHEET FOR THE 2013 NH MS4 DRAFT PERMIT	101
APPENDIX F: USEPA’S IDDE PROGRAM FLOWCHART	121

List of Figures

Figure 1: Mapping of an outfall in Upton on November 22, 2013	vii
Figure 2: Stormwater Runoff (Southern Indiana Stormwater Advisory Committee, n.d.).....	4
Figure 3: The Hydrologic Cycle (National Weather Services, 2010).....	5
Figure 4: Massachusetts' 28 Watersheds (Massachusetts Department of Environmental Protection, 2013a).....	12
Figure 5: A map of Central Massachusetts municipalities, highlighting the four we worked with. (Galvin, F. W., 2011)	35
Figure 6: A train station in Grafton, MA (Phelan, 2012).....	36
Figure 7: An entrance to Leicester, MA (Phelan, 2008).....	40
Figure 8: A catch basin in Leicester completely hidden by leaves (November 18, 2013)	42
Figure 9: The town hall of Shrewsbury, MA (GetACollage, 2005).	45
Figure 10: A picture of a water quality sampling unit Mr. Stone used on November 12, 2013...	48
Figure 11: The town hall of Upton, MA (Phelan, 2009).	50
Figure 12: Outfall in Upton with abrasion due to excessive sediment (Nov. 22, 2013).....	52

List of Tables

Table 1: A comparative table of municipal data. See Appendix C for a larger version of the municipalities' impervious surface maps.....	ix
Table 2: A comparative table of municipal data. See Appendix C for a larger version of the municipalities' impervious surface maps.....	57
Table 3: Consulting Firms Working for Municipalities	65
Table 4: Comparison of Leica GPS unit and Asus Tablet/iPad.....	66

ACRONYMS

BMP: Best Management Practice

BP: British Petroleum

CIC: Community Innovation Challenge

CMRSWC: Central Massachusetts Regional Stormwater Coalition

CWA: Clean Water Act

DPW: Department of Public Works

GPS: Global Positioning System

IDDE: Illicit Discharge Detection and Elimination

IQP: Interactive Qualifying Project

MassDEP: Massachusetts Department of Environmental Protection

MassDOT: Massachusetts Department of Transportation

MS4: Municipal Separate Storm Sewer System

NEWEA: New England Water Environment Association

NOI: Notice of Intent

NPDES: National Pollutant Discharge Elimination System

SWMP: Stormwater Management Program

SWQS: Surface Water Quality Standards

TBELs: Technology-Based Effluent Limitations

WHO: World Health Organization

WPI: Worcester Polytechnic Institute

WQBELs: Water Quality Based Effluent Limitations

WQRP: Water Quality Response Plan

USEPA: United States Environmental Protection Agency

1.0 INTRODUCTION

Have you ever swam in a lake, gone fishing, or even eaten fish caught in the United States? If so, you might be concerned to learn that the United States Environmental Protection Agency (USEPA) has assessed over 40% of the United States' streams and lakes as unusable for purposes as basic as fishing and swimming. This statistic points to a very prevalent pollution problem in urban and suburban areas: stormwater runoff (EPA, 2012i). Stormwater runoff is the flow of precipitation such as rainwater and melted snow across impervious surfaces. Impervious surfaces are manmade features such as parking lots that water cannot permeate (Weng, 2008). Not only can stormwater cause severe flooding, but when water flows across impervious surfaces into storm drains, it picks up and carries pollutants such as car oil, grease, and heavy metals into surface waterbodies via drainage systems. The effects on human health can be disastrous. For example, aluminum, a common heavy metal, has been proven to cause neurological disorders when ingested. When aluminum is washed away with stormwater runoff, it enters freshwater resources that are used for drinking water and swimming.

In order to reduce the impact of stormwater pollution, the United States Environmental Protection Agency (USEPA) created the Municipal Separate Storm Sewer System (MS4) permit which regulates ways in which municipalities across the United States can discharge stormwater into surface waterbodies. The most recently-released version of the MS4 that has gone into effect is the 2003 MS4 permit. USEPA has recently created a 2013 draft MS4 permit which is expected to be issued in February 2014, according to Newton Tedder, a Physical Scientist at the USEPA (N. Tedder, December 3, 2013). The 2013 draft permit was created for New Hampshire (NH), but a similar permit is expected to be released for Massachusetts. The requirements of the 2013 NH MS4 draft permit are much more specific and numerous than those in the 2003 MS4 permit (EPA, 2013d).

For our project, we worked collaboratively with the Massachusetts Department of Environmental Protection (MassDEP) to assist the four Central Massachusetts municipalities of Grafton, Leicester, Shrewsbury, and Upton with MS4 permit compliance. MassDEP is the state agency in charge of protecting the environment of Massachusetts through the management of toxic spills, the preservation of wetlands, and the management of air and water quality (Massachusetts

Department of Environmental Protection, 2013c). Through this project, we discovered the biggest reasons that municipalities struggle with compliance with the current 2003 MS4 permit. By using this information, we were able to gauge additional steps that municipalities would have to take in order to comply with the upcoming 2013 NH MS4 draft permit.

In order to accomplish this project, we analyzed the 2003 MS4 permit, 2013 NH MS4 draft permit, and annual reports from our four municipalities. We also conducted interviews with municipal employees, MassDEP employees, and environmental consultants. Lastly, we conducted participant observation by going to our four municipalities and performing catch basin and outfall mapping. The combination of these forms of research allowed us to not only gather data from pre-existing resources such as legal documents, but also collect new data about MS4 compliance issues.

The results of our project will be used by MassDEP to assist municipalities in Central Massachusetts with their MS4 permit compliance. Since the results clarified which aspects of the MS4 the four municipalities have difficulties complying with, we hope that MassDEP will use this information in order to give more targeted, specific advice to not only Grafton, Leicester, Upton, and Shrewsbury, but also other municipalities in Central Massachusetts. Additionally, we hope that by increasing compliance with the MS4 permit, municipalities will be able to reduce their stormwater pollution.

In Chapter 2, we discuss the background of our project, including detailed information about stormwater runoff and the MS4 permit. In Chapter 3, we explain our methodology for completing this project. In Chapter 4, we provide case studies of our four municipalities along with our findings. In Chapter 5, we explain our recommendations to USEPA, MassDEP, municipalities, and future researchers. In Chapter 6, we summarize our project and offer a conclusion.

2.0 BACKGROUND

While everyone knows that polluting water is bad, what many may not realize is how water becomes polluted in the first place. Some people think of water pollution as factories discharging chemical waste into streams and lakes. However, the majority of water pollution actually comes from other, much more difficult to trace sources such as stormwater. Stormwater runoff is precipitation such as rainwater or melted snow that runs off into streets, lawns, etc.

(Environmental Protection Agency [EPA], 2012a).

In Section 2.1, we discuss the causes and impacts of stormwater runoff. In Section 2.2, we explain ways in which stormwater runoff can be controlled and reduced. For instance, we discuss the role of the Municipal Separate Storm Sewer System (MS4) permit. In Section 2.3, we discuss methods and organizations that municipalities use in order to receive assistance with MS4 permit compliance.

2.1 STORMWATER

Stormwater comes from rainfall, which ideally would be infiltrated into the soil in the hydrologic cycle. However, some manmade features, like roads, driveways, parking lots, and rooftops, do not allow water to infiltrate through the ground. These manmade features are called impervious surfaces (Weng, 2008). When the water cannot drain into the ground, runoff occurs. As the stormwater runoff makes its way towards the nearest drain or body of water, it often picks up contaminants and pollutants along the way, such as fertilizers, herbicides, pesticides, trash, animal wastes, and automobile fluids (EPA, 2012b). The figure below is from the website of Southern Indiana Stormwater Advisory Committee, which is a regional partnership guiding stormwater quality programs. The figure provides an example of how stormwater runoff picks up pollutants and carries them into the nearby waterbody.

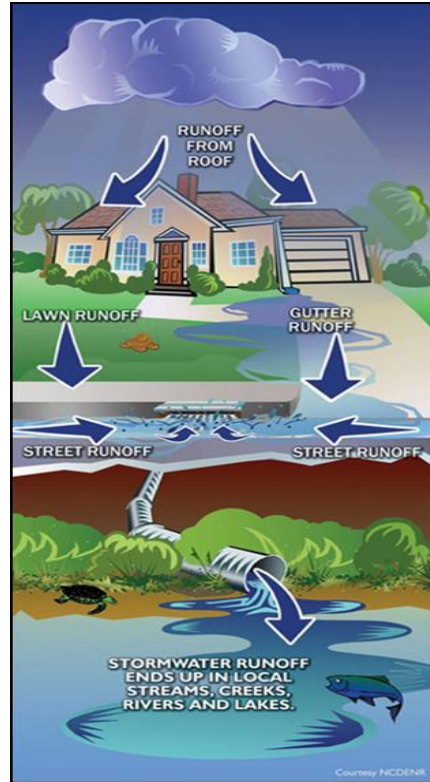


Figure 2: Stormwater Runoff (Southern Indiana Stormwater Advisory Committee, n.d.)

Without treatment, the pollutants carried by the runoff can prove disastrous for both human health and the health of animals and plants that live in or near the water source. For example, herbicides and pesticides can increase the level of toxic substances in water resources. As a result, the now toxic surface water can harm and kill the animals and plants which live nearby. In addition, the toxic water can sicken people who use these water resources for swimming, fishing, and drinking water (Nollet & Rathore, 2012).

Stormwater is a national, even global, issue. Although Massachusetts may not have the largest stormwater issue in the world, Massachusetts is facing significant stormwater runoff challenges. Roughly 60% of the state's water pollution originates from polluted stormwater runoff, and every single watershed in Southeastern Massachusetts has at least one body of water that violates one or more state Surface Water Quality Standards (SWQS), largely due to stormwater runoff (Watershed Action Alliance of Southeastern Massachusetts, 2012). The SWQS designate uses of waterbodies, set criteria to protect these uses, and establish provisions such as policies to protect waterbodies from pollutants (EPA, 2013c).

Stormwater comes from precipitation, a component of the hydrologic cycle which will be discussed in the next section.

2.1.1 The Hydrologic Cycle

In simple terms, the hydrologic cycle, commonly referred to as the water cycle, is the continuous circulation in which water makes its way from the atmosphere to the ground and then back again (Brooks, 2003). There is a fixed amount of water that is used in this cycle, but it is perpetually moving between the various components of the cycle (Freedman, 2008a). These components include evaporation, transpiration, condensation, precipitation, and runoff. Both evaporation and transpiration put water into the atmosphere. Evaporation is the transformation of water from liquid to gas in the atmosphere and transpiration is the release of water vapor from plants and soil. Condensation is the process that transforms water vapor to the liquid state (Silberberg, 2009). The condensed water vapor that falls to the Earth's surface is called precipitation. When the precipitation rate is greater than the infiltration rate, runoff occurs. Runoff enters surface waterbodies like lakes and rivers. Part of the runoff will evaporate into atmosphere, so the cycle starts again (Brooks, 2003).

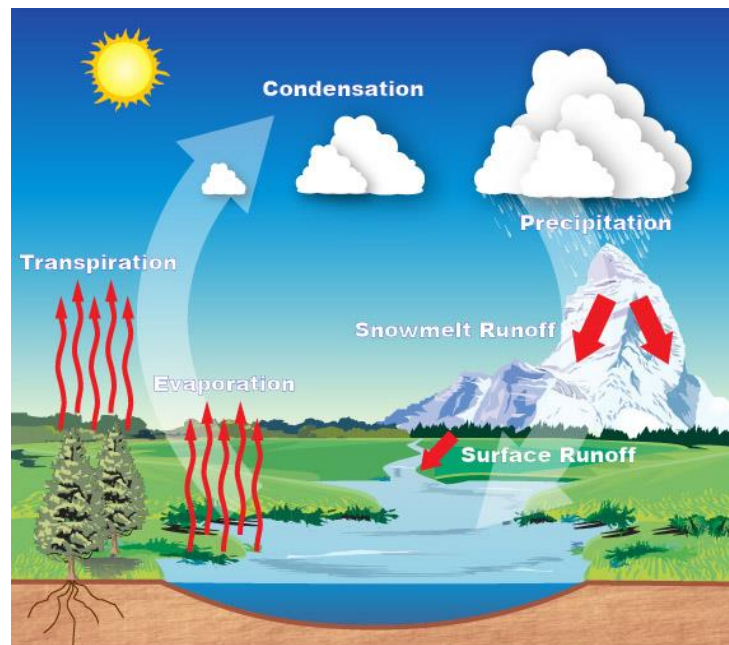


Figure 3: The Hydrologic Cycle (National Weather Services, 2010)

In order for the hydrologic cycle to continue functioning properly, the magnitude of precipitation that falls on a given area must remain consistent with the amount needed to sustain the cycle. Although it is difficult to plan land usage and water management in such a way that the hydrologic cycle remains mostly unaffected, it is necessary in order to protect the character and cleanliness of many bodies of water (Cahill, 2012).

2.1.2 How does Stormwater Runoff Begin?

If the amount of precipitation entering an area exceeds the amount of water being drained out of it, the ground becomes saturated, which means that the ground can no longer absorb any additional water. The remaining rainwater that falls on the surface then becomes runoff (Cahill, 2012). Although some runoff occurs naturally, urbanization has led to a dramatic increase in runoff volume.

Stormwater runoff has become more of a problem due to the rapid growth of the human population. More and more area has been developed to accommodate the growing population, resulting in increased amounts of impervious surfaces, which in turn yields increased stormwater runoff (Anderson, 1970). This is because impervious surfaces reduce potential water filtration. Also, impervious surfaces are not as rough as natural surfaces, and thus they offer less resistance to runoff (Sauer, Thomas, Stricker, & Wilson, 1983). However, the addition of impervious surfaces is not the only factor contributing to the increase of runoff as populations grow. To sustain the larger population, increased food production is necessary. This causes more land to be cleared for agricultural use. Expanded areas of cleared land increase the amount of exposed soil and decrease the natural vegetation, which is considered a protective cover helping water infiltration and preventing soil erosion (Larson, 2003). Therefore, the less vegetation, the weaker the ability of the land to store water, the more likely stormwater runoff will occur (National Research Council, 2009). Additionally, the fertilizers and pesticides used for agriculture become water pollutants when washed away with stormwater runoff.

2.1.3 Water Pollutants and their Impact

Stormwater carries with it a whole host of pollutants, including suspended solids, phosphorus, microbial pathogens, heavy metals, oil and grease, toxic organic compounds, and trash. These terms, which represent the most common types of pollutants, will be explained in detail below. These pollutants affect the quality of water in a variety of different ways. For example, dissolved oxygen levels in a body of water, which are necessary for aquatic life, are reduced by increased amounts of organic waste. Also, some pollutants can lead to health problems in humans.

Suspended Solids

Suspended solids are the most basic form of pollution found in aquatic environments (Davis & McCuen, 2005). They are composed of particulate matter with a diameter of less than 62 μm such as small particles of dirt, vegetation, and bacteria (Waters, 1995). All streams carry suspended solids under natural conditions and most suspended solids are not toxic (Ryan, 1991). However, when the concentration of suspended solids reaches a certain level, suspended solids will have detrimental impacts on the body of water that they enter (Bilotta & Brazier, 2008). For example, if a large amount of suspended solids are picked up by stormwater and carried into a nearby river, they can cover the bottom of the river, blocking organisms in the river from feeding. Additionally, the suspended solids that eventually settle to the bottom of the river can be easily picked back up by the next heavy storm. These redistributed suspended solids would cause the same problem numerous times (Davis & McCuen, 2005).

Suspended solids also block light from reaching critical parts of water sources. Aquatic plants, just like vegetation on land, need light to grow. When this light is blocked, many plants die. Since aquatic plants provide food and shelter for higher-level organisms, their death causes a chain reaction in the ecosystem, with larger organisms beginning to die off as well (Mulligan, Davarpanah, Fukue, & Inoue, 2009).

Finally, suspended solids can transport materials that can cause water quality problems. For example, toxic compounds such as heavy metals and pesticides are often combined with particulate matter (based on their physical and chemical properties) and transported with the solids. Biodegradable organic matter can also be transported in this way. Suspended solids can

include bacteria and other pathogens that pose health risks to anyone or anything in contact with the waters (Davis & McCuen, 2005).

Phosphorus

Phosphorus is used frequently in agriculture for fertilizing (Davis & McCuen, 2005). In urban areas, sources of phosphorus also include animal waste, leaf-fall, pollen, and chemicals used for lawn maintenance (Berretta & Sansalone, 2011). After rainfall, stormwater runoff transports phosphorus into nearby waterbodies. High levels of phosphorus in water can contribute to eutrophication, which is a process by which a body of water becomes overly productive to algae. Phosphorus can stimulate the excessive growth of algae. Large amounts of algae grow, die, and decompose. Those processes consume large amounts of oxygen. As a result, animal species like fish and mollusks are harmed because they are unable to live in water with low concentrations of oxygen (Lerner & Lerner, 2008a).

Microbial Pathogens

Microbial pathogens are disease-causing organisms including various bacteria and viruses (Davis & McCuen, 2005). Microbial pathogens are the water pollutants most responsible for compromising human health worldwide (Lerner & Lerner, 2008b). Microbial pathogens can cause infectious diseases, which are the third leading cause of death in the United States (Binder, Levitt, Sacks, & Hughes, 1999). Common water-related infectious diseases caused by pathogens include dysentery, cholera, and typhoid fever. These diseases can produce sickness on a large scale and may even be fatal. During January 1995 and December 1996, 13 states in the United States reported a total of 36 waterborne disease outbreaks associated with recreational water and estimated that 9129 people were affected. Thirteen states also reported a total of 22 outbreaks associated with drinking water, of which 15 were caused by infectious diseases (Andersson & Bohan, 2001).

Microbial pathogens also pose great threats to nonhuman species. For example, in the late 1880s and 1890s, the African rinderpest, a highly pathogenic disease, killed over 90% of the buffalo population in Kenya. The disease was introduced into Africa from Asia in 1889. This disease

traveled 5000 km in 10 years, also causing local extinctions of the tsetse fly (Daszak, Cunningham, & Hyatt, 2000).

Pathogens are typically introduced into the aquatic environment by animal waste, septic tank systems, and urban runoff, including stormwater and sewage spills (Ksoll, Ishii, Sadowsky, & Hicks, 2007; Field & Samadpour, 2007). Pathogens deposited on land, such as animal waste, can be washed into receiving streams by rainfall and runoff. This can be a major problem for surface waterbodies near agricultural areas, because people who eat the food later may get sick (Davis & McCuen, 2005). Approximately 6% of all health-related deaths in the world are attributable to an untreated water supply and poor sanitation (Schwarzenbach, Egli, Hofstetter, von Gunten, & Wehrli, 2010).

Heavy Metals

As mentioned before, suspended solids have the ability to transport several different types of material. One of these types of material is heavy metals (Davis & McCuen, 2005). Sources of heavy metals include metal processing facilities, mines, sewage sludge, and traffic (Furini, 2012). Usually, heavy metals adhere to the suspended solids in high concentrations, and many heavy metals are toxic at high concentrations to humans, animals, flora and fauna (Yong, Mulligan, & Fukue, 2006). The University of Oviedo in Asturias, Spain conducted a study about the impact of aluminum, a common heavy metal, on human health. The study showed that aluminum can induce degeneration of cells and cause neurons' death after 8 - 18 days exposure. This means that the toxicity of aluminum can cause neurological disorders (Suárez-Fernández, Soldado, Sanz-Medel, Vega, Novelli, & Fernández-Sánchez, 1999).

Oil, Grease, and Other Automotive Fluids

Oil, grease, and other fluids, such as transmission fluid and power steering fluid, leak from automobiles onto roadways and parking lots. These substances not only float in water and provide an unpleasant scene, but are also harmful to the ecosystem. In addition, oil and grease contain mixtures of hydrocarbons and other organic compounds, many of which are toxic (Davis & McCuen, 2005). These hydrocarbons can cause cell damage and death at high concentrations. Young aquatic animals are most sensitive to these toxic hydrocarbons (Blumer, 1972). Oil and

grease can also coat parts of aquatic animals, which reduces their ability to transfer oxygen (Davis & McCuen, 2005). Oil spills have happened several times in the past and caused adverse impacts on aquatic life. One example is the British Petroleum (BP) - Deepwater Horizon oil spill which began on April 20, 2010 and ended on July 15, 2010. The spill, which released 4,900,000 barrels of oil, took place roughly 80 kilometers off the shore of Louisiana. Five months after the spill began, researchers from a multitude of universities conducted a study on its effects on the ecology of Louisiana's shoreline. The researchers found that 95% of rhizomes, or roots that will eventually produce shoots and roots for new plants, in the affected area were dead (Silliman, van de Koppel, McCoy, Diller, Kasozi, Earl, Adams, & Zimmerman).

Toxic Organic Compounds

Herbicides and pesticides are common toxic organic compounds used to kill or alter the growth of the reproductive characteristics of a plant or animal species. They can be easily washed into a body of water during runoff. When this happens, the herbicides and pesticides are placed into an ecosystem where they could harm fish, plants, and other species (Nollet & Rathore, 2012).

Different toxic organic compounds interact with surrounding matter and air differently depending on their physical and chemical properties. As stormwater runoff washes toxic organic compounds over the landscape, some compounds get deposited onto the soil. When these compounds seep into soil, they may degrade into other compounds that could be even more toxic. Some of these toxic organic compounds can be stable and remain in the environment for many years (Davis & McCuen, 2005).

Trash

One of the most visible water pollutants is trash. Bottles, wrappers, plastic bags, and cigarette butts are frequently discarded along roadsides. Stormwater runoff can easily mobilize these materials during storms (Davis & McCuen, 2005). Large pieces of debris such as plastic bags have the potential to clog up storm drains and waterways. Blocked drains may cause flooding and blocked waterways can cause waterbodies to become stagnant pools of water where aquatic animals can hardly survive. Small pieces of debris such as cigarette butts have the potential to choke and kill animals such as ducks, fishes, turtles, and birds (Tjell, 2012). In addition, some

trash, especially the trash made of plastic, degrades very slowly, which means it will remain in the environment for a long period of time (Davis & McCuen, 2005).

2.1.4 Stormwater Situation in Massachusetts

In the United States, stormwater runoff is listed as the primary source of pollution for many bodies of water. Polluted urban stormwater runoff is responsible for polluting 13% of rivers, 18% of lakes, and 32% of estuaries (EPA, 2002). These percentages may seem low, but urban areas cover just 3% of the land mass of the United States, so the pollution stormwater runoff causes is disproportionately large (National Research Council, 2008).

Urban stormwater runoff is responsible for 60% of the water pollution in Massachusetts. The pollutants in stormwater consist of bacteria from animal waste, excessive nitrogen from lawn fertilizers, toxic herbicides and pesticides from farms, lawns, and gardens, and oil, gas, and trash from streets and parking lots. Massachusetts has 28 watersheds shown in Figure 3 below. Every watershed in Southeastern Massachusetts has rivers, streams, and estuaries that violate one or more state SWQS, largely due to stormwater runoff (Watershed Action Alliance of Southeastern Massachusetts, 2012). One example is the Blackstone River, which is a 48-mile-long river flowing through 29 municipalities in South Central Massachusetts and 10 municipalities in Rhode Island (Massachusetts Executive Office of Environmental Affairs, 2004). Since the Blackstone River has a multitude of entry points for stormwater outfalls which may contain polluted runoff, the river is badly contaminated (Blackstone River Coalition, 2008). The Massachusetts Executive Office of Environmental Affairs assessed the entire 28.8-mile length of the river in Massachusetts and found it unusable for aquatic life (Massachusetts Executive Office of Environmental Affairs, 2004).

