

Phase II MS4 Permit: Improving Central Massachusetts Stormwater Management

Increasing Municipality Compliance with MS4 Permits in Collaboration
with the Massachusetts Department of Environmental Protection and
Central Massachusetts Municipalities

An Interactive Qualifying Project submitted to the faculty of Worcester Polytechnic Institute in
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Abstract

Stormwater runoff is the leading cause of water pollution in the United States. It is precipitation that flows over impervious surfaces, collects pollutants, and discharges untreated into a surface water body. The goal of this project was to improve stormwater management programs in municipalities within Central Massachusetts (MA). We worked with the Massachusetts Department of Environmental Protection to help the towns of Auburn, Holden, and Upton prepare for the upcoming MA MS4 permit. With assistance from the Central Massachusetts Regional Stormwater Coalition, we developed the Catchment Area Priority Ranking System database and created several documents to aid municipalities in understanding the requirements of both the 2003 MA MS4 general and 2013 New Hampshire MS4 draft permit.

Acknowledgments

Our team would like to thank a number of people who helped us throughout the completion of our IQP Project.

We would like to express our sincere gratitude to our sponsor – Massachusetts Department of Environmental Protection for giving us the opportunity to work with such an important environmental issue in Central Massachusetts. Specifically, we would like to thank Fred Civian, Andrea Briggs, Stella Tamul, and Cheryl Porier for helping us throughout the various portions of our project. Additionally, we would like to thank Juliet Swigor for her assistance with accumulating GPS data points.

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Executive Summary

At the forefront of water pollution, stormwater runoff is the greatest threat to clean water in the United States (Swamikannu, Radulescu, Young, & Allison, 2003). Stormwater runoff looks like a simple flow of clean, natural rainwater that pours into drains on the street and eventually back into the nearby surface water. However, this flow of stormwater can be deceptively harmful.

Stormwater runoff is the result of precipitation that flows over land or impervious surfaces (EPA, 2003a). It becomes an environmental threat when it flows and collects numerous types of pollutants, such as sediments, oils, or fertilizers. The resulting contaminated water subsequently enters local stormwater sewer systems and is released into surface water bodies, causing great harm to the environment.

A well-known and ongoing water quality issue in Massachusetts (MA) is the health of the Charles River. Stormwater pollution in the Charles River Watershed is “a chief culprit in dramatic algae blooms... that have plagued the river in recent years” (EPA, 2013b). The United States Environmental Protection Agency (US EPA) believes that phosphorus levels caused by stormwater runoff must be reduced by 54% to restore the Charles River to a healthy state (EPA, 2013b). Stormwater pollution in water bodies like the Charles River threaten their capability for recreational use and degrade fish habitat and aesthetics.

In rural areas, stormwater can naturally penetrate into the ground and filter into the underground flow of groundwater. However, urbanization has increased the amount of surfaces that are impervious or impenetrable. By forcing the stormwater to flow over impervious surfaces as opposed to penetrating the ground, stormwater runoff collects debris and contaminants along its path to a water source (Robert, 2007). Many urbanized areas have catch basins that collect

stormwater runoff and reroute it, via underground piping, directly into rivers, streams, ponds, lakes, and oceans. Unlike sanitary wastewater, stormwater runoff is untreated throughout its journey to surface water bodies. The point at which untreated stormwater is discharged into a surface water body is called an outfall. Catch basins, piping, manholes, outfalls, and other stormwater infrastructure are collectively known as a Municipal Separate Storm Sewer System (MS4). A simplified example of an MS4 can be seen in Figure 1.

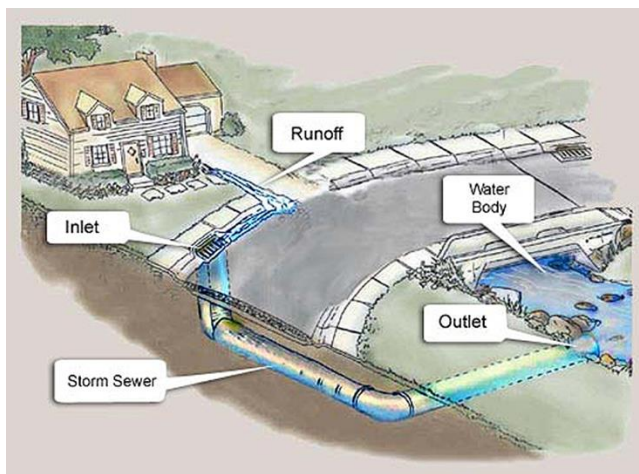


Figure 1 - A Simplified Example of an MS4
Retrieved from:
http://www.deldot.gov/stormwater/images2/drain_full.jpg

MS4s are considered a form of point source pollution because contaminated stormwater is being discharged from an identifiable place - outfalls. Point sources of pollution are considered to be relatively easy to regulate because each point source is at a known location and the owner of the source can be identified (Oana, Ioan, & Andrei, 2010).

Conversely, stormwater outside of the MS4 is considered a form of nonpoint source pollution since runoff is collecting debris from many diffuse sources. Nonpoint source pollution is difficult to control because pollutants can accumulate from a wide array of locations and can flow directly into surface water bodies. An example of how nonpoint source pollution can cripple a body of water is the Bosque River Watershed in Texas. The river is surrounded by dairy farms. Despite only 30% of the surrounding land being impervious, the polluted runoff filled with the manure and fertilizers from the approximately 100 dairy farms has forced the US EPA to list the river as impaired (Santhi, Arnold, Williams, Hauck, & Dugas, 2001).

In 1990, the US EPA created the MS4 Permit under the National Pollutant Discharge Elimination System (NPDES) of the Clean Water Act to address the problem of stormwater pollution. The