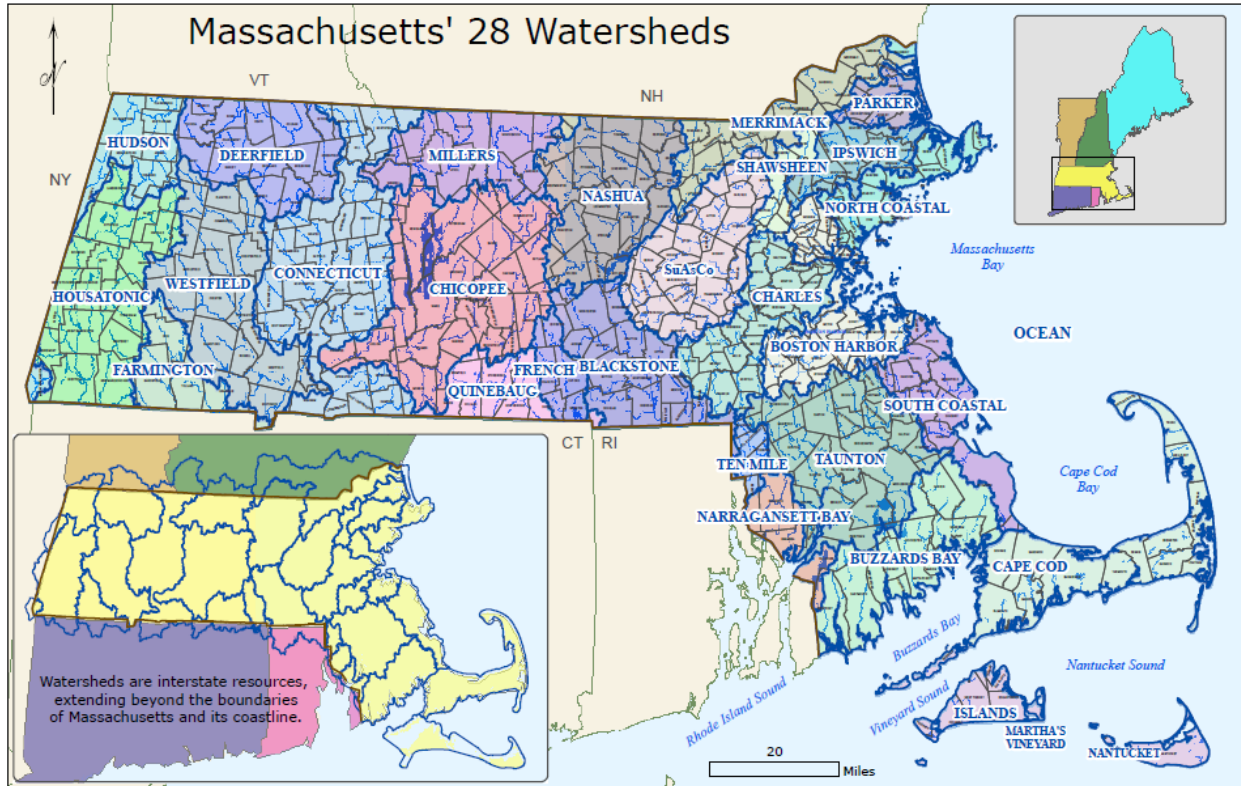


Figure 4: Massachusetts' 28 Watersheds (Massachusetts Department of Environmental Protection, 2013a)

Stormwater runoff has increased in recent years due to human activities (Anderson, 1970). It adversely affects human health and the animal and plant habitats. Fortunately, several solutions have been developed to reduce the impacts of stormwater.

2.2 REDUCING THE IMPACTS OF STORMWATER

Due to the highly damaging nature of stormwater and the growing rate at which it is becoming a problem, many solutions have been developed to mitigate the damage. These solutions include simple household fixes that any motivated individual could implement. They also include laws at the federal level meant to regulate the management of stormwater.

2.2.1 Mitigation at a Residential Level

Most people never stop to think about how stormwater is affecting the environment. Additionally, they do not think about how their actions affect the levels of pollution contained in stormwater (Nancarrow, Jorgensen, & Syme, 1995). A significant portion of stormwater

pollution originates in residential areas, therefore the lack of individual action can cause significant amounts of pollution to enter freshwater sources (Frazer, 2005). Since over half of the Earth's freshwater is already in use by humans, protecting this limited resource is essential to survival (Schmidt-Bleek, 2009). For those individuals concerned enough to modify their behavior, there are some ways to prevent stormwater pollution that are very simple to implement.

Solid Waste Disposal

By properly disposing of garbage, any concerned resident can limit their impact on non-point-source pollution like stormwater runoff. Everyday trash such as food waste and plastics is making its way into surface waterbodies. Litter becomes more abundant at social events such as school activities or weddings. Take, for example, balloon-releasing ceremonies. After the balloons are released, they will eventually come down to the ground, where they become litter. These latex pieces get washed into rivers, lakes, and the sea, where they are often ingested by aquatic creatures (National Resources Defense Council, 2002; Vermeulen, 2013). Throwing trash into a trashcan instead of littering leads to the trash going to a landfill instead of being swept away with a current of stormwater the next time there is a heavy rain.

Additionally, yard trimmings and pet waste are commonly-found pollutants that often originate from stormwater runoff (EPA, 2012d). Municipalities often place restrictions on how to dispose of yard trimmings and other plant-based waste, like that from farms or parks (Wirth, 2005). Plant-based waste in these municipalities is generally composted, however some methods of composting can lead to an increased amount of pollution in stormwater. For example, windrow composting, where the waste is laid out in lines on the ground to decompose, has been proven to cause an increase in stormwater pollution. This is due to rainwater washing the organic material into nearby surface waterbodies (Kalaba, Wilson, & Haralampides, 2007).

Lastly, as fecal matter in water supplies can lead to serious problems such as the growth of E. coli bacteria, picking up after a pet can have a large impact (Lerner & Lerner, 2009; South Carolina Department of Health and Environmental Control Bureau of Water, 2010).

Toxic Chemical Usage

Another way for individuals to reduce their impact on stormwater pollution is to reduce the amount of toxic chemicals used outdoors. Toxic chemicals are found in everything from yard care supplies to car washing detergent. When it rains, these chemicals get washed away into the water supply. In fact, it is estimated that 70% to 90% of all water used to wash cars by non-professional car washers flows directly into the street, then runs into the nearest river (EPA, 2012c). In order to combat this issue, individuals can invest in green cleaning supplies, which use natural cleaners instead of harsh chemicals, or try to reduce the amount of outdoor cleaning that they do.

2.2.2 Mandated Mitigation

Due to the scale of the stormwater pollution problem, the United States has taken action. Starting with the 1972 Amendments to the Clean Water Act, many bills have been considered in order to preserve the quality of America's freshwater resources.

The formation of the United States Environmental Protection Agency (USEPA) in 1970 under the administration of President Richard Nixon marked the beginning of a new age of environmental regulations, many of which focused on water safety (EPA, 2013b). The newly-formed agency was given the task of overseeing the enforcement of a wide variety of environmentally-focused laws and regulations.

Clean Water Act

Arguably the most significant piece of water-related legislation ever passed in the United States, the Clean Water Act (CWA) was ratified in 1972, two years after the formation of the USEPA. Consisting of the Federal Water Pollution Act of 1948 plus a number of amendments, the CWA set nationally-recognized limits on the amount of pollutants that waterbodies could contain. Before 1972, every state was left to decide what the limit on toxins and pollutants in water should be for their particular region (Jeffrey, 2007; Massachusetts Department of Environmental Protection, 2013b).

In addition to setting hard limits for pollutants, the CWA also set up a standard system for regulating point-sources of water pollution. Previously, states were left on their own to determine how best to handle this situation, but under the CWA a national permitting system called the National Pollutant Discharge Elimination System (NPDES) was created (Clean Water Act of 1972; Massachusetts Department of Environmental Protection, 2013b).

NPDES

Under the NPDES program, point-source polluters are required to comply with two distinct sets of limitations: “technology-based effluent limitations (TBELs)” and “water quality based effluent limitations (WQBELs).” Depending on the type of pollutant, the EPA has varying requirements for the technology used to filter it out. These limitations are pre-determined for most categories of industrial sources and are not based on the particular location or circumstances of the body being regulated. Water quality based effluent limitations are more strictly defined and require that pollutants not exceed given concentration levels (Jeffrey, 2007).

As defined by the CWA, the term "point source" means “any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged.” This term does not include agricultural stormwater discharges and flows from irrigated agriculture (Clean Water Act of 1972). For many years, these wastewaters from factories, industries, and municipal wastewaters did not receive treatment, and the impact on the receiving streams, in many cases, was severe (Marquis, 2009).

As defined by the CWA, the term non-point source is “used to identify sources of pollution that are diffuse and do not have a point of origin or that are not introduced into a receiving stream from a specific outlet” (Clean Water Act of 1972). Common non-point sources include rainwater, runoff from agricultural lands, industrial sites, parking lots, and timber operations, as well as gases escaping from pipes and fittings (EPA, 2012b).

Since stormwater was historically classified as non-point-source pollution, at first glance it would appear as though the NPDES permitting system does not apply. However, when municipalities collect their stormwater, they eventually discharge it from an outfall. An outfall is a drain where the water is conveyed into a body of water, such as a lake or stream. This discharge is a “discrete conveyance,” making it a source of point-source pollution. Due to the fact that the USEPA defines this conveyance as a point-source pollutant, it is regulatable under the CWA. In order to discharge stormwater, every municipality must have a Municipal Separate Storm Sewer System (MS4) permit as well (EPA, 2003).

MS4 Permits

MS4 permits are enforceable by the USEPA. In Massachusetts, they are also enforceable by the Massachusetts Department of Environmental Protection (MassDEP) because MassDEP co-signed the 2003 MS4 permit. MS4 permits require that every municipality discharging stormwater from their own storm sewer system follow six minimum control measures. These control measures are: 1) Public Education and Outreach, 2) Public Involvement and Participation, 3) Illicit Discharge Detection and Elimination (IDDE), 4) Construction Site Runoff Control, 5) Post Construction Runoff Control, and 6) Good Housekeeping measures (Barat, et al., 2012; EPA, 2003).

The Public Education and Outreach measure requires that the permittee distribute educational messages to its residents and/or businesses. These messages can take many forms, including advertisements, posters, or flyers (EPA, 2010a; EPA, 2003). Public Involvement and Participation requires that the public be given an opportunity to express their ideas on the stormwater management practices being considered. The IDDE measure has many parts. It requires that municipal employees systematically locate illicit discharges and remedy them as soon as possible. It also requires that municipalities map their storm sewer system and all of its outfalls (EPA, 2010a). The Construction Site Runoff Control and the Post Construction Runoff Control measures are both aimed at reducing the amount of sediment carried away from construction sites. The Good Housekeeping measure is designed to keep a municipality’s existing stormwater infrastructure functioning properly through upkeep such as cleaning out blocked outfalls (EPA, 2010a; EPA, 2003).

There are two different types of MS4 permit. In 1990, the USEPA published Phase I regulations for medium to large municipalities with a population of more than 100,000 residents. The 1990 regulations required Phase I municipalities to obtain a NPDES permit for stormwater discharge. In 1999, the USEPA released Phase II regulations, requiring urban and suburban cities with less than 100,000 residents to obtain a NPDES permit for stormwater discharges (Krukowski, 1999). Each municipality with a MS4 permit must compile their compliance information into a report and submit it to the USEPA annually.

A new version of the MS4 permit is supposed to be released every five years, as that is the length of a permit term (EPA, 2003). However, the most recently-released version of the MS4 that has gone into effect is the 2003 MS4 permit. The USEPA created a draft MS4 permit in 2010 that never came into effect (EPA, 2010b). USEPA has more recently created a 2013 draft MS4 permit which is expected to be put into effect in late 2013. The 2013 draft was created for New Hampshire, but a similar permit is expected to be released for Massachusetts. The requirements of the 2013 draft are much more specific and numerous than those in the 2003 permit (EPA, 2013d). Municipalities can meet the requirements of the MS4 permit through the use of stormwater Best Management Practices (BMPs).

Best Management Practices

A BMP for stormwater management is an optimal solution to meet one of the control measures of the MS4 permit. Each control measure has its own BMPs. The USEPA's website contains fact sheets that contain all known BMPs for each of the six control measures (EPA, 2012h). For instance, in order to create a Public Outreach/Education Program, a municipality could create a pamphlet or booklet on stormwater management for the community. Additionally, the municipality could decide to target specific audiences, such as homeowners or businesses, for education on stormwater management (Environmental Protection Agency, 2012f). Examples of Good Housekeeping BMPs include developing a street cleaning/sweeping program and creating a catch basin cleaning program (Environmental Protection Agency, 2012g).

In addition, MassDEP has its own BMP reference materials. The MassDEP stormwater handbook¹ introduces various stormwater management topics, such as legal frameworks, guidelines for stormwater documentation, and stormwater BMPs. These BMPs are mostly structural BMPs, which are physical structures that can be implemented in order to reduce stormwater runoff, such as deep sump catch basins. A deep sump catch basin is a type of drainage system designed to remove trash, debris, and other sediment from stormwater runoff (Massachusetts Department of Environmental Protection, 2002).

2.2.3 Obstacles with Mandated Mitigation

Despite the good intentions of the laws being passed, communities have a hard time actually complying. MS4 compliance can be especially difficult for municipalities because the requirements of the permit might seem unclear or because the municipalities lack the funding or technological know-how to put the necessary frameworks in place.

Noncompliance

Due to requirements such as the Public Education and Public Involvement control measures, complying with the 2003 MS4 permit can be a difficult task for some municipalities; not only must they keep track of data about their stormwater, but they must also act as ambassadors to the public about the dangers of stormwater pollution and how the problem can be mitigated. The problems complying with the MS4 guidelines are compounded by the lack of availability of members of the USEPA to answer questions the municipalities have about MS4 requirements (Barat, et al., 2012; EPA, 2012e; Massachusetts Department of Environmental Protection, 2013b).

In order to ensure compliance with 2013 MS4 standards, MassDEP has taken on the role of an educational liaison for Massachusetts municipalities trying to understand the new MS4 permit requirements. MassDEP offers guidance to Massachusetts' municipalities on MS4 permit requirements and methods to track necessary data. MassDEP does not yet have the authority from the USEPA to regulate general NPDES permits, but the agency has considered trying to

¹ The handbook can be found at: <http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/v2c2.pdf>

acquire that authority (Jaffe, 2008; Massachusetts Department of Environmental Protection, 2013b).

Financial Limitations

Even when municipalities understand the MS4 requirements and have a reliable system in place for tracking them, finances present another barrier to fulfilling MS4 permit requirements. Small and midsize municipal governments often have limited personnel and budgets, making compliance with new regulations difficult. For example Robert J. Moylan Jr., Commissioner of Public Works and Parks in Worcester, Massachusetts has stated that under the proposed 2010 MS4 guidelines, Worcester would need to spend \$1 billion in addition to what the city has already spent attempting to comply with the 2003 MS4 permit (Susan, 2012).

When municipalities fail to comply with MS4 requirements, they can receive steep fines. These fines make it that much harder for them to secure the necessary funds to put systems in place so that they are able to comply. In 2008, Gardner, Massachusetts was charged \$60,000 for noncompliance with the MS4 since the city failed to map all of its outfalls (Susan, 2012).

Despite the difficulties that municipalities sometimes have with MS4 compliance, adherence to the permit does serve a greater purpose. By adhering to the requirements of the MS4, municipalities reduce their stormwater impact and preserve the quality of waterbodies for generations to come.

In order to cover the costs of a storm water sewer system that is compliant with USEPA standards, municipalities are turning to innovative solutions.

Stormwater Utility Fees

Some states and municipalities have begun charging stormwater utility fees to both businesses and residences (Pyles, 2013). Often, these fees are based on the square footage of impervious surfaces on a given property. Businesses typically have to pay higher rates than residents, but residents generally do get charged the fees as well. Reduced rates are given if residents or

businesses implement BMPs in order to minimize their stormwater impact (Punam, Taylor, Hoagland, & Shuster, 2011).

Although a stormwater utility provides a municipality with a consistent source of funding for MS4 compliance, there are drawbacks to implementing them. There is a high up-front cost involved with starting a stormwater utility, and it takes a few years before the stormwater utility begins producing enough funds to make an impact in a municipality's stormwater management (Liedtke & McDonald, 2009).

Grants

One additional method municipalities use to raise funds to increase their ability to comply with MS4 standards is applying for grants. Since the USEPA and MassDEP do not typically provide funding for municipalities looking to upgrade their storm sewer systems, some communities have taken it into their own hands to band together and gather the funding to become compliant with MS4 standards (National Research Council, 2009; Susan, 2012). Some municipalities in Central Massachusetts have received funding from the Community Innovation Challenge (CIC) grant in order to take advantage of the economics of scale. However, there are other sources of assistance with the MS4 permit available to municipalities.

2.3 ASSISTANCE WITH MS4 PERMIT COMPLIANCE

Complying with MS4 permit standards can be difficult for municipalities to manage, especially smaller Phase II municipalities. Some of these communities may lack the proper funding necessary to comply with the permit within the given timeframe, and many worry that the USEPA and MassDEP would force them to exhaust their funds on complying with the MS4 permit. In reality, MassDEP wants to help municipalities manage stormwater more efficiently and economically. Even though MassDEP co-signed the MS4 permit and has enforcement power, their primary goals are to protect the environment and help municipalities across Massachusetts to do so. Therefore, MassDEP helps to communicate MS4 permit requirements to municipalities in order to mitigate the effects of stormwater runoff. Municipalities also face challenges with sufficient manpower. Because of this, many municipalities reach out to third parties in order to assist with compliance with the MS4 permit. However, additional manpower

could require additional funding as well. As a result, a group of Central Massachusetts municipalities applied for federal grant funding for meeting the requirements of the MS4 permit.

2.3.1 The Community Innovation Challenge Grant

In 2012, Massachusetts Governor Deval Patrick's administration developed the CIC grant program to incentivize municipal governments to improve local community services. In just two years, the program invested \$6.25 million across 49 unique projects involving 197 municipalities in the Commonwealth of Massachusetts (Commonwealth of Massachusetts, 2013b).

Some of the projects funded by this grant have included local educational projects, data management health projects, and environmental projects which include the Regionalization of Municipal Stormwater and Policy Development Project (Regionalization Project) (Commonwealth of Massachusetts, 2013a). The Regionalization Project encompasses 13 municipalities across Central Massachusetts that comprise the Central Massachusetts Regional Stormwater Coalition² (CMRSWC). The CMRSWC is a group of municipalities striving to control stormwater runoff more cost effectively and efficiently through a collaborative effort (Central Massachusetts Regional Stormwater Coalition [CMRSWC], 2012b). So far, the project has received at least \$310,000 since 2012, and the recipients have used the money to fund projects such as developing a training DVD/CD for town personnel and volunteers which summarizes the MS4 permit, creating a stormwater Best Management Practices (BMP) Toolbox, and developing an online database for regional stormwater management (CMRSWC, 2012a). As of November 2012, 17 new municipalities joined the CMRSWC³, which adds to the collaborative effort of the battle against stormwater runoff in Central Massachusetts.

Although the grant has benefitted the municipalities of the CMRSWC by providing funding to collaboratively meet the MS4 permit requirements, these municipalities still require more funding in order to meet the requirements of the greatly expanded, 2013 draft MS4 permit. In

² The 13 municipalities consist of Auburn, Charlton, Dudley, Holden, Leicester, Millbury, Oxford, Paxton, Shrewsbury, Spencer, Sturbridge, Webster, and West Boylston.

³ These new municipalities consist of Boylston, Grafton, Hardwick, Hopkinton, Monson, Northbridge, Northborough, North Brookfield, Palmer, Rutland, Southbridge, Sterling, Upton, Uxbridge, Ware, Westborough, and Wilbraham.

2013, the CMRSWC applied for \$200,000 from the CIC grant, but only received \$115,000 for the 2013 fiscal year. Because the funding was less than the CMRSWC's expectations, each of the municipalities participating in the CMRSWC had to provide an additional \$2,833 to compensate for the funding not received by the grant (Tata & Howard, 2013c).

Since the grant money is limited, the municipalities will need to make sure that they are spending it on projects with the greatest potential to increase current MS4 permit compliance. Although MassDEP does not provide the funding for the grant or receive any of its funds, MassDEP employees often attend CMRSWC meetings.

2.3.2 MassDEP's Role

MassDEP acts as an educational liaison for Massachusetts municipalities by providing professional advice on meeting the requirements of the MS4 permit and stormwater management BMPs. As stated previously, MassDEP has educational materials online such as its stormwater BMP handbook. MassDEP employees are also helping municipalities prepare for the 2013 MS4 draft permit by communicating the new requirements to municipalities. In the past few years, MassDEP has worked with the CMRSWC in order to collaboratively manage stormwater runoff and assist municipalities with compliance with the MS4 permit requirements. Although stormwater management information is available online, MassDEP still provides professional advice to municipalities in order to educate them on stormwater management programs, the MS4 permit requirements, stormwater BMPs, and other stormwater topics in order to prevent stormwater pollution (Massachusetts Department of Environmental Protection, 2013d). Besides MassDEP, environmental consulting firms also provide professional advice to municipalities.

2.3.3 Stormwater Engineering Consulting Firms

Meeting the requirements of the MS4 permit not only requires sufficient time and funding, but also enough manpower. Some municipalities seek external assistance from groups that are knowledgeable about stormwater management and the MS4 permit. One of these groups is a consulting firm. Consulting firms are groups of experts in a certain field who provide professional advice to clients for a fee (Darnay & Magee, 2007).

One stormwater engineering consulting firm that deals with stormwater management specifically for the CMRSWC is Tata and Howard. Tata and Howard is a stormwater engineering consulting firm specializing in water, wastewater, stormwater, and hazardous wastes (Tata and Howard, 2013a). Tata and Howard have been collaboratively working with municipalities in the CMRSWC by providing professional advice and assistance on creating stormwater by-laws, innovative technologies for IDDE, development of stormwater programs, and the creation of annual reports since 2011 (Tata and Howard, 2013b). Another consulting firm working with the CMRSWC is Verdant Water, a Professional Limited Liability Company (PLLC) owned by Aubrey Strause, a Professional Engineer who formerly worked with Tata and Howard. Verdant Water not only aids the CMRSWC, but also aids other organizations related to water management as well, such as the Seacoast (New Hampshire) Stormwater Coalition and the New England Water Environment Association (NEWEA) (Verdant Water, 2013). Collaboratively, these professional experts and municipal employees work towards compliance with the MS4 permit.

2.3.4 Volunteer Groups

Through the effort of volunteer groups, municipalities can not only fulfill the Public Involvement/Participation control measure of the MS4 permit, but also receive external assistance for compliance with the permit. Since the MS4 permit requires public involvement with the review and implementation of their Stormwater Management Program (SWMP), municipalities can utilize assistance from the general public and volunteer groups to achieve compliance with additional control measures. Such activities may include outfall mapping, stream cleaning, or public education campaigns. For instance, the towns of Leicester, Grafton, and Charlton all utilized the assistance of local residents and Boy Scout groups during a cleanup event on Earth Day, April of 2013 (Tata and Howard, 2013c; Szczurko, 2013; Girard, 2013). While this satisfies the Public Involvement/Participation control measure of the MS4, it is also a demonstration of Pollution Prevention/Good Housekeeping. Some municipalities have reached out to volunteers to stencil catch basins, which notify the general public that dumping into the basins is illegal and introduces pollutants into the environment. The town of Oxford has let volunteers from the public stencil catch basins, and one boy scout in Westborough even organized a project to stencil 150 catch basins for his Eagle Scout project (Zeneski, 2013;

Johnson 2013). While this contributes to Public Education and Outreach, this also would count towards fulfilling the Illicit Discharge Detection and Elimination (IDDE) control measure of the 2013 NH MS4 draft permit.

2.4 SUMMARY

Stormwater runoff presents a clear issue for both the environment and state/federal agencies, such as the USEPA and MassDEP, which strive to protect the environment. Not only can stormwater runoff pollute surface water bodies, but runoff also causes problems for municipalities that are non-compliant with the MS4 permit. One way Massachusetts is trying to improve compliance with the MS4 is through the CIC Grant, which provides municipalities with funding to improve local services for communities. Additionally, MassDEP is trying to help municipalities with MS4 compliance by educating them on the requirements of the current MS4 permit as well as the requirements of the upcoming MS4 permit. Municipalities can also seek the assistance of consultant engineering firms or volunteer groups for compliance with the MS4 permit. For our project, we collaborated with MassDEP in order to assist municipalities with tracking their compliance with the 2013 NH MS4 draft permit.

3.0 METHODOLOGY

The goal of this project was to assist the towns of Grafton, Shrewsbury, Leicester, and Upton with meeting the requirements of the 2013 New Hampshire (NH) Municipal Separate Storm Sewer System (MS4) draft permit, which has been implemented in NH and serves as a model for upcoming changes in Massachusetts. Municipalities must have an MS4 permit in order to discharge stormwater into surface waterbodies. The most recent version of the MS4 permit that is in effect in Massachusetts is the 2003 MS4 permit. Our sponsor, the Massachusetts Department of Environmental Protection (MassDEP), developed this project because many municipalities anticipate having difficulty with meeting the requirements of the upcoming Massachusetts MS4 permit. MassDEP, acting as an educational liaison for the United States Environmental Protection Agency (USEPA), offered mapping assistance and permit compliance tracking for these municipalities through this project. The project was not utilized to enforce permit requirements, but rather to educate and assist the Central Massachusetts municipalities. In order to accomplish our goal, we achieved the following three objectives: 1) learned the specifications of the 2003 MS4 permit and the 2013 MS4 draft permit, 2) assessed the degree to which our assigned municipalities met the requirements of the 2003 MS4 permit and the steps they would have to take to meet the requirements of the 2013 NH MS4 draft permit, and 3) created a tool to assist municipalities with meeting the requirements of the 2013 NH MS4 draft permit.

In Section 3.1, we outline each objective in more detail, describe the methodology we used to accomplish each objective, and explain why we chose that methodology. In Section 3.2, we describe the obstacles we faced during the project. In Section 3.3, we provide a brief summary of the chapter.

3.1 OBJECTIVES

3.1.1 Determining MS4 Specifications

Since our job was to assist municipalities in meeting the requirements of the 2013 MS4 draft permit, we worked to become knowledgeable about the permit requirements. Consequently, our first objective was to learn the specifications of the 2013 MS4 draft permit for New Hampshire, which is anticipated to be very similar to the new Massachusetts MS4 permit. This objective also

entailed learning the specifications of the 2003 MS4 permit. We chose two methodologies in order to accomplish this objective: document analysis and interviews. Additionally, MassDEP trained us on the history of stormwater and the MS4 permit.

Document Analysis

Document analysis is the systematic review of existing research on a given topic. We chose document analysis as our primary methodology for learning about the 2003 MS4 permit and 2013 MS4 draft permit for a few reasons. The most significant reason is that document analysis allowed us to study the current permit and draft permit themselves, along with summaries written in a more accessible manner to those unfamiliar with legal terms. These documents gave us a starting place for understanding the particulars of the permit.

Document analysis also worked well for accomplishing this objective because it tends to be very efficient. Glenn A. Bowen, Associate Professor of Sociology at Barry University and Social Sciences Scholar, argues that document analysis is a good choice when relevant documents are widely available, as they were in our case. He also states that their exactness can make them a valuable tool (Bowen, 2009; Connell, Lynch, & Waring, 2001).

Document analysis does have its drawbacks, however. As Bowen mentions, document analysis alone can often provide insufficient detail about a given topic (Bowen, 2009; Taylor & Francis, 2013). To address this shortcoming, we also conducted interviews with MassDEP employees.

Interviews

Our team utilized interviews to fill in the gaps of our understanding of the 2013 MS4 draft permit after we performed an analysis of the document. This way, any questions that we could not find the answer to on our own were directed to people who were already experts on the MS4 permit. We interviewed several MassDEP employees, including: Frederick Civian, Stormwater Coordinator; Cheryl Poirier, Enforcement Coordinator; Andrea Briggs, Deputy Regional Director of the Bureau of Administrative Services; and Stella Tamul, Environmental Analyst.

We used semi-structured interviews as this interview style is based off of a pre-determined set of questions, but simultaneously leave room for the interviewer to stray from these questions in order to follow up on emerging themes or for clarification (Berg & Lune, 2012; Connell, et al., 2001; DiCicco-Bloom & Crabtree, 2006).

Many times, when we began understanding one point better, we realized that our understanding of a different point was not as strong. The semi-structured interview allowed us to deviate from the set of questions we had come up with in order to pursue these other points as they came up. A set of interview questions can be viewed in Appendix A.

3.1.2 Assessing Municipality Compliance

Our second objective was to assess the degree to which the towns of Grafton, Leicester, Shrewsbury, and Upton meet the requirements of the 2003 MS4 permit and assess the steps they would have to take in order to meet the requirements of the 2013 NH MS4 draft permit. First, our team created a spreadsheet for each municipality and listed the requirements of 2003 MS4 permit. Then, our team reviewed the 2013 annual reports and conducted interviews with municipal employees from the four municipalities along with environmental consultants that worked for some of the municipalities. Finally, after collaborating with the municipal employees, our team analyzed the current state of stormwater management and MS4 compliance issues in these four municipalities. We did this by sorting the collected data from the reports and interviews into the spreadsheets. The spreadsheets gave us a clear view of which of the requirements of the current 2003 MS4 permit the four municipalities had met.

Document Analysis

Annual reports include municipalities' self-assessments of their compliance and detailed information about what they have done in order to meet the requirements of the six minimum control measures. Our team used document analysis as the primary methodology for analyzing the annual reports in order to get a basic knowledge of which requirements of the 2003 MS4 permit municipalities had met. This method also provided us with knowledge about whether municipalities were beginning to work towards meeting the requirements of the 2013 NH MS4 draft permit. We chose this methodology because document analysis allowed us to gather facts

about municipalities' stormwater programs and plans, assess the various Best Management Practices (BMPs) that the municipalities used, and understand municipalities' obstacles in meeting the requirements of the current 2003 MS4 permit.

Interviews

To achieve the second objective of our project, our team also conducted interviews. We interviewed the previous group of students who worked with MassDEP in winter 2012, municipal employees from each municipality, environmental consultants that some towns hired in order to assist with MS4 permit compliance, and MassDEP employees (See Appendix A for Interview Questions). Our team considered interviewing as a practical and feasible method for getting in-depth information about the current state of stormwater management and MS4 compliance in each of the municipalities. We chose to use interviews because they provide high response rates (Chambliss & Schutt, 2012). This is very important because our team assisted only four municipalities, so the interviewees consisted of a small number of employees. This is also the reason why our team did not conduct surveys. According to the report from the previous group of Worcester Polytechnic Institute (WPI) students that worked for the MassDEP, only two out of 13 municipalities responded to their stormwater management survey (Barat, et al., 2012). Because of the low response rates, the data from the survey became useless.

In addition, an interview is a type of face-to-face social interaction. During the interviews, our team got a chance to ask longer and more complex questions, as well as probe and clarify where appropriate. Therefore, our team gained a full understanding of respondents' answers (Chambliss & Schutt, 2012). In order to get the most out of the interviews, we used a semi-structured format. Our team also asked the interviewees if we could record the interview. If the interviewee agreed, we recorded the interviews because the audio records improved the reliability of our data analysis if any of our group members had difficulty remembering the exact words.

During our interview with the previous group of WPI students, Alexander Barat, Randy Chin, and William Feraco, our team got a clearer idea of how they assisted the municipalities. During our interviews with MassDEP, we interviewed Andrea Briggs, Frederick Civian, Cheryl Poirier, and Stella Tamul. All of these employees have been working at MassDEP for several years.

These MassDEP employees provided very useful guidance to our project. We used the interviews with MassDEP employees to clarify the information we received during our interviews with municipal employees and environmental consultants. We also used these interviews to determine the best initial contacts for contacting municipal employees in each of our four municipalities. Once we had an initial contact for each municipality, we interviewed these initial contacts. Sometimes, over the course of our interview, we asked for information that the interviewee did not know. If this was the case, we then asked for the name and/or contact information for appropriate people to contact with these questions. Then, we followed up with the appropriate people. When scheduling permitted, our team interviewed these people in person. When there were difficulties with scheduling, we utilized phone interviews. We also used phone interviews and e-mails for any follow-up questions we had following our initial interviews. Our team interviewed: Bradford Stone, Conservation and Stormwater Coordinator of Shrewsbury; Thomas Wood, Superintendent of Leicester's Highway Department; Patrick Navaroli, an employee of Leicester's Highway Department; Matthew St. Pierre, a Project Engineer at Tata and Howard; Jeffrey Thompson, Director of Upton's Department of Public Works (DPW); Aubrey Strause, the owner and manager of Verdant Water; and Brian Szczurko, an Engineering Assistant for Grafton's Engineering Division of the DPW. We asked this group of people for information about what methods of controlling stormwater runoff are currently used and whether the municipalities are facing any obstacles in meeting the requirements of the 2003 MS4 permit. We also asked which control measures their municipalities focused on the most currently and which they felt they would need to focus on the most in order to meet the requirements of the new 2013 NH MS4 draft permit.

Overall, through the interviews, our team sought to gain detailed information about how the municipalities are doing with stormwater management. In addition, we visited locations such as the municipalities' outfalls and catch basins.

Participant Observation

Participant observation is a type of data collection method in which the researcher gets involved in a social situation and makes observations (Macionis & Plummer, 2005). Using this method,

the researcher gains a close and intimate familiarity with the observed community (Adler & Adler, 1998).

Our team used participant observation to assist municipal employees with outfall mapping and assessment of mitigation strategies. This method was supplementary to the interviews. After using this methodology, our team became familiar with the local stormwater situation. Additionally, this method gave our team visible facts about stormwater problems, not just descriptions from MassDEP and municipal employees.

During the site visits, our team gained a clearer idea of what municipalities have done to control stormwater runoff and how serious the management problems are. We performed catch basin and outfall mapping in Leicester and Upton, but were unable to do so in Grafton or Shrewsbury because of scheduling conflicts. Mapping catch basins and outfalls directly assisted municipalities with meeting the requirements of the 2013 NH MS4 draft permit. While mapping outfalls, we recorded the condition of the outfall along with any visible pollution originating from it. Our team took pictures of the sites because pictures can provide important data in detail. Additionally, pictures help clarify the written discussion.

Data Analysis

First, our team created spreadsheets and listed the requirements of 2003 MS4 permit in Google Spreadsheets. Then, we combined the information gathered from MassDEP, municipal employees, environmental consultants, and the annual reports and sorted the collected data in the spreadsheets. Each municipality had their own spreadsheet, however we also created a spreadsheet of all municipalities side-by-side. Subsequently, we assessed which requirements of the 2003 MS4 permit municipalities had met. We compared the stormwater runoff situation in each municipality and determined the degree to which they met the requirements of the six minimum control measures. In the spreadsheets, we marked “+” for a requirement that had been met and “-” for a requirement that had not been met. We also color-coded the cells, with “+” cells being green and “-” cells being orange. The spreadsheets gave us a clear view of which requirements of the current 2003 MS4 permit the municipalities had met (See Appendix B for the spreadsheet).

3.1.3 Creating Tools to Assist Municipalities with Compliance

Finally, we analyzed the data obtained through our interviews and permit analyses to create tools to assist municipalities with meeting the 2013 NH MS4 draft permit requirements. These tools are in the form of a checklist and fact sheet that allows municipal employees to track the 2013 NH MS4 draft permit requirements. The checklist and fact sheet also act as guides that provide a list of timeframes and requirements for satisfying the six control measures of the 2013 NH MS4 draft permit. In order to begin creating these tools, our team used the data obtained from our first and second objectives and researched methods for creating an effective checklist.

A checklist is a list of tasks required in order to achieve a certain goal (Scriven, 2005). The checklist we created provides a way for municipalities to track their current compliance with the 2013 MS4 draft permit and also lists the requirements and timeframes for compliance. This way, municipalities can use the checklist for analyzing their current stormwater management program's compliance with the 2013 NH MS4 draft permit. The fact sheet we created also provides a reference to the 2013 NH MS4 draft permit without having to refer to the 60-page legal document. In order to collect sufficient data for the checklist and fact sheet, we analyzed documents on checklist creation in addition to interviewing municipal and MassDEP employees.

Document Analysis

Since the 2013 MS4 draft permit is approaching its official release date, municipalities must be prepared for the newest requirements of the permit. Through our research, we discovered many sources outlining the logistics of checklists and proper methodologies for creating them. For instance, Dr. Michael Scriven, a professor at Claremont Graduate University and a significant contributor in the fields of theory and practice of evaluation, published an article outlining the various types of checklists and their best implementation practices. In this article, he discusses the relative benefits and disadvantages of different types of checklists (Scriven, 2005). Using this source and several other sources, we determined that a diagnostic, sequential checklist would be the best type of checklist to create for our purpose. A sequential checklist is a type of checklist that contains tasks that are listed in chronological order. A diagnostic checklist is a type of checklist that one can use to draw conclusions from a certain topic (Scriven, 2005; Mathison,

2005). For the purposes of this project, the checklist was drafted to track compliance with the 2013 MS4 draft permit and show municipal employees which control measures need more attention. Even though the control measures do not need to be completed in any particular order, there are timeframes that municipalities need to complete certain requirements by: therefore, a diagnostic, sequential checklist would be useful. To create our fact sheet, we revisited the 2013 NH MS4 draft permit and compressed the 60-page legal document into a 20-page document that highlights key points in the 2013 NH MS4 draft permit. The fact sheet also reworded the legal jargon presented by the 2013 NH MS4 draft permit. In case of further confusion with the fact sheet, we set up hyperlinks within our fact sheet that direct the reader to corresponding sections within the 2013 NH MS4 draft permit.

Interviews

One of the reasons we decided to create a checklist of the requirements of the 2013 NH MS4 draft permit was because MassDEP thought that such a tool would be beneficial to municipalities. In order to ensure that the checklist and fact sheet we created would be as useful as possible to municipal employees, we conducted interviews of both municipal and MassDEP employees. First, we needed to collaborate with MassDEP on the checklist's content. Although we understood the differences between these two legal documents, we knew that stormwater experts would have the best recommendations for creating these tools. For instance, Frederick Civian of MassDEP has years of experience with stormwater management in places such as California and Massachusetts, and has assisted WPI students working for MassDEP in the past (Barat, et al., 2012).

In addition, we met with municipal employees to acquire feedback on our checklist and fact sheet for meeting the requirements of the 2013 NH MS4 draft permit. In addition to our other interviews, we attended a Central Massachusetts Regional Stormwater Coalition (CMRSWC) workshop where municipal employees from many of the 30 participating communities attended. At this workshop, we received helpful feedback on our tools from many municipal employees, including those from Charlton, Hopkinton, and Northborough. Since these employees are responsible for their municipalities' compliance with the MS4 permit, we wanted their feedback on what would make an effective checklist and fact sheet. Interviewing these people also allowed

us to receive more feedback on our tools since we could communicate verbally. Additionally, we worked closely with another group of WPI students working with MassDEP who provided municipal employee's feedback from the municipalities of Auburn and Holden. Finally, we met with employees from the USEPA in order to receive their advice on our tools.

3.2 OBSTACLES

Our team faced two primary obstacles: availability of the Leica Global Positioning System (GPS) units and difficulty scheduling meetings with municipalities. Municipalities in the CMRSWC use two Leica GPS units in order to map outfalls and other stormwater structures required by the MS4 permit. Participating municipalities share these two units. Additionally, some municipalities privately own their own GPS units. We had to cancel our first day of mapping in Shrewsbury as the Leica unit we were scheduled to use had been repaired by Tata and Howard before our project and was accidentally sent back uncharged and without the charger. Therefore, we did not have the tool available for our first day and had to return to map another day. This also set back our Leica unit training a few days and led to a postponement of our mapping in Leicester. Matthew St. Pierre of Tata and Howard was apologetic about the problems with the Leica and made sure to follow up later in order to make sure that it worked when we were mapping.

In addition, we needed to be flexible with our meetings with municipal employees. Many employees have other priorities to attend to, so we needed to be flexible with scheduling times for interviews and mapping.

3.3 CONCLUSION

By collaboratively working with MassDEP, environmental consultants, and municipal employees from the towns of Leicester, Shrewsbury, Upton, and Grafton, we assisted four municipalities with compliance with the 2013 NH MS4 draft permit. In order to achieve this goal, we researched the 2003 MS4 permit and 2013 NH MS4 draft permit, determined the degree to which these four municipalities were compliant with the 2003 MS4 permit and assessed the additional steps they would need to take in order to meet the requirements of the 2013 NH MS4 draft permit, and created a checklist and fact sheet to assist the four municipalities with

compliance with the 2013 NH MS4 draft permit. By accomplishing this goal, we also assisted the CMRSWC in managing stormwater runoff issues, thereby reducing stormwater pollution. Finally, we documented our research and findings on municipal compliance with the 2003 MS4 permit and the 2013 NH MS4 draft permit in this final report for MassDEP, future researchers working with MassDEP, or people interested in researching stormwater management.

4.0 FINDINGS AND DISCUSSION

4.1 INTRODUCTION

We discovered that many municipalities share similar experiences with compliance with the 2003 Municipal Separate Storm Sewer System (MS4) permit and 2013 New Hampshire (NH) MS4 draft permit through our research of the four Central Massachusetts municipalities of Grafton, Leicester, Shrewsbury, and Upton. Despite the many similarities, there are still differences in how each municipality has worked to comply with the 2003 MS4 permit and how they are preparing for complying with the upcoming Massachusetts MS4 permit based on the 2013 NH MS4 draft permit. In section 4.2 we present case studies for each of the four municipalities. These case studies include some general background on each municipality as well as observations about each municipality's stormwater management. In section 4.3, we compare the qualitative data that we obtained from our four case studies and draw general conclusions about MS4 compliance in these Central Massachusetts municipalities.

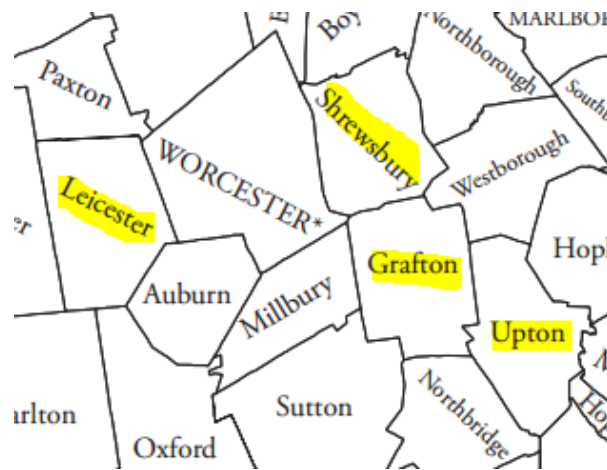


Figure 5: A map of Central Massachusetts municipalities, highlighting the four we worked with. (Galvin, F. W., 2011)

4.2 CASE STUDIES OF FOUR MUNICIPALITIES

Grafton, Massachusetts

The semi-rural town of Grafton, Massachusetts resides southeast of Worcester and is home to approximately 17,000 residents. Grafton is roughly 23.33 sq. miles in size with 2.48 sq. miles covered with impervious surfaces, which is about 10.64% of the town's total area. Originally, the

town was home to a tribe of Nipmuc Indians; eventually, pilgrims from England colonized Grafton during the 17th century, as occurred in most of Massachusetts. During the 19th century, many manufacturing sites were developed in Grafton, such as a cotton mill, saw mill, and wool mill. Today, many of these sites still remain, although they are not in use (“History of Grafton”, 2013).



Figure 6: A train station in Grafton, MA (Phelan, 2012).

In order to learn the current state of Grafton’s compliance with the 2003 MS4 permit and 2013 NH MS4 draft permit, we set up an interview with Brian Szczurko, the town’s Department of Public Works (DPW) Engineering Assistant. Through our interview with Mr. Szczurko, we learned about Grafton’s stormwater management program and how they meet the requirements of the 2003 MS4 permit and what steps they would need to take in order to meet the requirements of the 2013 NH MS4 draft permit. We discovered several findings based on the information we gathered.

Focus on Public Education

Before meeting with Mr. Szczurko, we analyzed Grafton’s 2013 MS4 annual report. We first noticed that Public Education control measure seemed to be a focus of the town’s stormwater

program. We came to this conclusion since Grafton created residential and business stormwater flyers, coordinated with local schools, and provided stormwater information on the town's website (Szczurko, 2013). While interviewing Mr. Szczurko, we confirmed that Public Education is a large focus with their stormwater management program. Additionally, we learned that Grafton has volunteers cleaning the town's streets on Earth Day during April (B. Szczurko, December 6, 2013).

Challenges with Outfall Mapping

From Grafton's 2013 annual report, we determined that Grafton is still working towards completion of mapping all of their outfalls (Szczurko, 2013). Mr. Szczurko later confirmed this finding. He informed us that while completing the 2013 annual report, he had estimated that the town was 80% done mapping their outfalls, but upon further investigation, he discovered they were actually closer to 50% or 60% done. He told us that Grafton was considering contracting out the remainder of their outfall mapping to an environmental consultant. This is because so many outfalls were left unmapped and he determined that Grafton needed to finish its outfall mapping before filing their next annual report (B. Szczurko, December 6, 2013).

Challenges with the Upcoming MS4 Permit

In order to determine additional steps Grafton would need to take to meet the requirements of the 2013 MS4 permit, we asked Mr. Szczurko what the town was currently doing in preparation for the new permit's release. At this point, Mr. Szczurko had not read through the 2013 NH MS4 draft permit even though he was familiar with many of its requirements. Mr. Szczurko commented that he would rather focus on the town's current stormwater program than prepare for an unreleased permit since he fears that the United States Environmental Protection Agency (USEPA) will only postpone its release further. However, he believes that Grafton will have challenges with water quality sampling. Grafton will have to finish mapping its outfalls before it can accurately sample them for pollutants. Additionally, Grafton will need extra time for water quality sampling since it would further take up Mr. Szczurko's time. Provided that the town had the time and money for completing these requirements, Mr. Szczurko feels confident that he could complete the requirement as detailed in the 2013 NH MS4 draft permit (B. Szczurko,

December 6, 2013).

Lack of Manpower

Even though Grafton has four town departments with responsibilities related to the MS4 permit, Grafton still requires additional manpower for meeting both the current and upcoming permit requirements. The town departments that deal with MS4-related tasks are the Engineering Department, Planning Department, Highway Department, and the Conservation Commission. Grafton's DPW encompasses the Engineering Department, Highway Department, and Planning Department. Each department has its own jurisdictions in regards to stormwater management. For instance, the Planning Department focuses on construction and subdivisions while the Conservation Commission accomplishes specific tasks detailed in Grafton's stormwater management bylaw. The Engineering Department focuses on stormwater-related tasks such as water quality sampling, while the Highway Department performs catch basin cleaning and street sweeping.

In 2010, Grafton had three full time engineers and one part time engineer. Currently, Mr. Szczurko is the town's only engineer and has additional responsibilities besides stormwater management. Although there are nine employees in Grafton's Highway Department who could perform stormwater-related tasks such as mapping or catch basin cleaning, typically only one employee is available to work on a task at a time. Occasionally two employees will work on stormwater tasks, but that only occurs when Mr. Szczurko needs to train the staff. Since Grafton still has all 2,500 of its catch basins and approximately 175 of its outfalls to map, having only one or two employees dedicated to the task is insufficient. As a result, the town is planning to hire an environmental consultant to finish mapping their outfalls. They have also already hired a consultant to fill out their next annual report since Mr. Szczurko's position requires him to split his time amongst a variety of tasks (B. Szczurko, December 6, 2013).

Issues with the Implementation of a Stormwater Utility

When we asked Mr. Szczurko about whether Grafton has considered a stormwater utility, we received an unexpected response. Mr. Szczurko commented that the implementation of a stormwater utility is akin to "political suicide" (B. Szczurko, December 6, 2013). In order to

successfully implement a stormwater utility, the town would have to pass a stormwater tax on its residents, which would be difficult to get approval for. Mr. Szczurko commented that the town's residents are already taxed in order to fund entities such as schools, the fire department, and the police department, so a stormwater tax would not bode well. Additionally, Grafton recently funded construction of a new high school. Prior to the high school's construction, Mr. Szczurko was considering implementing a stormwater utility. However, taxes in Grafton increased in order to fund the new high school, and Mr. Szczurko decided that attempting to garner support for a stormwater utility would not work at this time.

Utility of Regionalization

Even though the Central Massachusetts Regional Stormwater Coalition (CMRSWC) was only formed two years ago, it has proved to be a valuable asset for 30 Central Massachusetts municipalities' compliance with the MS4 permit. When asked about the utility of the CMRSWC, Mr. Szczurko gave us useful feedback on the benefits and drawbacks of the CMRSWC. The CMRSWC provides resources for municipalities to use, such as water quality sampling kits and two Leica Global Positioning System (GPS) units. Mr. Szczurko stated that these resources are beneficial to Grafton. Mr. Szczurko said that the training offered is beneficial to municipal employees who are new to stormwater management (B. Szczurko, December 6, 2013).

However, Mr. Szczurko also commented on some of the inefficiencies of the CMRSWC. Although he stated that the Leica GPS units were useful for mapping, he expressed concern about the fact that each municipality in the CMRSWC only receives a Leica GPS unit for two weeks per year. He also expressed concern over how often the Leica GPS units were unavailable due to technical difficulties. Additionally, although he felt the CMRSWC's training on water quality sampling was useful to some municipal employees, he personally found it too extensive due to his background in engineering. Lastly, he stated that the CMRSWC is difficult to manage due to its size and the variation in knowledge between its members (B. Szczurko, December 6, 2013).

Altogether, Mr. Szczurko believes that the regionalization of the CMRSWC has provided Grafton with resources that the town would not be able to fund on their own. Although he

explained the inefficiencies of the CMRSWC, he also stated that it provided Grafton the opportunity to comply with the MS4 permit much better than it could have before joining the CMRSWC (B. Szczurko, December 6, 2013).

Leicester, Massachusetts

Although it borders the city of Worcester, which is the second largest city in New England, Leicester is a largely rural Massachusetts town. Like many Central Massachusetts municipalities, Leicester is a former mill town. During the Industrial Revolution, it was home to a multitude of carding and textile mills (“About Leicester”, 2012).

In more recent years, industry in Leicester has faded, leaving the town’s developed areas mostly residential in nature. Leicester is home to roughly 11,000 residents and is 24.6 square miles in size (“Leicester, Massachusetts”, 2013). When we visited Leicester to assist Patrick Navaroli with catch basin mapping on two days in December 2013, we observed that the town seemed largely rural, with few impervious surfaces. In fact, only 5.73% of the town is covered with impervious surfaces. Additionally, the town has been experiencing only a medium level of development, with an average of 5.5 – 7.4 acres of new development being added per year between 1999 and 2005 (EPA Region 1 GIS Center, 2010b).



Figure 7: An entrance to Leicester, MA (Phelan, 2008).

In Leicester, the Highway Department is primarily responsible for MS4 permit compliance, even though a few other entities also directly deal with the town's stormwater management.

Accordingly, when we visited Leicester, the first person we met with was Thomas Wood, the Superintendent of the Highway Department. He informed us that Matthew St. Pierre of the consulting firm Tata & Howard has been in charge of the administrative side of MS4 compliance since 2011, including the filing of Leicester's annual report. He also introduced us to Patrick Navaroli, a Highway Department employee who is in charge of Leicester's mapping and catch basin cleaning.

While mapping catch basins, we interviewed Mr. Navaroli in order to make observations about the state of Leicester's stormwater management.

A High Level of Knowledge is Needed in Order to Map Leicester's Catch Basins

The level of knowledge needed in order to map catch basins in Leicester is very high. Because of this, employees from divisions that do not deal with the roads as much as the Highway Department may struggle with it. Many of the catch basins that we mapped were completely covered by leaves and therefore impossible for us to spot. Mr. Navaroli, however, remembered where catch basins were located just from memory of what the streets looked like in spring when there were no fallen leaves. If someone without as much experience were to attempt to map Leicester's roughly 2,500 catch basins, there is a good chance that they would overlook many of them.



Figure 8: A catch basin in Leicester completely hidden by leaves (November 18, 2013)

The Leica CS-25 GPS Unit is Unreliable

After mapping with Mr. Navaroli, it became clear that the Leica CS-25 GPS unit was unreliable. The Leica GPS unit frequently lost its signal, even on clear days when we were not under any sort of plant, building, or cloud covering. Additionally, at one point the Leica GPS unit lost its connection to the Wi-Fi signal, leaving us unable to map for the rest of the day. Since the municipalities receive the Leica GPS unit for only two weeks per year, any time lost due to technical difficulties is a significant problem.

The Leicester Highway Department is Understaffed for its Scope of Responsibilities

While mapping with Mr. Navaroli, we became acutely aware of the fact that the Highway Department is understaffed and that sometimes maintenance of the MS4 falls by the wayside due to lack of manpower. Mr. Navaroli explained that many Highway Department workers had recently been laid off (P. Navaroli, November 18, 2013). In our interview with Mr. Wood, he confirmed that in 2008, the Highway Department had 13 employees, and that now the Highway Department consists of only seven employees (T. Wood, December 11, 2013). Mr. Navaroli also explained that he does the overwhelming majority of MS4 mapping and cleaning of approximately 2,500 catch basins himself. Additionally, he has other responsibilities as a Highway Department employee and must sometimes leave catch basins unchecked for debris more often than the Highway Department would prefer (P. Navaroli, November 18, 2013).

Due to Leicester's limited staff, Mr. St. Pierre was hired in order to help the municipality with MS4 permit compliance. While interviewing Mr. St. Pierre, he informed us that Leicester's current challenges are mostly due to lack of manpower, and that challenges with the 2013 NH MS4 draft permit will be due to the same cause. He informed us that the Highway Department is "stretched thin," and confirmed that it had recently lost a few employees.

More specifically, Mr. St. Pierre felt that the lack of manpower would especially make the Illicit Discharge Detection and Elimination (IDDE) portion of the 2013 NH MS4 draft permit difficult for compliance. He informed us that IDDE was the control measure of the 2013 draft permit that he thought most municipalities would struggle the most to comply with, due to its numerous time-consuming requirements. These requirements include mapping stormwater structures such as catch basins, which Leicester has already begun working on (M. St. Pierre, November 26, 2013).

Benefits of Regionalization

Despite the anticipated difficulty meeting the requirements of the IDDE portion of the draft permit, Matt did express a way for Leicester to meet the requirements more easily; he said that the Coalition's IDDE materials would be very helpful to Leicester once the 2013 NH MS4 draft permit is released. This is due to the availability of the Leica GPS unit and the availability of water sampling kits. Because the CMRSC owns these resources, Leicester will not have to purchase these expensive materials on their own, leaving them more funds with which to acquire additional manpower.

Mr. St. Pierre also suggested another avenue for Leicester to work towards compliance with the 2013 NH MS4 draft permit: increased use of environmental consultants. Since Leicester does not have the staffing capacity to meet all the requirements of the 2013 NH MS4 draft permit, Mr. St. Pierre felt that contracting some work out to a consultant would provide them with the extra manpower needed to fulfill the permit's requirements. Although we are aware that there is a potential for a conflict of interest since Mr. St. Pierre is a consultant himself, it was clear throughout the project that Mr. St. Pierre is genuinely interested in assisting the municipalities of the CMRSWC with their stormwater management (M. St. Pierre, November 26, 2013).

Funding

Leicester struggles with funding the tasks needed to meet the requirements of the 2013 NH MS4 draft permit, including hiring consultants if they chose to do so. Matt told us that Leicester will have to consider how it will fund meeting the requirements of the 2013 NH MS4 draft permit once it becomes law, and informed us that Mike Knox of Leicester's Sewer Department is interested in the development of a stormwater utility for this purpose. Despite the interest in a stormwater utility, however, the planning stage has not yet begun. Mr. St. Pierre says it is being considered, but that "no one has supported or denied it yet" (M. St. Pierre, November 26, 2013).

Unclear Wording

We determined that phrasing of the Public Education minimum control measure of the 2003 MS4 permit was unclear. We drew this conclusion based on information gained in our interview with Mr. St. Pierre. We determined that there was some confusion about exactly what sort of public education the control measure required. The permit states that "information regarding both industrial and residential activities including illegal dumping into storm drains" is required (EPA, 2003). According to Mr. St. Pierre, Leicester's public education does include information about illegal dumping in the form of storm drain stenciling, but it does not specifically address industrial activities (M. St. Pierre, November 26, 2013). We found that the wording of the permit made it unclear whether or not Leicester's public education met the permit's requirements, since illegal dumping is partially an industrial issue.

Shrewsbury, Massachusetts

The town of Shrewsbury is a suburban community located in Central Massachusetts residing east of Worcester. Neighboring Worcester, the suburban community contains a blend of lakes, forests, and colonial-styled buildings and homes that reflect the history of Massachusetts. The town is home to approximately 35,000 residents. Shrewsbury is approximately 21.73 sq. miles in size; 4.02 sq. miles are covered by impervious surfaces, which is 18.48% of the town's area ("Shrewsbury, Massachusetts", 2013; EPA Region 1 GIS Center, 2010). While visiting Shrewsbury, we traveled mostly through the downtown area and a nearby park which is home to

Dean Pond. We also went to Shrewsbury's Town Hall, which is adjacent to the police station and houses Shrewsbury's Engineering and Planning Departments and Conservation Commission.



Figure 9: The town hall of Shrewsbury, MA (GetACollage, 2005).

In order to gain more information about Shrewsbury's challenges with meeting both the 2003 MS4 permit requirements and the 2013 NH MS4 draft permit requirements, we spoke with Bradford Stone, the town's Conservation and Stormwater Coordinator. Mr. Stone has been the Stormwater Coordinator for Shrewsbury since the 2003 MS4 permit was released and has been almost solely responsible for ensuring Shrewsbury's compliance with the permit. He spends roughly 20 hours per week on stormwater tasks, in addition to the other responsibilities of his position.

Shrewsbury's Compliance with the MS4 Permit

While analyzing Shrewsbury's 2013 MS4 annual report and stormwater bylaw, we noticed that Shrewsbury has strong IDDE and Construction Site Stormwater Runoff Control programs, as required in the 2003 MS4 permit. For instance, Shrewsbury has completed mapping of their outfalls, frequently tests waterbodies for pollution levels, and has completed a case study on King's Brook for illicit discharges (B. Stone, November 12, 2013). Conversely, Shrewsbury seemed to have issues with meeting the Public Education control measure since they did not mention any coordination with local groups in their annual report (Perreault, 2013).

While interviewing Mr. Stone, we confirmed that Shrewsbury focuses their stormwater efforts on the IDDE and Construction Site Stormwater Runoff Control measures. Since Mr. Stone does most of the stormwater work for Shrewsbury -- outfall mapping, water quality sampling, and keeping track of important stormwater documents -- he focuses on the third and fourth control measures of the MS4 permit (B. Stone, November 12, 2013). To Mr. Stone's credit, these are arguably the most important control measures as they focus on finding the causes of illicit discharges, elimination of illicit discharges, and management of potential illicit discharges in construction projects (N. Tedder, December 3, 2013). Shrewsbury also makes every new construction project file with the USEPA in order to ensure that the project will not introduce pollution to stormwater runoff within the area. Shrewsbury's bylaw, passed in 2007, defines procedures that site operators must implement for proper sediment, erosion, and waste control at construction sites (B. Stone, November 12, 2013).

Challenges with Meeting the IDDE Requirements of the 2013 NH MS4 Draft Permit

Mr. Stone mentioned that he would need to spend a significant amount of time mapping additional stormwater structures and performing wet weather sampling in order to meet the requirements of the 2013 NH MS4 draft permit. Since the IDDE portion of the 2013 NH MS4 draft permit contains much more detail than that of the 2003 MS4 permit, Shrewsbury will need to put more time and effort into meeting the IDDE control measure once the permit is put into effect. Mr. Stone also mentioned that wet weather monitoring would require dozens of people to be mobilized simultaneously. Therefore, Mr. Stone anticipates the town of Shrewsbury would need to contract out wet weather monitoring in order to meet the requirements on time (B. Stone, November 12, 2013).

Another concern brought up with the IDDE portion of the 2013 NH MS4 draft permit was the required monitoring of transfers, which are the connections between MS4s. Mr. Stone was unsure as to why the 2013 NH MS4 draft permit requires the monitoring of transfers if it also requires the monitoring of outfalls. According to Mr. Stone, if there are no problems at the outfalls, there should also be no problems at the transfers. Because many of these transfers are located on the Massachusetts Department of Transportation (MassDOT) roads, Shrewsbury would have to open up manholes in the middle of six lanes of traffic, specifically on Route 9 and

20 in Shrewsbury. Doing so would not only exhaust police resources, but would likely yield an onslaught of traffic-related complaints from the public (B. Stone, November 12, 2013).

Challenges with Meeting the Public Education Requirements of the 2013 NH MS4 Draft Permit

Since Shrewsbury does not dedicate much time and resources on the Public Education control measure, they would have to put extra effort into complying with the 2013 NH MS4 draft permit. The 2013 NH MS4 draft permit requires the submission of at least two messages to each of four target audiences (78 FR 27964). Therefore, Shrewsbury would have to spend more time and funding in order to meet the requirements of the Public Education control measure of the 2013 NH MS4 draft permit (B. Stone, November 12, 2013).

Lack of Manpower, Funding, and Time

Mr. Stone believes the largest issue for Shrewsbury's compliance with the 2013 NH MS4 draft permit is the fact that there is little money, manpower, and time for its implementation. Since the upcoming Massachusetts MS4 permit is currently unreleased, Shrewsbury is hesitant to fund any tasks that need to be completed in fear of the draft's release being postponed. Even with a 60, 90, or 120 day grace period between the official release of the permit and the effective date of the permit, there will still not be enough time for compliance given their current number of staff members. Additionally, Shrewsbury is currently working on a stormwater utility, but Mr. Stone pointed out that the utility would still require a few years of operation in order for sufficient funding to be produced for meeting the 2013 NH MS4 permit requirements (B. Stone, November 12, 2013). Since Shrewsbury does not have a dedicated source of funding, this would hinder their compliance with the 2013 NH MS4 draft permit when released.

One of the requirements of the 2013 NH MS4 draft permit that will exacerbate Shrewsbury's problem with a lack of manpower is water quality testing. While interviewing Mr. Stone, he showed us water quality kits that tested for ammonia, chlorine, phosphorus, turbidity, and a few other possible pollutants. After this, we traveled to Dean Pond in Shrewsbury to test an outfall for phosphorus. Since it had been raining the day we tested, we were performing wet weather sampling of the outfall. Figure 6 below shows a picture of a water quality sampling unit Mr. Stone used on November 12, 2013 to complete a wet weather sampling of phosphorus. The 0.24

mg/L reading indicates higher levels of phosphorus than normal, since a typical dry weather reading is under 0.1 mg/L. However, this level is not high enough to cause concern since the phosphorus is most likely draining from lawn fertilizers into the MS4 (B. Stone, November 12, 2013).



Figure 10: A picture of a water quality sampling unit Mr. Stone used on November 12, 2013.

As mentioned above, Mr. Stone spends about 20 hours per week with stormwater-related tasks. Because of his civil engineering background and experience working as Shrewsbury's Conservation and Stormwater Coordinator for over 10 years, he is one of the most knowledgeable people on the MS4 permit and stormwater management. However, he is only one person and cannot take on the additional tasks required by the 2013 NH MS4 draft permit alone. He estimates that he would need at least an additional 80 hours per week, or two full time employees, just for filling out paperwork in order to meet the anticipated upcoming permit requirements. The town requires additional people to sweep their streets, map their stormwater structures, and clean their catch basins. Because of this, Shrewsbury would almost certainly have to contract their work out, which requires funding from a dedicated source (B. Stone, November 12, 2013). Even though Shrewsbury is one of the more populous municipalities we studied, the town is still facing challenges with budgeting and manpower with meeting the requirements of

the 2003 MS4 permit. They would also face additional challenges with meeting the requirements of the 2013 NH MS4 draft permit.

Inefficient Storage of Documents

Mr. Stone told us that all of Shrewsbury's stormwater documents are kept on paper and that this is not an efficient method for organizing their data. He believes a database to house their documents would greatly benefit their stormwater management and annual report process. Additionally, streamlining the annual report process through a database would help Shrewsbury reflect their compliance more accurately (B. Stone, November 12, 2013).

The 2013 NH MS4 Draft Permit Fact Sheet from the USEPA is Complex

The USEPA provided a fact sheet of the 2013 NH MS4 draft permit in order to assist municipalities with compliance. Unfortunately, Mr. Stone did not find this fact sheet useful for assisting with compliance with the 2013 NH MS4 draft permit. Specifically, he stated that the fact sheet is approximately 100 pages in length whereas the actual draft permit is 60 pages. It is very time consuming for municipal employees to read through this document. Mr. Stone also felt that due to the fact sheet's legal nature, it is difficult for municipal employees to dissect and interpret the legal jargon. He said that the USEPA released a helpful 10-page document summarizing the 2003 MS4 permit requirements, but the fact sheet for the 2013 NH MS4 draft permit was more of a burden than a reliable tool for compliance (B. Stone, November 12, 2013).

Upton, Massachusetts

The town of Upton is a suburban community located in Worcester County in South Central Massachusetts. It has an area of 21.7 square miles, of which 21.5 square miles are land and 0.2 square miles are water. It has 1.42 square miles of impervious surfaces, which is 6.5% of its total area.

Upton was first settled in 1728. The main industry in Upton for 100 years was boots and shoes. Between 1730 and 1850, small shoe shops in Upton had been developed in large assembly-line manufacturing companies. In 1837, the factories in Upton produced 21.7% of all boots in

Worcester County. The population expanded significantly during the 1980s and nearly doubled from 3,884 in 1980, to the 7,542 in 2010 (“About Upton”, 2012).



Figure 11: The town hall of Upton, MA (Phelan, 2009).

Through our project, our team studied the status of Upton’s compliance with the 2003 MS4 permit by reviewing Upton’s 2013 annual report and conducting interviews on Upton’s compliance. We interviewed Jeffrey Thompson, the Director of the DPW of Upton, and several MassDEP employees include Frederick Civian, Stormwater Coordinator; Andrea Briggs, Deputy Regional Director of the Bureau of Administrative Services; and Stella Tamul, Environmental Analyst. To assist Upton with compliance with the upcoming 2013 MS4 permit, our team mapped three outfalls and about 30 catch basins in Upton with Aubrey Strause, the owner and manager of Verdant Water, a stormwater and wastewater consulting firm. Ms. Strause assisted the town of Upton in filing its 2013 annual report and spoke to us as an environmental consultant.

Difficulty of the IDDE Control Measure in Both Permits

While reviewing the 2013 annual report, our team found that Upton did not complete their storm sewer system mapping as required by the IDDE control measure in 2003 MS4 permit (Tata & Howard, 2013d). Also, no illicit discharges had been identified in Upton. During our interview

with Mr. Thompson, our team confirmed these two findings. Mr. Thompson explained that Upton does not have illicit discharges because Upton is mainly residential. He also admitted that mapping is Upton's biggest challenge to the 2003 MS4 permit compliance due to the lack of manpower. Currently there are five DPW employees, including four workers and one supervisor. The Upton DPW employees' primary job responsibilities are in wastewater. Consequently, these workers are not familiar with stormwater management. Because of the lack of manpower and experience with stormwater management, Upton hired Verdant Water to complete its outfall mapping.

Experience Using Mapping Devices

While mapping, our team used two mapping devices: the Leica GPS unit and an iPad. A variety of tablets can be used to perform outfall and catch basin mapping, since all tablets can access the PeopleGIS forms that members of the CMRSWC use to map. Each municipality in the CMRSWC was given an Asus Transformer Infinity TF700T tablet, but Ms. Strause brought her own iPad for the mapping. The Leica GPS unit is much more expensive than the iPad or Asus tablet; the Leica GPS unit costs \$13,200, the Asus tablet costs \$400, and the iPad costs about \$500 (M. St. Pierre, December 3, 2013). However, the Leica GPS unit is more accurate than the iPad or Asus tablet. The accuracy of the Leica GPS unit was in the range of 2 centimeters, and the iPad's was usually in the range of 3 to 5 meters, although it sometimes ranged all the way to 70 meters. Another group of WPI students working with MassDEP was also mapping in Upton. They used the Asus tablet and reported that its level of accuracy could be as bad as 60 meters, but that it typically remained in the range of 2 meters. Despite the lower accuracy of the iPad and Asus tablet, Ms. Strause noted that people can always go back to move the location of the catch basins and outfalls manually and make these mapped points more accurate (A. Strause, November 22, 2013).

Our team mapped about 30 catch basins and three outfalls near the area of some streets including Whitney Lane, Hazeltine Road, and Laurel Lane. Our team found oil, trash, bacteria, sediment, and fallen leaves around some of the catch basins and outfalls. These water pollutants have adverse impacts on the environment as explained in Chapter 2 of this report. In addition, trash, sediment, and fallen leaves may cause catch basins and outfalls to work less efficiently. For

example, piles of fallen leaves and trash covered some catch basins, which made it hard for our team to find their locations while mapping. Also, fallen leaves and trash covering the catch basins decreases the flow rate of runoff entering the catch basins, which could cause flooding in a large storm. Furthermore, sediment can cause abrasion to the inside of outfalls. One of the outfalls we mapped showed evidence of abrasion due to excessive sediment. The inside of the pipe looked almost as though it had been sanded down, and there was sediment lining the area where the outfall discharged. This outfall is shown in Figure 7 below.



Figure 12: Outfall in Upton with abrasion due to excessive sediment (Nov. 22, 2013)

Ms. Strause has several years of experience working with municipal stormwater management. She is very knowledgeable and taught us a lot about stormwater management. We went out mapping on a rainy day, so our team was able to observe the flow of runoff in the streets. While our team was having difficulties spotting the location of some catch basins because of the fallen leaves, Ms. Strause told us to observe the flow direction of the runoff along the street. For example, once, Ms. Strause observed a flow of runoff entering a big pile of leaves with no runoff flowing out. After clearing off these leaves, our team surprisingly found a catch basin.

While mapping, Ms. Strause also taught us how to find the locations of outfalls. One of the methods for finding an outfall is by observing the location of pipes through the cover of the catch basin. This way, our team could estimate the direction in which the outfall is located. Also, our

team found outfalls by observing low points in the road. After our team found an outfall, we filled out the inspection form in the Leica GPS unit. We recorded the size of the outfall, its location, its material, and any flow or water pollutants we observed.

4.3 COMPARATIVE QUALITATIVE DATA ANALYSIS

After performing case studies of Grafton, Leicester, Shrewsbury, and Upton, we determined that the municipalities' experiences with the 2003 MS4 permit and the 2013 NH MS4 draft permit shared many common themes. We also used data collected from interviews with MassDEP employees and Newton Tedder, a Physical Scientist at the USEPA, to draw our conclusions. In this section, we outline these common threads. We also outline any significant differences we found between the municipalities' experiences.

Unclear Wording in the 2003 MS4 Permit

We determined that one issue posed by the 2003 MS4 permit is that its wording is frequently unclear. We first began to suspect this while performing document analysis on the 2003 MS4 permit, and our hypothesis was later confirmed in our interviews with employees from Leicester and MassDEP. As mentioned in Leicester's case study, the wording of the Public Education minimum control measure caused confusion. The wording made it unclear whether public education involving the dangers of illegal dumping counted as education directed at industrial groups.

Additionally, Frederick Civian, Stella Tamul, and Cheryl Poirier of MassDEP all agreed that the permit's wording was vague (F. Civian, S. Tamul, C. Poirier, November 21, 2013). Other examples of vague phrasing include numerous sections of the permit where the permittee is required to "consider" implementing certain Best Management Practices (BMPs) or tactics for managing stormwater (78 FR 27964). It is unclear how, if at all, the municipalities are required to demonstrate that they considered certain options. Mr. Civian, Ms. Tamul, and Ms. Poirier suggested that USEPA left the permit's wording vague on purpose as a way to make municipal employees at least begin to think about stormwater management. The prevalent train of thought was that USEPA left the permit vague in order to encourage municipalities to begin working on stormwater management without making it overwhelming (F. Civian, S. Tamul, C. Poirier,

November 21, 2013). USEPA employee Newton Tedder confirmed that the some of the requirements are intentionally worded vaguely in order to encourage municipal employees to begin implementing the various requirements they need to meet in the MS4 permit, as opposed to overwhelming them with requirements. However, we found that the end result of this vagueness was that municipalities were confused about how they were supposed to comply with the permit and whether or not the Best Management Practices (BMPs) they were implementing caused them to be compliant.

IDDE: The Greatest Challenge of the 2003 MS4 Permit

Another common statement we heard from municipal employees was that the IDDE control measure of the 2003 MS4 permit was the one that required the most effort for compliance. The IDDE control measure requires that municipalities map all of their outfalls by the end of the permit term. It also requires a regulatory mechanism by which municipalities prohibit illicit discharges and assert the authority to enforce such a rule. As some municipalities, such as Shrewsbury, have upwards of 350 outfalls, mapping all of these has proved to be very time consuming (Shrewsbury Board of Selectmen, 2011).

In fact, as of December 2013, neither Grafton nor Upton has been able to complete the mapping requirements of the 2003 MS4 permit. This is due to a lack of available personnel, as noted in both municipalities' case studies.

An additional challenge many municipalities face with the IDDE control measure is the development of an IDDE plan. Out of the four municipalities we worked with, only Shrewsbury had an IDDE plan that fully satisfied the permit's numerous requirements, including procedures for identifying priority areas, for locating and removing illicit discharges, and for evaluating the illicit discharge's impacts.

Lack of Funding

Municipalities face challenges funding the resources needed for meeting the requirements listed in the MS4 permit. In fact, none of the municipalities we worked with had a dedicated source of funding for their stormwater work. Instead, the money for the municipalities' stormwater

management comes out of their town budgets. Additionally, every town except Upton specifically mentioned the difficulty that they are already having with securing the funding needed to meet the 2003 MS4 permit requirements. Since the 2013 NH MS4 draft permit is so much more involved, it is clear that even more funding will be needed in order to comply with it once it is issued.

Some municipalities have begun the process of looking into a stormwater utility in order to generate the funding that will be necessary to comply with the 2013 NH MS4 draft permit. Shrewsbury, for example, is in the process of working with a consulting firm in order to determine the details of implementing a stormwater utility (B. Stone, November 12, 2013). Leicester is only in the beginning stages of considering a stormwater utility, but Matt St. Pierre stated that the municipality will have to look into a dedicated funding source once the upcoming MS4 permit is issued (M. St. Pierre, November 26, 2013).

Although a stormwater utility would provide these municipalities with a dedicated funding source, creating a stormwater utility is not a simple task. As mentioned by Mr. Szczurko, a DPW Engineer from Grafton, being in favor of a stormwater utility is akin to “political suicide” (B. Szczurko, December 6, 2013). Since the stormwater utility would force residents of municipalities to start paying stormwater taxes, public approval of the utility would not be likely. This leads us to believe that many municipalities will face difficulties convincing their town’s residents and municipal employees to vote in favor of a stormwater utility.

USEPA acknowledges the lack of funding that many municipalities will face once the 2013 draft permit is issued. In our interview with Newt Tedder of USEPA, he stated that he doesn’t “believe anyone can implement the [2013] permit without a dedicated source of funding” (N. Tedder, December 3, 2013). Since none of the towns we worked with had a dedicated source of funding available, we determined that a lack of funding would pose a significant challenge to municipalities looking to comply with the upcoming MS4 permit.

In order to fund the resources for meeting the requirements of the MS4 permit, municipalities can collaboratively work with other municipalities to share necessary resources. Municipalities

in the CMRSWC can share resources related to the MS4 permit and stormwater management in order to assist with some funding issues. For instance, the CMRSWC purchased two Leica GPS units for municipalities to share in order to map outfalls, catch basins, and other stormwater structures. Additionally, each of the 30 municipalities in the CMRSWC received an Asus tablet for outfall inspections and mapping of stormwater structures. Although municipalities still must map stormwater structures individually, the sharing of these resources allows them to focus their funding on other requirements of the MS4 permit.

Lack of Manpower

Municipalities face a severe lack of manpower when trying to meet the requirements of the 2003 MS4 permit is a lack of manpower. Every town we worked with expressed that they were struggling to pull together the necessary manpower to complete their stormwater tasks. The lack of manpower was usually a direct result of a lack of funding. If towns could not finance the hiring of additional workers or had to lay off existing workers, more of a workload was placed on the remaining employees. This did not allow them to have enough time to complete stormwater tasks. For more details on the number of staff within the departments of each municipality, see Table 2 below.

Table 2: A comparative table of municipal data. See Appendix C for a larger version of the municipalities' impervious surface maps.

	Grafton	Leicester	Shrewsbury	Upton
Population at the 2010 census	17,765	10,970	35,608	7,542
Area (sq. miles)	23.33	24.64	21.73	21.8
Type	Semi-rural	Rural	Suburban	Suburban
Department in charge of stormwater	- DPW - Conservation Commission	- Highway Department - Sewer Department	- Engineering Department - Highway Department	- DPW - Conservation Commission
Number of people available to work on stormwater management	10 DPW employees (1 engineer and 1 worker at a time)	- 2 employees from Highway Department (1 superintendent, 1 worker)	1 Engineer	5 DPW employees including 1 supervisor and 4 workers
Number of Outfalls	~ 350	89	~ 520	72
Number of Catch Basins	~ 2,500	~ 2,500	~ 5,600	Unknown
Area of Impervious Surfaces (sq. miles)	2.48 (10.64%)	1.41 (5.73%)	4.02 (18.48%)	1.42 (6.5%)
Map of Impervious Surfaces and Watershed	<p>Legend</p> <ul style="list-style-type: none"> Subbasins Groundwater Contributing Areas (GWCA) Impervious Area MS4 Urban Area MA Towns Water Bodies 			

As mentioned previously, Mr. Stone deals with the majority of Shrewsbury's compliance with the MS4 permit. In Leicester, the Highway Department shrank from 13 employees to 7 employees over the past few years. The downsizing of this department has led to just one employee taking on the majority of stormwater-related tasks. Lastly, in Upton, the DPW was understaffed to the point where Jeffrey Thompson, its director, needed to hire a consultant to fill out the annual report and perform outfall and catch basin mapping.

Time Constraints

Municipalities will face many time constraints with meeting the requirements of the 2013 MS4 draft permit. While meeting the requirements of the 2013 MS4 draft permit will reduce stormwater pollution across Massachusetts, both MassDEP and municipal employees worry that the permit does not allow enough time for municipalities to realistically comply with all of its requirements.

When we analyzed the 2013 NH MS4 draft permit, we noticed that municipalities have many tasks to complete within the first year that it becomes effective. For instance, within the first year of the permit, town employees have to develop a Stormwater Management Plan (SWMP) detailing various tasks such as procedures for public education, completion of a problem catchment inventory, and the development of a written IDDE program. Frederick Civian from MassDEP also expressed concern with the amount of time municipalities have to meet many requirements of the 2013 MS4 draft permit (F. Civian, November 6, 2013).

Mr. Civian noted that many of the requirements listed in this permit have been adding up and carried over from previous drafts (F. Civian, November 6, 2013). However, since an official permit has not been released since 2003, municipalities have been hesitant to work towards meeting the draft permits' requirements (B. Stone, November 12, 2013). Because of this, municipalities will struggle to comply with all of these additional requirements within the given timeframe.

Shrewsbury's municipal employees have notified the USEPA of their concerns with the upcoming permit. In 2011, Shrewsbury sent a letter to the USEPA detailing the various

challenges the town would face with meeting the requirements of the 2013 NH MS4 draft permit. One of these challenges was time. Town employees from Shrewsbury agreed that one year is not enough time to develop a written SWMP. Additionally, one year is not enough time for a stormwater utility to provide a dedicated source of funding for implementation (Shrewsbury Board of Selectmen and Sewer Commission, 2011).

Brad Stone from Shrewsbury expressed great concern about the implementation time of the 2013 NH MS4 draft permit requirements. Since he is the town's Conservation and Stormwater Coordinator, he is almost solely responsible for Shrewsbury's implementation of many control measures of the MS4 permit. With Shrewsbury's current manpower, there is simply not enough time to meet the upcoming permit requirements. For instance, the 2013 NH MS4 draft permit requires the cleaning of a catch basin when it is 50% full. Cleaning the catch basins in this manner would require frequent inspection of all of Shrewsbury's approximately 5,000 catch basins. Even if Shrewsbury was to contract out some of this work, completion of the rest of this requirement would consume Mr. Stone's time. Even though Shrewsbury's IDDE and Construction Site Stormwater Runoff programs exceed the requirements of the 2003 MS4 permit and are partially compliant with the requirements of the 2013 NH MS4 draft permit, Mr. Stone stated that compliance within the given timeframe is impossible given their current manpower and funding (B. Stone, November 12, 2013). See Table 2 for details on levels of staffing.

Leicester also expressed concern with timeframes for completion of requirements in another letter to the USEPA. Town employees commented that the timeframe allowed for the development of a SWMP is far too short for actual implementation (Reed, 2011). In addition, mapping of the required elements detailed in the 2013 NH MS4 draft permit is unrealistic for Leicester considering their current staff numbers. In Leicester, Patrick Navaroli almost solely deals with the mapping of outfalls, catch basins, and other stormwater structures that the 2013 NH MS4 draft permit lists (T. Wood, November 18, 2013). Since Leicester is also facing funding challenges, hiring the help of additional employees is not an option (M. St. Pierre, November 26). Therefore, Leicester will face challenges with meeting the requirements on time.

Although the towns we worked with had varying levels of staffing and funding, all agreed that the timeframes in the 2013 NH MS4 draft permit were unrealistic for implementation. Larger municipalities like Shrewsbury have larger budgets and therefore have hired more employees who can work on stormwater tasks. Smaller municipalities such as Upton and Leicester have smaller budgets and consequently cannot afford as many workers. This leaves their Highway Department and DPW employees struggling to balance stormwater management tasks along with their other duties, which can include road and cemetery maintenance.

Knowledge of Stormwater Management/Training

While attending CMRSWC meetings and interviewing municipal employees from Grafton, Leicester, Shrewsbury, and Upton, we noticed varying levels of stormwater knowledge among municipal employees. Part of this is due to which town department is responsible for MS4 compliance. For instance, in Shrewsbury, Brad Stone is a civil engineer who deals with stormwater management as the town's Conservation and Stormwater Coordinator. Weekly, Mr. Stone spends about 50% of his time with stormwater management related tasks (B. Stone, November 12, 2013). Alternatively, Leicester's Highway Department and Upton's DPW each respectively work towards their town's compliance (Tata & Howard, 2013c; Tata & Howard, 2013d). These departments have even less time devoted weekly to stormwater management due to other responsibilities. Therefore, many municipal employees and employees do not have the time to interpret the legal jargon of the permit. Because of this, some municipal employees may know a great deal about stormwater management, pollution, water quality testing, locating catch basins, or other tasks the MS4 permit requires while others are less knowledgeable with the topic. While the CMRSWC provides training on water quality testing and mapping, the actual work is still left to municipalities.

The water quality testing requirement of the 2013 MS4 draft permit will pose one of the biggest training issues for municipalities. While municipal employees with engineering backgrounds may be very knowledgeable about water quality testing, many other municipal employees will need training (B. Szczurko, December 6, 2013). The mapping of stormwater structures will also be a challenge for municipal employees. Highway Department and DPW workers may have

more knowledge of roadways and locations of catch basins than many other municipal employees, which will make the completion of mapping easier for them.

Unclear Wording of 2013 MS4 Draft Permit

Through our document analysis of the 2013 NH MS4 draft permit, we found a lot of requirements to be unclear. Even though the draft permit is much more detailed than the 2003 MS4 permit, the wording of some requirements still leaves room for multiple interpretations. Newton Tedder from the USEPA said that both the 2003 MS4 permit and 2013 NH MS4 draft permit were intentionally worded to allow for multiple interpretations (N. Tedder, December 3, 2013). Although this has caused some confusion amongst municipal employees, the wording was not intended to be confusing. Confusing wording is present, for example, in the section on the priority ranking of catchments in IDDE. USEPA released a flowchart that attempts to solve any confusion that arose in the catchment ranking portion of the permit, but even with the flowchart, the ranking is still confusing since municipalities do not know how to interpret the requirements. See Appendix F for the IDDE Flowchart.

The Water Quality Response Plan (WQRP) is another confusing section of the 2013 NH MS4 draft permit. Occurring in section 2.2.2.a.ii of the permit, it asks municipalities to “consider” listed Best Management Practices (BMPs) to address pollutants causing impairments to waterbodies (78 FR 27964). Municipalities could interpret this requirement in a variety of different ways. Municipal employees might *consider* implementing one of the BMPs listed, such as a modified educational program or a revision of good housekeeping procedures, but actually disregard the BMP altogether. Under the Directly Connected Impervious Area (DCIA) section of the Post Construction control measure, as seen in section 2.3.6.8 of the permit, municipalities are required to “consider” areas that could be retrofitted with BMPs (78 FR 27964). Since municipalities will still face other challenges with meeting the requirements of the 2013 MS4 draft permit, many municipalities may overlook some of these requirements to focus on ones that are more definitive, such as public education programs, mapping, or good housekeeping.

Difficulty of the IDDE Control Measure in Upcoming MS4 Permit

The Illicit Discharge Detection and Elimination control measure of the 2013 NH MS4 draft permit contains the most additions from the 2003 MS4 permit. Consequently, we determined that municipalities will struggle the most with this control measure. As mentioned previously, once the 2013 permit is issued municipalities will need to map many other stormwater structures in addition to outfalls, such as catch basins, catchments, manholes, and culverts. Not only is fulfilling this requirement time consuming, but it is also difficult to complete. As mentioned in the case study of Leicester, some catch basins were completely covered by leaves. The only reason we were able to map them was because of Mr. Navaroli's knowledge base and familiarity with Leicester's roads. We encountered a similar situation in Upton. Due to Ms. Strause's knowledge of stormwater management, she was able to identify spots where catch basins were hidden under piles of leaves. Town employees expansive knowledge of the local geography or stormwater management will face additional challenges meeting the IDDE requirement.

Additionally, municipalities that have not completed the IDDE requirements from the 2003 MS4 permit will be at a distinct disadvantage for complying with the upcoming 2013 MS4 permit. This point was demonstrated in Grafton's case study. Since Grafton has not yet mapped all of its outfalls, the town will face additional challenges meeting the water quality sampling requirements that are present in the IDDE control measure of the 2013 NH MS4 draft permit.

Another challenge with IDDE is the priority ranking of catchments. Municipalities must create an inventory of all catchments within their community and rank them based on the risk they pose to introducing runoff pollution into the environment. As stated above, the priority ranking of catchment requirements in the 2013 NH MS4 draft permit are unclear. Therefore, creating an inventory of all catchments within the municipality and inspecting them for ranking will be a difficult, time consuming process for municipal employees and may not produce the results the USEPA is looking for.

Difficulty of Public Education Control Measure in Upcoming MS4 Permit

By analyzing the 2003 MS4 permit and the 2013 NH MS4 draft permit, we determined that the Public Education control measure became significantly more involved in the 2013 NH MS4 draft

permit. For example, section of 2.3.2.1.c of the 2013 NH MS4 draft permit requires educational messages targeted to four different audiences while the 2003 permit does not (78 FR 27964; EPA, 2003). These audiences include residents, businesses, developers, and industrial facilities. As mentioned in the Shrewsbury, Mr. Stone found the 2013 NH MS4 permit public education control measure is difficult to comply with. He is unclear how to target the four different audiences specifically. He hopes that the USEPA will provide more guidance on how to comply with this control measure.

In addition, the Public Education measure of 2013 NH MS4 draft permit requires municipalities to assess the effectiveness of their educational messages. This is one of the unclear parts of the permit since it does not explain how municipalities assess each message's effectiveness. Our team talked about this requirement with Mr. Civian as well as Isabel McCauley, a Senior Civil Engineer with the town of Holden, Massachusetts, who worked closely with the other group of WPI students working with MassDEP. Both Mr. Civian and Ms. McCauley agreed that this requirement is unclear and left them with little guidance on how to evaluate the impact of the educational messages. The unclear requirements make compliance with the Public Education control measure more difficult to understand. Although common practices of permit writing include giving leeway with meeting permit requirements through wording that can be interpreted multiple ways, municipal employees are unclear as to how the USEPA wants employees to evaluate their educational messages (Farber, 1999).

Utility of Regionalization

When municipalities collaboratively work on stormwater management issues, they are able to accomplish more. Through our project, our team saw how regionalization of stormwater management benefits the member municipalities in the CMRSWC. Ms. Strause and Mr. Pierre usually host a CMRSWC Steering Committee meeting every month. During the meeting, municipal employees learn from each other and build relationships. Our team attended a CMRSWC training workshop in the town of Holden on November 20. Municipal employees at that meeting received training on water quality testing kits and mapping devices. This training helped municipalities to prepare for complying with the IDDE control measure in the upcoming MS4 permit.

In addition, the municipalities in the CMRSWC share resources, which helps them save money on their stormwater management. These shared resources include training, mapping devices, IDDE documentation, water quality testing kits, and stormwater educational materials on the CMRSWC's website.

Since a mapping device such as a Leica GPS unit is very expensive, municipalities can share a device instead of each municipality buying a device for their own town. This sharing of resources allows each municipality to utilize the GPS unit without having to pay its full cost.

However, a large group of municipalities is difficult to organize because municipalities are different from each other in factors such as size and landscape. Topics that are of interest to one municipality may not apply to all the other municipalities present, and scheduling meetings with many people can pose a challenge. The CMRSWC needs dedicated leadership in order to make the group work together efficiently. Additionally, the municipal employees that attend CMRSWC meetings are from different departments from each municipality, so they have different types of background knowledge. The municipal employees who attended the CMRSWC's training on November 20 were from different municipal departments including the DPW, Engineering Department, Planning Department, and Conservation Commission. Both Mr. Stone from Shrewsbury and Mr. Szczurko from Grafton agreed that keeping the CMRSWC organized and efficient is difficult and time consuming (B. Stone, November 12, 2013; B. Szczurko, December 6, 2013).

Use of Environmental Consultants

Environmental consultants provide additional manpower and professional advice to municipalities. As shown in the table below, Shrewsbury is working with Weston & Sampson to develop a stormwater utility. Leicester hired Tata & Howard to file the town's annual report. Upton hired Aubrey Strause of Verdant Water to file their municipality's annual report and do outfall and catch basin mapping. As mentioned in the case study of Upton, the municipality's DPW has only five workers and these workers have other duties besides stormwater management. Hiring Ms. Strause to do mapping and file the annual report helped Upton solve

the issue of lack of manpower. For more information on the different tasks consultants completed within the four municipalities we worked with, see Table 3 below.

Table 3: Consulting Firms Working for Municipalities

Municipalities	Subcontract to Environmental Consultant?	Consultant Responsibilities
Grafton	No	N/A
Leicester	Yes - Tata & Howard	Filed 2013 annual report
Shrewsbury	Yes - Weston & Sampson	Developing stormwater utility
Upton	Yes - Verdant Water	Filed 2013 annual report; Conducted outfall and catch basin mapping

Experience Using Mapping Devices

Our team used two different mapping devices while completing this project, which are the Leica GPS unit and iPad. We also received information about the experiences the other group of WPI students working with MassDEP had while mapping. We found that the devices each have their own benefits and drawbacks which is listed in Table 3. The accuracy of the Leica GPS is higher than the accuracy of the Asus tablet or iPad, as discussed in Upton’s case study. However, the Asus tablet and iPad are less expensive to purchase and easy to carry around. Furthermore, the Asus tablet and iPad have longer battery life. The battery life of the Leica GPS unit is about six hours which is not long enough to last a working day. In addition, when our team used the Leica in Leicester, we found that it sometimes has problems connecting to the Wi-Fi hotspot and satellites. In addition, while our team was mapping in Upton, there were times when the submit button on the PeopleGIS form did not work. We had to turn the Leica off and on twice before it began working again, which took about 15 minutes because the operating system and software had to reboot each time. Conversely, the other WPI student researchers working with Central Massachusetts municipalities to assist with catch basin and outfall mapping did not have any problems while using the Leica GPS unit. They found the Leica GPS unit to be quick and accurate.

Table 4: Comparison of Leica GPS unit and Asus Tablet/iPad

	Leica GPS Unit	Asus Tablet/iPad
Cost	\$13,200	\$400 - \$500
Start Up Time	~ 20 minutes	~ 1 minute
Time to Map a Location	~ 30 seconds	~ 30 seconds
Accuracy	~ 2 centimeters	Normally 2 - 5 meters, sometimes ~ 60 meters
Battery Life	~ 6 hours	More than 8 hours
Maneuverability	Bulky	Small, very light to carry

Through our research of the these four municipalities of Grafton, Leicester, Shrewsbury, and Upton's compliance with the 2003 MS4 permit and 2013 NH MS4 draft permit, we discovered several findings. According to these findings, our team then created several recommendations.

5.0 RECOMMENDATIONS

After performing case studies of Grafton, Leicester, Shrewsbury, and Upton followed by a comparative qualitative data analysis on these case studies, we discovered that: the 2003 Municipal Separate Storm Sewer System (MS4) permit and 2013 New Hampshire (NH) MS4 draft permit requirements are confusing; municipalities will face future challenges due to the lack of funding, manpower, and time; and municipalities will face challenges meeting the Illicit Discharge Detection and Elimination (IDDE) requirements specifically. Based on these findings, we offer a series of recommendations targeted to different stakeholders in stormwater management. We offer our detailed recommendations to the United States Environmental Protection Agency (USEPA), the Central Massachusetts municipalities, Massachusetts Department of Environmental Protection (MassDEP), and future student researchers who may work with MassDEP or central Massachusetts municipalities in their stormwater management.

Recommendations to the USEPA:

Encourage Regionalization of Stormwater Management

We recommend that USEPA encourage the regionalization of stormwater management. Throughout the course of our project, we were able to see firsthand all the benefits the Central Massachusetts Regional Stormwater Coalition (CMRSWC) provides to its members. Member towns of the CMRSWC receive training on technology such as water quality monitoring kits and GPS devices, something that many departments in charge of stormwater tasks will need before being able to work toward meeting the requirements of the 2013 NH MS4 draft permit once it is issued.

Regionalization also provides municipalities with financial benefits. By sharing common resources, the cost of compliance with the 2013 NH MS4 draft permit is decreased. Anything that can be done to reduce the costs of compliance with the 2013 NH MS4 draft permit once it is issued will be helpful to municipalities. This is especially true since USEPA recognized that the upcoming 2013 NH MS4 draft permit will be extremely difficult to fund without a dedicated source of funding and none of the municipalities we worked with had dedicated funding (N. Tedder, December 3, 2013).

Develop a Method for Assessing Educational Messages' Effectiveness

The municipalities we worked with expressed interest in additional guidance on how they might assess the effectiveness of their educational messages. Consequently, we recommend that the USEPA develop a standard way that municipalities can test an educational message's effectiveness. One unclear point in the 2013 NH MS4 draft permit is under the Public Education control measure. In Section 2.3.2.2, the permit requires that municipalities measure the effectiveness of their educational messages in order to determine any modifications that need to be made to more efficiently educate the general public. The permit requires that municipalities develop a method for measuring a message's effectiveness and modify the message if it is deemed ineffective (78 FR 27964). However, there are no methods provided within the 2013 NH MS4 draft permit itself and municipalities are left to devise their own methods for testing effectiveness. As detailed in the previous chapter, multiple municipal employees requested concrete options for assessing messages' effectiveness. Not only would this recommendation save municipalities time and effort, but it would also ensure that their methods are accurately evaluating the educational messages sent to the public.

Create a More Condensed Fact Sheet for the Upcoming MS4 Permit

Our team recommends that USEPA create a more condensed fact sheet for the upcoming MS4 permit. USEPA has already created a fact sheet for 2013 NH MS4 draft permit which some municipal employees do not find helpful, as Bradford Stone from Shrewsbury mentioned during our interview with him (B. Stone, November 12, 2013). The 2013 NH MS4 permit itself has only 60 pages, but the fact sheet from USEPA has over 100 pages. The contents of the fact sheet from USEPA additionally include comments from municipalities about the 2013 NH MS4 draft permit and USEPA's response to these comments (EPA, 2013f). Thus, finishing reading the fact sheet is very time consuming and it does not serve to condense the requirements for municipal employees. Our team created a fact sheet for the 2013 NH MS4 draft permit, however there is potential for the Massachusetts version of the permit to differ. Thus, when USEPA issues the new Massachusetts MS4 permit, our team recommends that USEPA also provide a short fact sheet which condenses the content of the new MS4 permit and does not include municipalities' comments in it.

Provide Funding for Meeting the Requirements of the Upcoming Permit

Due to the increased requirements in the 2013 NH MS4 draft permit and the additional funding municipalities will need to meet these requirements, we recommend that the USEPA provide funding to municipalities. While the Community Innovation Challenge (CIC) Grant provides the CMRSWC with some additional funding for meeting the permit requirements, the grant money currently does not provide enough for all to be in full compliance with 2003 MS4 permit. The release of the 2013 MS4 draft permit will further exacerbate budgeting issues within municipalities, and as stated previously, most municipal budgets do not have sufficient funds for addressing stormwater issues.

Provide Training on the Upcoming Permit Requirements

Our team recommends that USEPA provide municipalities with training on the upcoming Massachusetts MS4 permit prior to its release. As detailed in our comparative qualitative data analysis, municipal employees have a wide range of knowledge levels on stormwater and the MS4 permit. Additionally, we found that there was a lack of uniform agreement on how to interpret the requirements of the 2013 NH MS4 draft permit. We believe that by providing municipalities with training, this confusion can be resolved.

Recommendation for Municipalities:

Develop a Schedule for Implementation of Public Education

Due to the increased specificity of the 2013 NH MS4 draft permit's Public Education minimum control measure, our team recommends that municipalities develop a schedule for the implementation of the control measure. Since we determined that many municipalities, such as Leicester and Shrewsbury, have only provided educational messages for residential audiences, we came to the conclusion that municipalities will need additional planning in order to meet the requirements of Public Education according to the 2013 NH MS4 draft permit (M. St. Pierre, November 26, 2013; B. Stone, December 6, 2013).

Section 2.3.2.1 of the 2013 NH MS4 draft permit requires that municipalities send at least two messages to four different audiences throughout the course of the permit term. The messages to the same audience must be separated by at least a year (78 FR 27964). Because of this, our team

recommends that municipalities plan the order and timing of the educational messages they plan to send.

Order of Completion of IDDE Mapping Requirements

We recommend that municipalities first finish mapping their outfalls, if they have not already. We recommend that they then map their catch basins. After mapping catch basins, we recommend that they map their other stormwater structures, such as manholes and pipes. There are multiple reasons for this: (1) the mapping of catch basins will allow municipalities to meet other requirements more easily; (2) the CMRSWC currently has resources available for mapping catch basins. According to Section 2.3.7.1.d of the 2013 NH MS4 draft permit, municipalities must perform inspections of their catch basins in order to determine when they are 50% full (78 FR 27964). By knowing the locations of their catch basins, they can perform these inspections without going through the hassle of finding unmapped catch basins. In addition, knowing the locations of catch basins can help municipal employees locate the source of a potential illicit discharge.

Another reason why municipalities should map their catch basins directly after mapping their outfalls is due to the availability of the CMRSWC's mapping tools. Each municipality within the CMRSWC has their own map dedicated to outfall and catch basin mapping. The forms for mapping each are straightforward and allow a municipal employee to view the map from any computer device.

Recommendations to the CMRSWC and MassDEP:

Pilot the 2013 NH MS4 Draft Permit Checklist and Fact Sheet

Our team recommends that MassDEP test the utility of the checklist and fact sheet that our team created for tracking compliance with the 2013 NH MS4 draft permit (See Appendix D for the checklist and Appendix E for the fact sheet). In order to create a checklist that municipal employees and environmental consultants found useful, we interviewed several municipal employees and environmental consultants, including Jeffrey Thompson, Director of the DPW for Upton; Bradford Stone, the Conservation & Stormwater Coordinator for Shrewsbury; Brian Szczurko, a DPW Engineering Assistant for Grafton; Todd Girard, a Conservation Agent for

Charlton; John Westerling, the Director of DPW for Hopkinton; Aubrey Strause, a Professional Engineer from Verdant Water; and Matthew St. Pierre, a Project Engineer from Tata & Howard. Through our interviews with these municipal employees and environmental consultants, they all agreed that they would find a checklist for tracking compliance with the 2013 NH MS4 draft permit useful. Our team received widespread support for the draft checklist and draft fact sheet from the MassDEP employees, municipal employees, and the environmental consultants that we interviewed.

If MassDEP finds that the checklist and fact sheet will benefit municipalities, we highly recommend that the 30 municipalities of the CMRSWC pilot the checklist and give suggestions about further adjustments. If these municipalities also find the checklist and fact sheet helpful, we recommend that MassDEP make the checklist and fact sheet available to all Massachusetts municipalities.

Recommendation to Future Researchers:

Research the Logistics of Creating a Stormwater Utility

We recommend that future researchers perform additional research into the logistics of creating and implementing stormwater utilities. Due to the lack of funding that many municipalities already face while trying to comply with the 2003 MS4 permit and the anticipated additional financial limitations that will occur when the 2013 NH MS4 draft permit is issued, we determined that municipalities will soon need a dedicated, consistent source of funding for stormwater management, such as a stormwater utility. At the time of our project, none of the four municipalities we worked with had a dedicated source of funding for stormwater management; the funds for stormwater tasks instead came out of the towns' budgets.

However, after researching stormwater utilities, we determined that the process of creating a stormwater utility is very involved and takes a significant amount of time. Not only must municipal employees and consultants work out the details of a stormwater utility, but they must also convince municipal employees and residents to vote for its implementation. However, as Frederick Civian, MassDEP's Stormwater Coordinator, and Brian Szczurko, Grafton's DPW Engineering Assistant confirmed, convincing people to vote for more taxes is never easy (B.

Szczurko, December 6, 2013; F. Civian, November 6, 2013). The process of creating a stormwater utility can also be costly, so we recommend that future researchers conduct a cost/benefit analysis for creating a stormwater utility. Due to the potential difficulties in creating a stormwater utility, we also recommend that future researchers look into additional dedicated sources of funding.

6.0 CONCLUSION

Throughout the course of our project, our team worked collaboratively with the Massachusetts Department of Environmental Protection (MassDEP) and Central Massachusetts Regional Stormwater Coalition (CMRSWC) in order to improve four municipalities' compliance with the upcoming 2013 New Hampshire (NH) Municipal Separate Storm Sewer System (MS4) draft permit. By helping these municipalities improve their compliance with the MS4 permit, the amount of pollution contained in stormwater runoff flowing through the communities will be reduced. Stormwater pollution is a major contributor to the degradation of freshwater resources. Since fresh water is both a scarce resource and necessary for human survival, the reduction of stormwater pollution is an important goal. By reducing stormwater pollution, a direct impact will be made on the quality and usability of limited freshwater resources.

A significant portion of the data we collected came from interviewing MassDEP employees, municipal employees, and environmental consultants. Through these interviews, we learned that although municipal employees do want to reduce stormwater runoff and comply with the MS4 permit, municipalities often face significant obstacles in doing so. These obstacles to compliance include a lack of funding, time, and manpower, and unclear specifications in the permit.

During our project, we created a checklist and fact sheet for the 2013 NH MS4 draft permit requirements that will assist Central Massachusetts municipalities with compliance with the upcoming MS4 permit. By using this checklist and fact sheet, municipalities will be better able to keep track of which control measures they have complied with and which they still need to work on. This is especially useful to municipalities because the 2013 NH MS4 draft permit is detailed, lengthy, and at times confusing. Although we only worked with four municipalities, our checklist will be available to the other 26 Central Massachusetts municipalities who are members of the CMRSWC, and it may be made available to other Massachusetts municipalities.

We hope that by utilizing our fact sheet and checklist, and by following the recommendations laid out in Chapter 6, central Massachusetts municipalities, MassDEP, and the EPA can work together to reduce stormwater pollution and ultimately improve the quality of surface waterbodies in Massachusetts.

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APPENDICES

APPENDIX A: INTERVIEW QUESTIONS

Previous WPI Students Who Worked with MassDEP

- Could you describe what your typical daily tasks were?
- How are the municipalities reporting their annual data currently?
- What were the biggest reasons that municipalities were not complying with the MS4 (technical or financial)?
- What were some unexpected obstacles you faced along the way?
- Do you have any advice for us before we begin working with MassDEP?

MassDEP Employees

- What are the three municipalities we will be assisting?
- Why have these three municipalities been chosen?
- What concerns do municipalities have about compliance with the MS4 permit?

General Municipal Employees

- How long have you been working in this municipality? What are your primary responsibilities?
- How many outfalls and catch basins are there in your town? Have you finished mapping these?
- Which of the control measures do you feel your municipality focuses on the most currently?
- Which control measure has posed the biggest obstacle in meeting the 2003 MS4 permit requirements? Why? Do you have thoughts on how your municipality might overcome those obstacles?
- Which of the control measures do you think you would have to put the most work into in order to meet the 2013 NH MS4 draft permit requirements (if read)?
- Currently, how do you know if you are meeting the 2003 permit requirements? Do you have some sort of checklist?

- Would your town find a checklist of permit requirements helpful in keeping track of the town's progress in meeting the MS4 requirements? If so, what level of detail would you prefer to see?
- Do you think a checklist listing timeframes in sequential order would be more beneficial than ordering the requirements by control measure? Also, what sort of fields would you find beneficial in such a checklist?
- How many people does your town currently have working on stormwater issues, and how many do you anticipate needing in order to comply with the 2013 NH MS4 draft permit?
- What other stormwater documents (such as Notice of Intents (NOIs), outfall maps, etc.) do you have that help you track MS4 compliance besides the annual report?
- Have you experienced any unexpected events this year in regards to your stormwater management?
- Do you feel like the growth of the Central Massachusetts Regional Stormwater Coalition (CMRSWC) will make it more effective? What about in regards to IDDE?
- If we can put your name on our report as a reference?
- Have you taken a look at the 2013 New Hampshire draft permit fact sheet from EPA? If so, what are your comments? Do you feel the fact sheet is helpful?

Additional Questions for Bradford Stone, Stormwater Coordinator of Shrewsbury

- Is Shrewsbury still considering a stormwater utility? If so, how far along has the planning stage gotten?
- What consulting firm is Shrewsbury working with to develop the stormwater utility?
- Have you received any responses from the EPA in regards to the letters town employees have written? If so, what were they?
- Does the public have any opportunity to contribute to the Stormwater Management Program (SWMP) or help with cleanups, etc?
- Has Shrewsbury accomplished the following tasks (Questions are according to the 2013 annual report):
 - Industrial educational messages comply with 2003 permit? What about illegal dumping/illicit discharges?
 - Maintenance activities for parks and open space?

- IDDE plan?
- Does Shrewsbury has a develop plan to comply with Public Education measure of the 2013 permit?
 - Do you think it will be more difficult to comply with the public education control measure of 2013 NH MS4 draft permit? If does, Why?
- What do you think about the Zoho database?

Additional Questions for Brian Szczurko, DPW Engineering Assistant, Grafton

- Which departments work on stormwater or MS4-related tasks? What stormwater tasks do each of these departments work on?
- Do any employees perform water quality testing in any municipal department?
- Has Grafton used the Leica and the tablet for mapping? Do you have any feedback on either/both devices?
- Has Grafton been using the materials developed by the CMRSWC for IDDE (e.g.: Illicit Discharge Incident Tracking Sheet, etc.) to develop a systematic plan for identifying illicit discharges? If so, do you find these materials helpful? Why/why not?
- Has Grafton been using the educational materials?
- What do you think about the coalition training workshop on November 20, 2013?
- What do you think about the utility of the CMRSWC ?
- How many people does your town currently have working on stormwater issues, and how many do you anticipate needing in order to comply with the 2013 draft?
- Are you familiar with a stormwater utility program? If so, has your town considered developing a stormwater utility program?

Additional Questions for Aubrey Strause, the Owner and Manager of Verdant Water

- Does Upton collaborate with local groups on public education? Does it have public education aimed at industrial groups (anything about illegal dumping)?
- Does Upton have an IDDE plan?
- Does Upton have inspection procedures for their stormwater structures in place?
- Does Upton have maintenance activities for parks and open space?

- What do you think the benefits and drawbacks of a municipality being in the CMSWC are?

APPENDIX B: SPREADSHEET OF MUNICIPAL COMPLIANCE WITH THE 2003 MS4 PERMIT

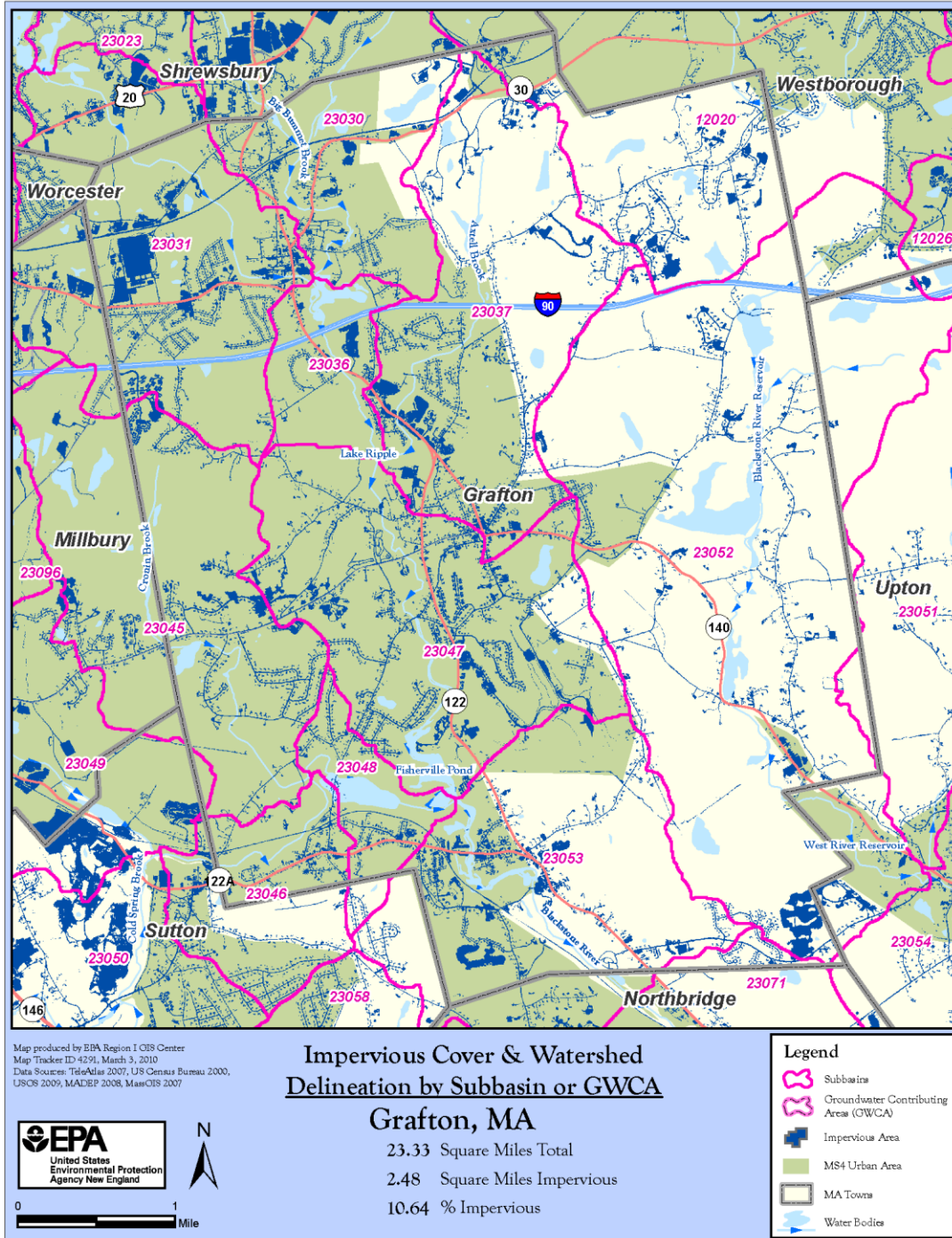
Control Measure	Sub-Control Measure	Grafton	Leicester	Shrewsbury	Upton
1. Public Education		+	+	+	+
	Identify the person/department responsible for the measure	+	+	+	+
	Identify all BMPs for the measure	+	+	+	+
	Identify measurable goals for each BMP	+	+	+	+
	Identify time lines and milestones for implementation	+	+	+	+
	Info about industrial AND residential activities, including illegal dumping	+	+	+	+
	Coordination with local groups	+	+	+	+
2. Public Involvement		+	+	+	+
	Identify the person/department responsible for the measure	+	+	+	+
	Identify all BMPs for the measure	+	+	+	+
	Identify measurable goals for each BMP	+	+	+	+
	Identify time lines and milestones for implementation	+	+	+	+
	Provide an opportunity for the public to participate in the implementation/review of the SWMP	+	+	+	+
3. IDDE		-	-	+	-
	Identify the person/department responsible for the measure	+	+	+	+
	Identify all BMPs for the measure	+	+	+	+
	Identify measurable goals for each BMP	+	+	+	+
	Identify time lines and milestones for implementation	+	+	+	+
	Storm sewer system map (outfalls, names of all waters that receive discharges from those outfalls)	-	+	+	-
	Ordinance or regulatory mechanism to prohibit illicit	+	-	+	+

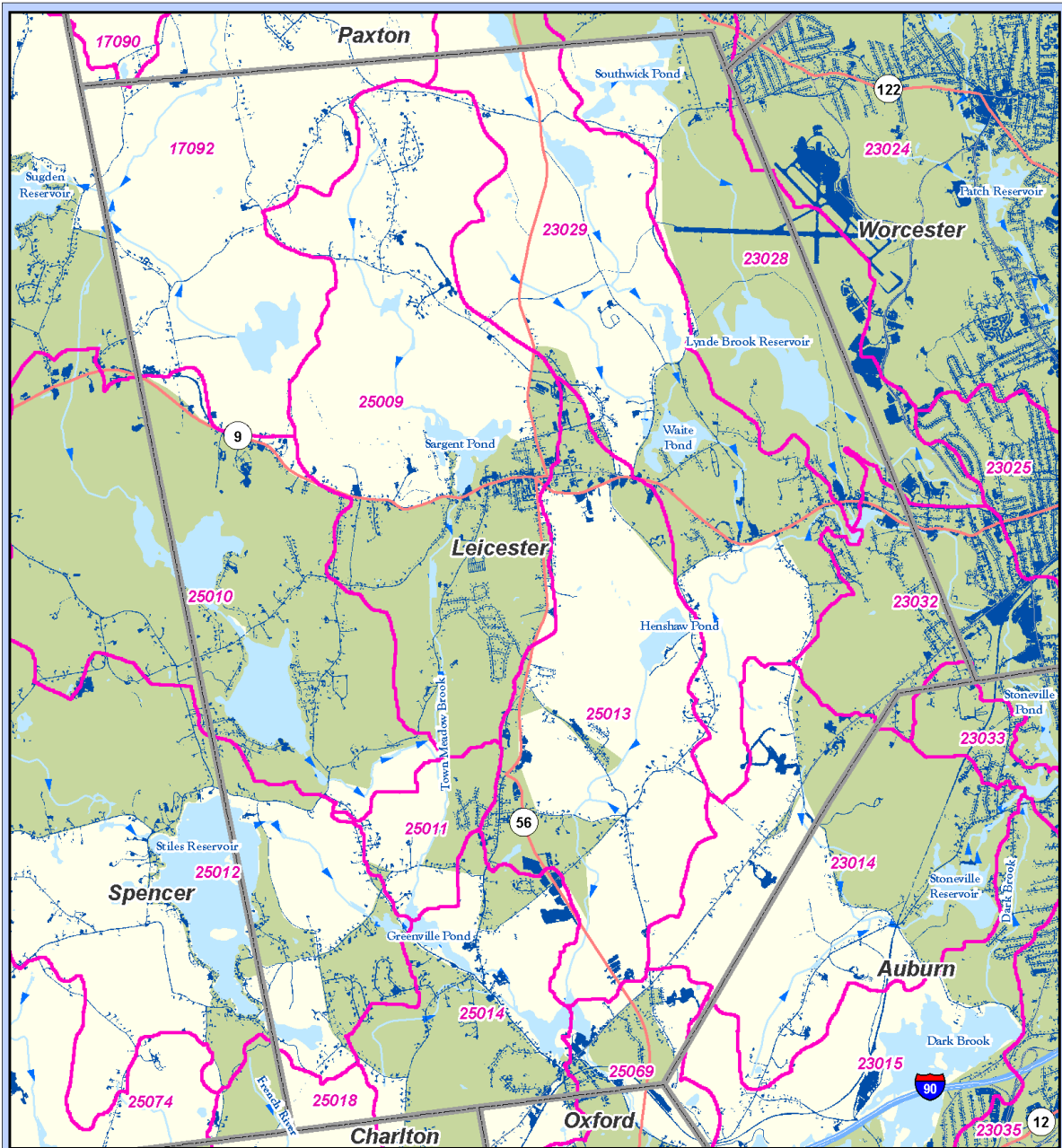
	discharges				
	Development of an illicit discharge plan (procedures to identify priority areas, procedures for eliminating illicit discharges, procedures for locating the source of the discharge & removing the source, procedures for documenting actions & evaluating impacts)	-	-	+	-
	Inform public employees/businesses/general public of hazards associated with illicit discharges	+	+	+	+
4. Construction Site Storm Water Runoff Control		+	+	+	+
	Identify the person/department responsible for the measure	+	+	+	+
	Identify all BMPs for the measure	+	+	+	+
	Identify measurable goals for each BMP	+	+	+	+
	Identify time lines and milestones for implementation	+	+	+	+
	Ordinance or regulatory mechanism to require control of erosion & sediment at construction sites	+	+	+	+
	Sanctions as part of the ordinance	+	+	+	+
	Require construction site operators to implement sediment & erosion control BMPs at construction sites	+	+	+	+
	Control of wastes like litter, concrete truck wash out	+	+	+	+
	Site plan review	+	+	+	+
	Incorporate consideration of info submitted by public	+	+	+	+
	Procedures for inspections and enforcement of control measures at construction sites	+	+	+	+
5. Post Construction Storm Water Management in		+	+	+	+

New Development and Redevelopment					
	Identify the person/department responsible for the measure	+	+	+	+
	Identify all BMPs for the measure	+	+	+	+
	Identify measurable goals for each BMP	+	+	+	+
	Identify time lines and milestones for implementation	+	+	+	+
	Develop, implement and enforce a program addressing stormwater runoff from new/redevelopment projects disturbing 1+ acres	+	+	+	+
	Procedures to ensure adequate long-term operation and maintenance of BMPs	+	+	+	+
	Procedure to ensure that the controls put in place will prevent/minimize impacts to water quality	+	+	+	+
6. Pollution Prevention and Good Housekeeping in Municipal Operations		+	+	-	-
	Identify the person/department responsible for the measure	+	+	+	+
	Identify all BMPs for the measure	+	+	+	+
	Identify measurable goals for each BMP	+	+	+	+
	Identify time lines and milestones for implementation	+	+	+	+
	Develop and implement a program with a goal of preventing and/or reducing pollutant runoff (must include an employee training component).	+	+	+	+
	Maintenance activities for parks and open spaces; fleet maintenance, building maintenance; new construction and land disturbance; and road way drainage system maintenance	+	+	-	-

	and storm water system maintenance				
	Develop schedule for maintenance activities described above	+	+	-	-
	Inspection procedures and schedules for long term structural controls	+	+	+	-

APPENDIX C: MAPS OF IMPERVIOUS AREA IN GRAFTON, LEICESTER, SHREWSBURY, AND UPTON, MASSACHUSETTS





Map produced by EPA Region I OIS Center
 Map Tracker ID 4291, March 3, 2010
 Data Sources: TeleAtlas 2007, US Census Bureau 2000,
 USCR 2009, MADEP 2008, MassGIS 2007

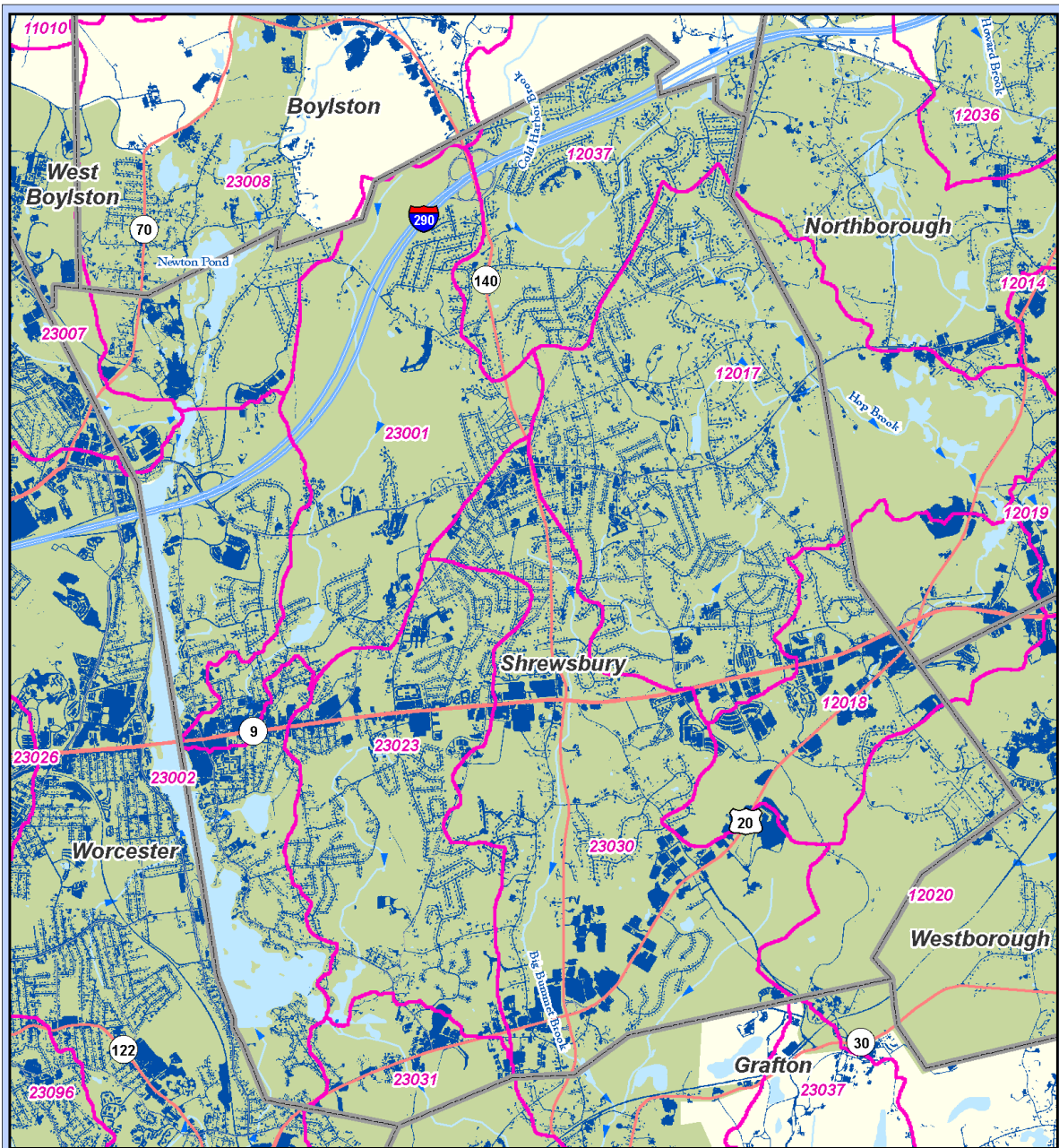
Impervious Cover & Watershed Delineation by Subbasin or GWCA

Leicester, MA

24.64 Square Miles Total
 1.41 Square Miles Impervious
 5.73 % Impervious



Legend	
	Subbasins
	Groundwater Contributing Areas (GWCA)
	Impervious Area
	MS4 Urban Area
	MA Towns
	Water Bodies



Map produced by EPA Region I OIS Center
 Map Tracker ID 4291, March 3, 2010
 Data Sources: TeleAtlas 2007, US Census Bureau 2000,
 USCR 2009, MADEP 2008, MassGIS 2007

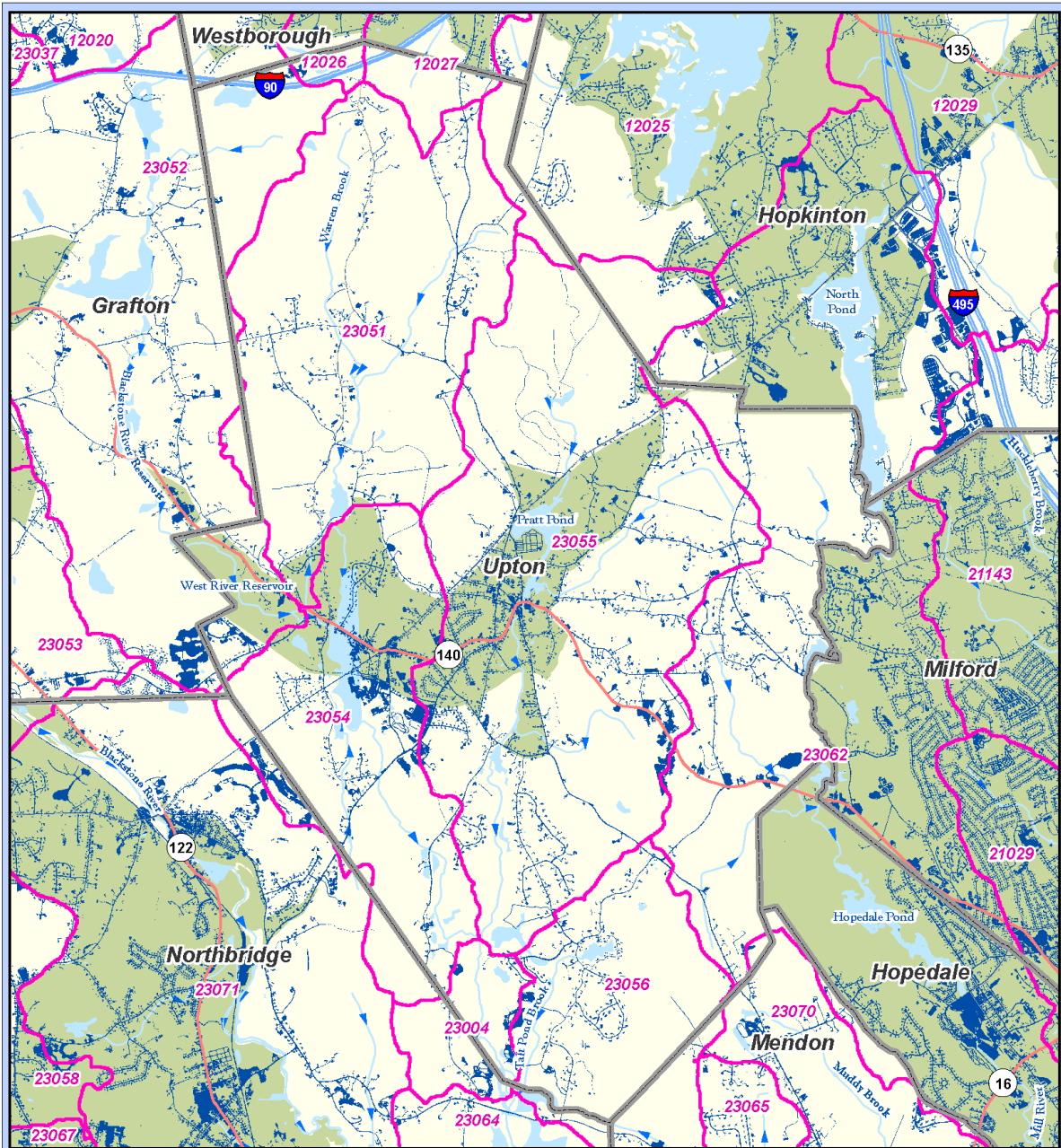
Impervious Cover & Watershed Delineation by Subbasin or GWCA

Shrewsbury, MA

21.73 Square Miles Total
 4.02 Square Miles Impervious
 18.48 % Impervious



Legend	
	Subbasins
	Groundwater Contributing Areas (GWCA)
	Impervious Area
	MS4 Urban Area
	MA Towns
	Water Bodies



Map produced by EPA Region I OIS Center
 Map Tracker ID 4291, March 3, 2010
 Data Sources: TeleAtlas 2007, US Census Bureau 2000,
 USCR 2009, MADEP 2008, MassGIS 2007

Impervious Cover & Watershed Delineation by Subbasin or GWCA

Upton, MA

21.8 Square Miles Total
 1.42 Square Miles Impervious
 6.5 % Impervious



Legend	
	Subbasins
	Groundwater Contributing Areas (GWCA)
	Impervious Area
	MS4 Urban Area
	MA Towns
	Water Bodies

APPENDIX D: CHECKLIST OF THE 2013 NH MS4 DRAFT PERMIT REQUIREMENTS

2013 New Hampshire MS4 Draft Permit Requirement Checklist

This document is for guidance only. It has no regulatory significance and does NOT specify all the details of the requirements of the 2013 New Hampshire MS4 draft permit. For more in-depth guidance, please see the attached fact sheet. For a complete description of all requirements, please see the 2013 New Hampshire MS4 draft permit.

** = MUST be included in annual report.*

Annually:

Public Education:

*Educational messages:

*Noted method of distribution

*Assessed effectiveness of messages

*Assessed overall educational program

Public Involvement:

*Provided opportunities for public to participate in review and implementation of
SWMP

IDDE:

*Noted the progress towards completion of the MS4 map

*SSO Inventory

*Outfall and Interconnection Inventory

*System Vulnerability Factors for each catchment

*Progress of Catchment Investigation Procedure

*Noted the manhole inspections conducted within the current year

*Information on removed illicit discharges or SSOs

*Noted overall progress on IDDE program

Noted all data on the results from dry and wet weather screening of
outfalls and interconnections

*Assessed the effectiveness of IDDE program

*Employee training for IDDE

Construction:

*Noted the number of site reviews, inspections, and enforcement actions

Post-Construction:

*Procedures for the submission of as-built drawings and assurance of long-term operation and maintenance of stormwater management practices

Housekeeping:

*Noted the total number of catch basins, number of catch basins inspected, number of catch basins cleaned, and the volume or mass removed from cleaned catch basins

*Noted the status of the inventory of O&M facilities

*Noted the number of miles of streets cleaned and volume or mass of material removed

Inspected all stormwater treatment structures

*Noted the progress towards completion of the Operations and Maintenance programs

*Completed maintenance activities associated with Operations and Maintenance programs

120 Days:

IDDE:

*Inventory of all SSOs discharged within previous 5 years

6 Months:

Housekeeping:

*Inventory of parks and open spaces, buildings/facilities exposed to stormwater runoff, and permittee-owned vehicles and equipment

Year 1:

SWMP:

Written SWMP

Discharges to Impaired Waterbodies without an Approved TMDL:

- *Assessed whether MS4 discharges are potential contributors to the impairment
- *Developed a written WQRP
 - *Identified and evaluated sources of pollutant of concern in the MS4 area draining to the impaired waters
 - *Determined additional BMPs for addressing pollutant of concern
 - *Created schedule for implementing additional BMPs
 - *Described method of assessing effectiveness of the WQRP

IDDE:

- *Outfall and Interconnection Inventory
- Written IDDE Program
- *Priority ranking of catchments

Construction:

- Written procedures for site inspections
- Written procedures for site plan review

Post-Construction:

- *Noted annual increase/decrease in acres of impervious area and directly connected impervious area

Housekeeping:

- Written Operations and Maintenance procedures
- Written program detailing activities and procedures for MS4 maintenance
- Developed plans for optimization of catch basin cleaning
- Developed plans for catch basin inspections
- Developed a schedule for gathering information used to develop the optimization plan for catch basin cleaning
- *Developed an inspection, documentation, and sweeping plan for uncurbed, limited access highways

15 Months:

IDDE:

- Begin investigations using the procedure developed in accordance with Outfall

and Interconnection Screening and Sampling

Year 2:

- Discharges to Impaired Waterbodies without an Approved TMDL:**
 - (If Implementation of BMPs for WQRP is infeasible in 3 years) - Have a schedule for completion of BMPs within 5 years
- IDDE:**
 - Completed the updated map of the MS4
- Post-Construction:**
 - Bylaw/Ordinance that addresses post-construction site stormwater runoff
 - *Report assessing current street design and parking lot guidelines (including local requirements) that affect the creation of impervious cover
 - *Inventory and priority ranking of permittee-owned property and existing infrastructure with the potential of BMP retrofitting
 - *For each sub-basin: estimation of the number of acres of impervious area and directly connected impervious area draining to the MS4 added/removed within the previous year
- Housekeeping:**
 - Development and implementation of a written Stormwater Pollution Prevention Plan (SWPPP)

Year 3:

- Discharges to Impaired Waterbodies without an Approved TMDL:**
 - Implemented BMPs from WQRP (unless infeasible)
 - *Final Source Identification and Assessment Report
- IDDE:**
 - Completion of dry weather screening and sampling of every outfall and interconnection
 - Completed the Catchment Investigation Procedure for 80% of all problem catchments
- Post-Construction:**

- *Report assessing local regulations to determine the feasibility of implementation of green infrastructures
- *For each sub-basin: estimation of the number of acres of impervious area and directly connected impervious area draining to the MS4 added/removed within the previous year
- *Inventory of permittee-owned properties that have been retrofitted with BMPs to mitigate impervious area and directly connected impervious area

Year 4:

- Discharges to Impaired Waterbodies Without a TMDL:**
 - Reassessed BMPs' effectiveness
 - Provided a schedule for implementation of additional BMPs
 - *Reviewed sources of pollutant of concern in the MS4 area draining to the impaired waters
 - *Developed an additional WQRP for discharges determined to be a potential contributor to the impairment
- Post-Construction:**
 - *For each sub-basin: estimation of the number of acres of impervious area and directly connected impervious area draining to the MS4 added/removed within the previous year
 - *Inventory of permittee-owned properties that have been retrofitted with BMPs to mitigate impervious area and directly connected impervious area

Year 5:

- Discharges to Impaired Waterbodies without an Approved TMDL:**
 - Identified prospective BMPs (if further reductions are necessary)
 - Implementation of BMPs for WQRP (if infeasible in 3 years)
 - *Listing of prospective BMPs and schedule for implementation
- Public Education:**
 - 2 educational messages sent to each of the following:
 - Residents

- Businesses/Institutions/Commercial Facilities
- Developers
- Industrial Facilities

IDDE:

- Completed Catchment Investigation Procedure on 100% of Problem Catchments
- Completed Catchment Investigation Procedure on 40% of all catchments
- Completed Catchment Investigation Procedure on every catchment that has indications of sewer input

Post-Construction:

- *For each sub-basin: estimation of the number of acres of impervious area and directly connected impervious area draining to the MS4 added/removed within the previous year
- *Inventory of permittee-owned properties that have been retrofitted with BMPs to mitigate impervious area and directly connected impervious area

Year 10:

IDDE:

- Completed Catchment Investigation Procedure on 100% of all catchments

Extended Timelines for New Permittees

- Timelines for Public Education: Extended by 1 year
- Outfall inventory: Completed within 2 years
- Outfall mapping: Completed within 4 years
- All other IDDE requirements: Extended by 2 years
- Ordinances/bylaws: Completed within 3 years
- Timelines for discharges to TMDLs: Extended by 2 years

APPENDIX E: FACT SHEET FOR THE 2013 NH MS4 DRAFT PERMIT

2013 New Hampshire MS4 Draft Permit Requirement Fact Sheet

This document is for guidance only. It has no regulatory significance and does NOT specify all the details of the requirements of the 2013 New Hampshire MS4 draft permit. For a complete description of all requirements, please see the 2013 New Hampshire MS4 draft permit.

The hyperlinks in this fact sheet link to pages either on the USEPA's website or the corresponding page of the 2013 NH MS4 draft permit.

Allowable Non-Stormwater Discharges:

For more clarity on allowable non-stormwater discharges, click [here](#).

1. Water line flushing
2. Landscape irrigation
3. Diverted stream flows
4. Rising groundwater
5. Uncontaminated groundwater infiltration
6. Uncontaminated pumped groundwater
7. Discharge from potable water sources
8. Foundation drains
9. Air conditioning condensation
10. Irrigation water, springs
11. Water from crawl space pumps
12. Footing drains
13. Lawn watering
14. Individual residential car washing
15. Flows from riparian habitats or wetlands
16. Dechlorinated swimming pool discharges
17. Street wash waters
18. Residential building wash waters without detergents

Stormwater Management Plan (SWMP)

For more information on the SWMP, click [here](#).

A SWMP must be developed, implemented, and enforced. A written SWMP is due within 1 year of the permit effective date. The written SWMP describes implementation measures for meeting the MS4 requirements. The written SWMP must be available at the office of the person listed as the program contact and must contain each of the following:

1. Names and titles of responsible persons for the program's implementation
2. Lists of: 1) receiving waterbodies of the MS4, 2) public drinking water sources that may be impacted by MS4 discharges, and 3) all interconnected MS4s and other separate storm sewer systems receiving a discharge from the permitted MS4. For each of the above, the SWMP must also include:
 - a. Classification under applicable state water quality standards
 - b. Impairments and/or pollutants of concern
 - c. Applicable TMDLs and WLAs
 - d. Number of outfalls that discharge into the waterbody

3. Map of the MS4
4. List of all illicit discharges identified and a description of the response
5. A description of practices to achieve the TMDL requirements, Water Quality Response Plans (WQRPs) (also needed for each BMP), and a description of practices to achieve compliance with each of the 6 control measures. Each requires documentation of:
 - a. Person/department responsible for the measure
 - b. BMPs for the control measure or permit requirement
 - c. Measurable goals for each BMP including milestones and timeframes
6. Description of measures to avoid/reduce impacts to public and known private drinking water sources
7. An annual program evaluation

Water Quality Standards

For more information on meeting water quality standards, click [here](#).

For each waterbody receiving a discharge from the MS4, permittees must consult the water quality standards applicable to that waterbody. A link to a database of water quality standards can be found [here](#).

Water Quality Response Plan (WQRP)

For more information on the WQRP, click [here](#).

If the USEPA determines a discharge from the MS4 is impairing waters, permittees have 60 days to eliminate the discharge. If elimination within 60 days is infeasible, permittees must develop a WQRP. If so, then the annual report must include:

1. A listing of discharges during the reporting period
2. A description of the measures taken to eliminate the discharge
3. A description of the WQRP

Permittees must identify in the Stormwater Management Plan (SWMP) and every annual report all known discharges (including outfalls and interconnections) to other separate storm sewer systems that are subject to approval of Total Maximum Daily Loads (TMDLs).

Waterbodies without an Approved TMDL

For more information on discharges to waterbodies without an approved TMDL, refer to the permit [here](#).

If a discharge to a non-TMDL waterbody is found (besides chloride impaired waterbodies) permittees must address in the SWMP and annual report how the discharge will be controlled. If such a discharge is detected, the following steps must be taken:

Phase 1 (completed within 1 year of effective permit date):

1. **Preliminary evaluation of discharges to impaired waters.** Within 1 year of the permit effective date, permittees must evaluate all discharges to impaired waters in order to:
 - Assess whether the MS4 discharge(s) is/are potential contributors to the identified impairments.
 - Identify sources of pollutants of concerns in the MS4 area draining to the

impaired waters.

In addition, permittees must reassess the plan of action over the course of the permit term and assess the following categories:

1. Fertilizer use (nutrient and bacteria impairments)
2. Illicit discharges (nutrient and bacteria impairments)
3. Leaf litter (nutrient impairments)
4. Pet waste (nutrient and bacteria impairments)
5. Industrial areas (metal impairments)
6. Construction (total suspended solids (TSS)/solids and turbidity impairments)
7. Highly impervious area - nutrient, metal, bacteria, and TSS impairments

If permittees cannot find the contributors within 1 year, then they must report the reasoning for that conclusion in the annual report. In addition, permittees must include the following water quality response plan (WQRP) in the SWMP.

2. Water Quality Response Plan (WQRP)

For more information on the WQRP, refer to the permit [here](#).

Within 1 year of the permit effective date, permittees must develop a WQRP that identifies BMPs to be implemented to ensure the discharges do not add to the impairment. The WQRP must contain the following elements:

- a. Preliminary source assessment (a list of receiving water segments, impairments, and pollutants of concern).
- b. A comprehensive listing of BMPs to address pollutants causing impairments. The following are suggested types of BMPs to implement:
 - i. Additional/modified public education programs
 - ii. Increasing the priority of catchments discharging to the impaired water
 - iii. Stricter development/redevelopment requirements
 - iv. Revision of Good Housekeeping/Pollution Prevention procedures, which may include:
 1. Increased catch basin cleaning
 2. Increased street sweeping
 3. Reduced fertilizer use
 4. Leaf litter collection programs
 - v. Implementation of programs leading to disconnection of directly connected impervious area (DCIA) on municipal and/or private property. These programs may include:
 1. Downspout disconnection programs
 2. Green roofs installation programs
 3. Residential rain garden programs
 4. Programs targeting the removal of unnecessary impervious area
 - vi. Structural BMP retrofits

3. Schedule of Implementation of BMPs

Includes (as appropriate): funding, training, purchasing, construction, monitoring, and other assessment and evaluation components. Development of these planned BMPs must begin no later than 18 months from the effective permit date and complete implementation must be completed no later than 3 years from the effective permit date.

Phase 2 (completed within 3 years of effective permit date):

1. **Implementation of planned BMPs.**
2. **Final Source Identification and Assessment.** Within 3 years of the permit effective date, permittees must complete a final Source Identification and Assessment report to be submitted with the year 3 annual report. This document must include:
 - a. Specific receiving water segments, impairments, and pollutants of concern
 - b. Calculation of total MS4 area draining to the impaired receiving waterbodies
 - c. All screening and monitoring results from the waterbodies
 - d. Impervious area and DCIA for the target catchment (where available)
 - e. Updated pollutant source categories and their physical location

Phase 3 (completed within 5 years of effective permit date):

1. **Reassessment of planned BMPs.** Within 4 years of the permit effective date, permittees must reassess the implemented BMPs to determine whether any additions and/or modifications need to be made in order to reduce impairments to waterbodies within the MS4. If so, then permittees must revised the BMPs as appropriate, provide a new schedule for implementation, and implement them to that schedule. Permittees must document its reassessment in the year 4 annual report.
2. **Prospective BMPs.** Within 5 years of the permit effective date, permittees must identify prospective BMPs if any further pollutant reductions are necessary and evaluate properties that present the opportunity for retrofitting within the drainage area of the impaired water. This evaluation must be submitted with the year 5 annual report and must include:
 - a. Identification of potential redevelopment or retrofit BMPs that would reduce pollutants of concern
 - b. The next planned infrastructure, resurfacing, or redevelopment activity planned for that area
 - c. The estimated cost of redevelopment or retrofit BMPs
 - d. The engineering and regulatory feasibility of redevelopment or retrofit BMPs

Control Measures

1. Public Education/Outreach

For more information on the Public Education control measure, refer to the permit [here](#). The program must include educational goals based on significant stormwater issues related to impaired and TMDL waters receiving discharge from the MS4. During the permit term, at least 2 educational messages must be sent to each audience listed below.

Target audiences:

- a. Residents
- b. Businesses, Institutions (Private colleges, private schools, hospitals), Commercial Facilities
- c. Developers (Construction)
- d. Industrial Facilities

The distribution of materials to each audience must be separated by 1 year. Educational materials may be any of the following:

- Brochures or newsletters
- Electronic materials (Websites)
- Mass media (Newspaper articles or public service announcements)
- Public displays (In public areas such as town/city hall)

Some educational materials provided by the EPA are available here:

<http://cfpub.epa.gov/npstbx/index.html>

Permittees must also document the following in each annual report:

- a. Method of distribution
- b. Measures/methods to assess effectiveness of messages
- c. Measures/methods to assess overall education program

Some of the programs for consideration are:

a. Residential program:

For more information on the residential program, refer to the permit [here](#).

- i. Effects of outdoor activities/proper lawn maintenance (pesticides, herbicides, fertilizers) on water quality
- ii. Benefits of on-site infiltration of stormwater
- iii. Effects of automotive work and car washing on water quality
- iv. Proper disposal of swimming pool water
- v. Proper management of pet waste
- vi. Maintenance of septic systems

Note: If the MS4 area has more than 30% of its residents serviced by septic systems, permittees must include maintenance of septic systems in its educational program.

b. Business/Commercial/Institution program:

For more information on the business/commercial/institution program, refer to the permit [here](#).

- i. Proper lawn maintenance
- ii. Benefits of on-site infiltration of stormwater
- iii. Building maintenance (use of detergents)
- iv. Use of salt or other deicing and anti-icing materials
- v. Proper storage of materials
- vi. Proper management of waste materials and dumpsters
- vii. Proper management of parking lot surfaces
- viii. Proper car care activities
- ix. Proper disposal of swimming pool water

c. Developers and construction:

For more information on the developers and construction, refer to the permit [here](#).

- i. Proper sediment and erosion control management practices
- ii. Information about Low Impact Development (LID) principles and technologies
- iii. Information about EPA's construction general permit (CGP) (can also be part of Construction Site Stormwater Runoff control measure)

d. Industrial program:

For more information on the industrial program, refer to the permit [here](#).

- i. Equipment inspection and maintenance
- ii. Proper storage of industrial materials
- iii. Proper management and disposal of wastes
- iv. Proper management of dumpsters
- v. Minimization and proper use of use of salt or other de-icing materials
- vi. Benefits of on-site infiltration of stormwater runoff from areas with low exposure to industrial materials (such as roofs or employee parking)
- vii. Proper maintenance of parking lot surfaces
- viii. Requirements for coverage under EPA's Multi-Sector General Permit.

2. Public Involvement/Participation

For more information on the Public Involvement control measure, refer to the permit [here](#).

- a. Permittees must provide the public opportunities to participate in the review AND implementation of the Stormwater Management Program (SWMP) annually.
- b. All activities must be compliant with state public notice requirements.
- c. The SWMP and all annual reports must be made available to the public.

3. Illicit Discharge Detection and Elimination (IDDE)

For general information on the IDDE control measure, refer to the permit [here](#).

- a. Permittees must prohibit Sanitary Sewer Overflows (SSOs) and require removal of such discharges. All illicit discharges to the MS4 must be removed unless allowed under a separate NPDES permit.
- b. When an illicit discharge is discovered, permittees must notify all responsible authorities responsible and eliminate it as quickly as possible (within 30 days, if feasible). If removal within 30 days is infeasible, permittees must create a schedule for the elimination of the illicit discharge(s).
- c. Within 120 days of the permit effective date, permittees must document (in an inventory) all SSOs discharged to the MS4 within the previous 5 years. The inventory must be maintained as part of the SWMP annually and included in each annual report. This inventory must include the following for each SSO:
 - i. Location (approx. street address and receiving water, if applicable).
 - ii. A statement declaring whether the discharge entered any waterbodies or the MS4 directly.
 - iii. Date and time (beginning and end times of discharge if possible)
 - iv. Estimated volume of occurrence
 - v. Description of SSO including possible causes
 - vi. Mitigation and corrective measures completed with dates implemented
 - vii. Mitigation and corrective measures planned with implementation schedules.
- d. Upon awareness of an SSO discharge to the MS4, permittees must orally notify the USEPA within 24 hours. Additionally, permittees must provide written notice to the USEPA and MassDEP within 5 days of the discharge.
- e. Permittees must include a map of the MS4 and report its progress annually in the annual report. Required mapping elements are:
 - i. Outfalls and receiving waters
 - ii. Pipes
 - iii. Open channel conveyances
 - iv. Catch basins
 - v. Manholes
 - vi. Interconnections with other MS4s
 - vii. Municipality owned stormwater treatment structures
 - viii. Catchment delineations
 - ix. Waterbodies (identified by name and use of all impairments)
- f. Permittees must include the following elements on the map if available:
 - i. Municipal sanitary sewer system
 - ii. Municipal combined sewer system
- g. Permittees must include an outfall and interconnection inventory to be completed within the 1st year of the permit and updated annually. The inventory should include the following information on each outfall and interconnection:
 - i. Unique identifier
 - ii. Receiving water
 - iii. Date of most recent inspection

- iv. Dimensions
 - v. Shape
 - vi. Material (concrete, PVC)
 - vii. Spatial location (latitude and longitude)
 - viii. Physical condition and indicators of potential non-stormwater discharges (odor, color, turbidity, floatables, oil sheen)
- h. IDDE Program
- For more information on the specific IDDE Program, refer to the permit [here](#). The written IDDE program must be completed within year 1 of the permit, updated annually, and provide the following information:
- i. Legal Authority: Demonstrates that permittees have legal authority to:
 - 1. Prohibit illicit discharges
 - 2. Investigate suspected illicit discharges
 - 3. Eliminate illicit discharges
 - 4. Implement enforcement procedures and actions
 - ii. Statement of IDDE program responsibilities: Written statement identifying responsibilities with regards to eliminating illicit discharges.
 - iii. Assessment and priority ranking of catchments: Classify each catchment into one of the following categories:
 - 1. Excluded catchments (roadway drainage in undeveloped areas with no sanitary sewers, drainage for athletic fields, parks or undeveloped green space)
 - 2. Problem catchments (known or suspected contributions of illicit discharges)
 - 3. High Priority catchments (discharging to areas of concern to public health due to proximity of public water areas)
 - 4. Low Priority catchments
 - iv. Outfall and interconnection screening and sampling: Written procedures for screening and sampling outfalls and interconnections in dry and wet weather. Must include procedures for sample collection, use of field kits, and storage and conveyance samples.
 - Dry weather:* To be completed only when less than 0.1 inches of rainfall has occurred within the past 24-hours.
 - Wet weather:* To be completed during or after a storm during the months of March-June.

Samples must be analyzed for:

 - 1. Ammonia (less than or 0.5 mg/L)
 - 2. Chlorine
 - 3. Conductivity
 - 4. Salinity
 - 5. E.Coli
 - 6. Surfactants (less than 0.25 mg/L)
 - 7. Temperature

Indicators of High Priority Catchments are relevant information indicating an illicit discharge or the following sampling results:

- Ammonia ≥ 0.5 mg/L
 - Surfactants ≥ 0.25 mg/L
 - Bacteria levels exceed water quality criteria applicable to the receiving water OR
 - Detectable levels of chlorine are present
- v. Catchment Investigation Procedure:
For more information on the catchment investigation procedure, refer to the permit [here](#).
1. Review of mapping and historic plans and records for each catchment: Permittees must identify and record the presence of any of the following System Vulnerability Factors in each annual report:
 - a. History of SSOs
 - b. Sewer pump/lift stations, siphons, or other known mechanisms where power/equipment failures could result in SSOs
 - c. Inadequate sanitary sewer level of service (LOS)
 - d. Common or twin-invert manholes serving storm and sanitary sewer alignments
 - e. Common trench construction serving both storm and sanitary sewer alignments
 - f. Crossings of storm and sanitary sewer alignments
 - g. Sanitary sewer alignments known or suspected to have been built with an underdrain system
 - h. Sanitary sewer infrastructure defects
 - i. Areas formerly served by combined sewer systems
 - j. Any sanitary sewer and storm drain infrastructure greater than 40 years old in medium to densely developed areas
 - k. Code-required septic system upgrades
 - l. History of multiple Board of Health actions addressing septic system failures
 2. Manhole inspection methodology: Permittees must develop a storm drain network investigation procedure for observing, sampling, and evaluating key junction manholes for suspected illicit discharges and SSOs. The inspection methodology typically starts from the outfall and works up the system, but may start from the catchment and work down the system. All inspections must be reported in each annual report.
 - Dry weather investigation: Key junction manholes must be opened and inspected for visual and olfactory evidence of an illicit discharge. If there is a flow, then the manhole must at least be inspected for ammonia, chlorine, and surfactants. If a potential illicit discharge or SSO is determined, then the area draining to the manhole must be flagged for further investigation.

- Wet weather investigation: If a catchment is determined to have one of the System Vulnerability Factors listed above, then permittees must also inspect and sample under wet weather. This should determine whether wet weather induced flows result in SSOs and/or illicit discharges to the MS4.
- 3. Procedures to identify illicit discharge sources: Permittees must develop procedures to isolate and confirm sources where manhole investigations or other screening evidence has caused SSOs and/or shown illicit discharges to the MS4. These procedures must include the following:
 - a. Isolation of drainage area for investigation
 - b. Inspection of additional manholes
 - c. Methods to isolate and confirm sources (caulk dams, targeted internal plumbing inspections, dye testing, video inspections, or smoke testing)
- vi. Removal and confirmation: Permittees must remove any illicit discharges or SSOs where the source has been confirmed. For each confirmed source, permittees must include the following in each annual report:
 1. Location of discharge and source
 2. Description of discharge
 3. Method of discovery
 4. Date of discovery
 5. Date of elimination
 6. Mitigation or enforcement action
 7. Estimation of volume of flow removed

Within 1 year of removal, permittees must conduct confirmatory or outfall screening in dry weather, unless one of the System Vulnerability Factors is present.

Note: Confirmatory screening is not required in catchments with no previous illicit discharges and none of the System Vulnerability Factors present.

- vii. Follow-up screening: Permittees must screen any catchments, outfalls, or interconnections known to have created an illicit discharge or SSO within 5 years for follow-up. The follow-up screening should be dry weather unless the initial screening was done in wet weather.

Note: Depending on the priority of a catchment, follow-up screening may need to be performed sooner.

- viii. Illicit Discharge Prevention Procedures: Permittees must develop and implement mechanisms and procedures designed to prevent illicit discharges and SSOs, such as:
 - 1. Spill response and prevention procedures (including identification of spills)
 - 2. Reporting procedures
 - 3. Containment procedures
 - 4. Documentation
 - 5. Public awareness (may be part of Public Education)
 - 6. Reporting (hotlines)
 - 7. Training of public employees involved in the IDDE program on ways to identify illicit discharges and SSOs
- i. IDDE Program Implementation Goals and Milestones:

For more information on the IDDE Program Implementation Goals and Milestones, refer to the permit [here](#).

Permittees must implement the IDDE Program to meet the following goals and milestones:

- i. Permittees must complete dry weather screening and sampling of every MS4 outfall and interconnection (except Excluded and Problem Catchments) no later than 3 years from the permit effective date. All data from these findings must be included in each annual report.
- ii. Permittees must begin investigations using the procedure developed in accordance with Outfall and Interconnection Screening and Sampling within 3 months of investigation procedure finalization and no later than 15 months (1 year and 3 months) from the permit effective date.
- iii. Permittees must implement the Catchment Investigation Procedure in every catchment as described above. Permittees must complete 80% of the Problem Catchments served by the MS4 within 3 years of the permit effective date, and 100% of the Problem Catchments within 5 years of the permit effective date. Permittees must also complete 40% of all catchments within 5 years of the permit effective date and 100% of all catchments within 10 years of the permit effective date.
- iv. If a catchment does not contain a junction manhole, dry weather sampling and screening is sufficient for meeting the manhole inspection requirement.
- v. Permittees must track goals and milestones in each annual report.

4. Construction Site Stormwater Runoff Control

For more information on the Construction control measure, refer to the permit [here](#). Permittees must implement a program to reduce stormwater pollution in any construction site ≥ 1 acre. Permittees must include construction sites ≤ 1 acre if the project is part of a plan for a land disturbance of 1 acre or greater. The program must include:

- a. Ordinance that requires the use of sediment and erosion control practices.
- b. Written procedures for site inspections and enforcement of sediment and erosion control measures. These written procedures must be completed within 1 year of the permit effective date, and must clearly identify responsible persons and authorities responsible for enforcement. These procedures must also be documented in the SWMP.
- c. Requirements for construction operators to implement a sediment and erosion control program. Some sediment and erosion control measures are:
 - i. Minimize the amount of disturbed area and protection of natural resources
 - ii. Stabilize sites when projects are complete or operations temporarily cease
 - iii. Protect slopes on construction sites
 - iv. Protect storm drain inlets and armor newly constructed outlets
 - v. Use perimeter controls at the site
 - vi. Stabilize construction site entrances and exits to prevent off-site tracking
 - vii. Inspect stormwater controls at consistent intervals
- d. Requirements to control wastes including:
 - i. Discarded building materials
 - ii. Concrete truck wash-out
 - iii. Chemicals
 - iv. Litter
 - v. Sanitary wastes
- e. Written procedures for site plan review. The procedure for review must be completed within 1 year of the permit effective date. Each site plan review must include:
 - i. A review by permittees of the site design
 - ii. Planned operations at the construction site
 - iii. Planned BMPs during construction
 - iv. Planned BMPs to be used to manage runoff created after development

The site plan review procedure must include procedures for:

- i. Consideration of potential water quality impacts
- ii. Pre-construction review
- iii. Receipt and consideration of information submitted by the public
- iv. Evaluation of opportunities for use of low impact design and green infrastructure

Permittees must include the number of site reviews, inspections, and enforcement actions in each annual report.

5. **Post-Construction Site Stormwater Runoff Control**

For more information on the Post-Construction control measure, refer to the permit [here](#).

Permittees must implement a program to reduce stormwater pollution in any new development/redevelopment sites ≥ 1 acre. Permittees must include

development/redevelopment sites \leq 1 acre if the project is part of a plan for a land disturbance of 1 acre or greater. The program must include:

- a. Ordinance that regulates runoff from new construction projects. The ordinance must be amended within the first 2 years of the permit.
- b. Procedures to ensure that the practices will prevent or minimize the impacts to water quality.
- c. Required submission of as-built drawings to be submitted no later than 1 year after the completion of a construction project. These drawings must depict all on-site controls designed to manage stormwater. Permittees must also develop a new development/redevelopment program to ensure long term operation and maintenance of stormwater management practices. The procedures for the requirement of as-built drawings and insurance of long term operation and maintenance must be included in the SWMP and be reported in each annual report.
- d. Within 2 years of the permit effective date, permittees must create a report including current street design, parking lot guidelines, and other local requirements that affect the creation of impervious cover. If the assessment shows that changes can be made, the assessment must include recommendations and proposed schedules to incorporate policies and standards into relevant documents and procedures to minimize impervious cover. Permittees must also involve any local planning boards and transportation boards in the assessment if feasible.
- e. Within 3 years of the permit, permittees must create a report assessing local regulations (zoning/construction codes, green infrastructure practices) to determine the feasibility of making the following green infrastructures:
 - i. Green roofs
 - ii. Infiltration practices (rain gardens, curb extensions, planter gardens, porous and pervious pavements)
 - iii. Water harvesting devices (rain barrels and cisterns)
- f. Permittees must estimate and report the annual increase/decrease of the number of acres of impervious area (IA) and directly connected impervious area (DCIA) in each annual report. Permittees must tabulate its estimates by sub-basins or by the catchments delineated.

2 years from the permit effective date, permittees must complete an inventory and priority ranking of permittee-owned property and existing infrastructure with the potential for BMP retrofitting. This ranking must be at least a screening-level ranking, and consider the following properties:

- i. Access for maintenance purposes
- ii. Subsurface geology
- iii. Depth to water table
- iv. Site slope and elevation
- v. Proximity to aquifers and subsurface infrastructure (including sanitary sewers and septic systems)

While determine its priority ranking, permittees must also consider the following factors:

- i. Planned capital improvements to storm and sanitary sewer infrastructure and paving projects
- ii. Current storm sewer level of service
- iii. Control of discharges to impaired waters, 1st or 2nd order streams, and critical receiving waters (including):
 - a. Public swimming beaches
 - b. Public drinking water supply sources
 - c. Outstanding resource waters
 - d. Cold water fisheries
 - e. Shellfish growing areas
- iv. Complexity and cost of implementation
- v. Opportunities for public use and education

Beginning with the 2nd year annual report and in each thereafter, permittees must estimate for each sub-basin the number of acres of IA and DCIA draining to the MS4 that have been added or removed during the prior year. Permittees must also include estimates in additions or reductions resulting from new development/redevelopment projects undertaken.

Beginning with the 3rd year annual report and in each thereafter, Permittees must report on permittee-owned properties and inventoried infrastructure that have BMP retrofitted to mitigate IA and DCIA.

6. Pollution Prevention/Good Housekeeping

For more information on the Pollution Prevention control measure, refer to the permit [here](#).

- a. Operations and Maintenance (O&M) Program: Within 6 months of the permit, permittees must develop an inventory of the following facilities (parks and open spaces, buildings and facilities, vehicles and equipment) . Within 1 year of the permit, permittees must develop written O&M procedures:
 - i. Parks and open spaces: Establish procedures to address the proper use, storage, and disposal of pesticides, herbicides, and fertilizers. Evaluate lawn maintenance and landscaping activities. Establish procedures for management of trash containers.
 - ii. Buildings and facilities where pollutants are exposed to stormwater runoff. These facilities include:
 1. Schools
 2. Town offices
 3. Police stations
 4. Fire stations
 5. Municipal pools
 6. Parking garages

Evaluate the use, storage, and disposal of potential stormwater

pollutants. Provide employee training as necessary. Ensure that Spill Prevention Plans are in place. Develop management practices for dumpsters and sweep parking lots to reduce the runoff of pollutants.

- iii. Vehicles and equipment: Establish procedures for the storage of permittee vehicles. Evaluate fueling areas and if possible, place such areas under cover to minimize runoff. Establish procedures to ensure that vehicle fluids are not discharged to the MS4.
- iv. Infrastructure O&M: Within 1 year of the permit effective date, permittees must develop a written program detailing activities and procedures permittees will implement in order to preserve MS4 infrastructure maintenance.
 - 1. Permittees must implement routine inspections, cleaning, and maintenance of catch basins and allow proper disposal of wastes.
 - a. Ensure that no sumps are more than 50% full for any catch basins serving catchments draining to impaired waters where pollutants of concern are sediment, Nitrogen (Total), or Phosphorus (Total). If the majority of waters are impaired, permittees must prioritize cleaning efforts based on the cause of impairment and potential for the MS4 to contribute to the impairment. Permittees must document this prioritization in the SWMP.
 - b. Prioritize inspection and maintenance for catch basins located near construction activities. Clean catch basins in these areas more frequently if inspection and maintenance activities reveal excess sediment and/or debris.
 - c. For other catch basins, establish a schedule to ensure the frequency of routine cleaning will prevent catch basins from reaching 50% capacity.
 - d. If a catch basin sump is more than 50% full during 2 routine inspections, permittees must document the finding in that year's annual report and investigate the contributing drainage area for sources of excessive sediment or debris loading.
 - e. Permittees must document in the SWMP and year 1 annual report their plans for optimizing catch basin cleaning, inspection plans, or schedules for gathering information to develop the optimization plan. Documentation must include metrics and other information used to determine that the proposed schedule is optimal for cleaning and maintenance of the MS4. Permittees must keep a log of catch basins cleaned and inspected.
 - f. Permittees must report in each annual report the total number of catch basins, the number of catch basins

inspected, the number of catch basins cleaned, and the volume or mass of material removed from each basin draining to impaired waters and the total volume or mass of material removed from all catch basins.

2. Permittees must establish and implement procedures for sweeping and/or cleaning streets and permittee-owned parking lots. All streets (with the exception of high-speed limited access highways) must be swept/cleaned at least once per year in the spring. The procedures must also include more frequent sweeping of targeted areas (determined by permittees) on the basis of:
 - a. Pollutant load reduction potential
 - b. Inspections
 - c. Pollutant loads
 - d. Catch basin cleaning/inspection results
 - e. Land use
 - f. Impaired or TMDL waters
 - g. Other relevant factors determined by permittees

Permittees must report in each annual report the number of miles cleaned and the volume or mass of material removed.

For uncurbed, limited access highways, the permittee must meet the requirements above or develop and implement an inspection, documentation, and sweeping plan within 1 year of the permit effective date, and submit the plan with the year 1 annual report.

3. Permittees must ensure proper storage of catch basin cleanings/street sweepings prior to disposal.
4. Permittees must establish and implement procedures for winter road maintenance including:
 - a. The use and storage of salt and sand
 - b. Minimization of the use of sodium chloride and other salts
 - c. Evaluate opportunities for use of alternative materials
 - d. Ensure that snow disposal activities do not result in the disposal of snow into surface waters
5. Permittees must establish and implement inspection and maintenance procedures for storm drain systems and all stormwater treatment structures such as:
 - a. Water quality swales
 - b. Retention/detention basins
 - c. Infiltration structures
 - d. Proprietary treatment devices
 - e. Other similar structures

All stormwater treatment structures must be at least inspected

annually.

- v. Permittees must report in each annual report:
 - 1. The status of the inventory required by this section and any other relevant updates
 - 2. The status of the O&M programs
 - 3. Maintenance activities associated with each
 - vi. Permittees must keep a written record of all activities including but not limited to maintenance activities, inspections, and training required. Permittees must maintain all records associated with these maintenance and inspection activities.
- b. Stormwater Pollution Prevention Plan (SWPPP)
Permittees must develop and implement a SWPPP for each of the following facilities:
- i. Maintenance garages
 - ii. Public works
 - iii. Yards
 - iv. Transfer stations
 - v. Other waste handling facilities with pollutants exposed to stormwater

In addition, permittees may develop one SWPPP for any of the above shared properties.

Note: The SWPPP is a separate and different document from the SWMP.

- i. Within 2 years of the permit effective date, permittees must develop and implement a written SWPPP for the above facilities and must contain the following elements:
 - 1. Pollution prevention team
 - 2. Description of the facility and identification of potential pollutant sources
 - 3. Identification of stormwater controls
 - 4. The following management practices:
 - a. Minimize or prevent exposure: Permittees must locate materials and activities inside or protect them with storm-resistant coverings.
 - b. Good housekeeping: Permittees must keep all areas with potential sources of pollutants clean. Ensure that trash containers are closed when not in use, keep storage areas well swept and free from leaking or damaged containers, and store leaking vehicles needing repair indoors.
 - c. Preventative maintenance: Permittees shall regularly inspect, test, maintain, and repair all equipment and systems to avoid situations that may result in leaks, spills or other releases of pollutants to stormwater. Inspections

- must occur at least once per quarter.
- d. Spill prevention and response: Permittees must minimize potentials for leaks, spills, and other releases potentially exposed to stormwater. Permittees must also develop plans for effective response, such to such spills. Permittees must at least have procedures that include:
 - i. Preventative measures such as barriers between material storage and traffic areas, secondary containment provisions, and procedures for material storage and handling.
 - ii. Response procedures that include notification of facility personnel, emergency agencies, regulatory agencies. Procedures should also include stopping, containing, and cleaning up hazardous material spills or leaks. Employees who may cause, detect, or respond to spills or leaks must be trained appropriately.
 - iii. Contact information for individuals and agencies that must be notified in the event of a leak or spill. This information must be stored in locations that are easily accessible and available.
 - e. Erosion and sediment control: Permittees must use structural and non-structural control measures at facilities to stabilize and contain runoff from exposed areas.
 - f. Management of runoff: Permittees must manage runoff from facilities.
 - g. Salt storage piles: For these piles used for deicing purposes, permittees must prevent exposure of the piles from precipitation. Such piles must be covered within 2 years of the permit effective date.
 - h. Employee training: Permittees must regularly train employees who work in areas where materials or activities are exposed to stormwater, or employees who are responsible for implementing activities defined in the SWPPP. Permittees must document the following for each training:
 - i. Training date, title, and duration
 - ii. List of municipal attendees
 - iii. Subjects covered during training
 - i. Maintenance of control measures: Permittees must maintain all control measures. Permittees must keep documentation on site that describes procedures and a schedule for preventative maintenance of all control measures.
5. Site inspections: Permittees must inspect all areas exposed to

stormwater runoff. Inspections must take place at least once each quarter and must be performed while the facility is operating. At least one of the quarterly inspections must occur when stormwater is discharging. Permittees must document the following information for each facility inspection and document the findings in each annual report:

- a. Inspection date and time
- b. Name of inspector
- c. Weather information and a description of discharges occurring at the time of inspection
- d. Identification of previously unidentified discharges
- e. Control measures needing maintenance or repair
- f. Failed control measures that need replacement
- g. SWPPP changes required as a result of inspection

Note: If during inspections or any other time permittees identify control measures needing repair, permittees must repair or replace them before the next storm if possible.

Program Evaluation

For more information on program evaluations, refer to the permit [here](#).

Permittees must annually self-evaluate with the requirements of this permit and maintain the evaluation documentation as part of the SWMP. Permittees must evaluate the appropriateness of selected BMPs in achieving the objectives of each control measure. Any changes made with BMPs must be documented in the SWMP and contain the following information:

1. Analysis of why the BMP is ineffective or infeasible
2. Expectations of the effectiveness of the replacement BMP
3. Analysis of why the replacement BMP is expected to achieve the defined goals

Permittees must also indicate BMP modifications along with a brief explanation of the modification in each annual report.

Note: The USEPA may require permittees to add, modify, repair, replace, or change BMPs or other measures described in annual reports as needed.

Record Keeping

For more information on record keeping, refer to the permit [here](#).

Permittees must keep all records required by this permit for at least five years from the permit effective date. Records include information used in the development of required written programs, monitoring results, copies of reports, records of screening, follow-up and elimination of illicit discharges, maintenance records, inspection records, and data used in the development of the NOI, SWMP, SWPPP, and annual reports. Permittees must make records relating to the permit available to the public to be viewed during normal business hours. Permittees are encouraged to satisfy this by posting records online.

Reporting

For more information on reporting, refer to the permit [here](#).

Permittees must submit an annual report. The reporting period will be a 1 year period starting on the permit effective date. The 1st annual report must include the period between May 1st and the permit effective date. All annual reports must contain the following information:

1. Self-assessment review of compliance with the permit requirements
2. Assessment of the appropriateness of the selected BMPs
3. Status of plans or activities required by the Water Quality OWOWOWOW
4. Assessment of the progress made towards meeting the requirements of the 6 minimum control measures
5. All outfall screening and monitoring data collected by permittees during the reporting period. Permittees must also include descriptions of additional monitoring data.
6. Description of activities for the next reporting cycle
7. Description of changes in identified BMPs or measurable goals
8. Description of activities undertaken by any contracting entities for meeting any requirements or control measures.

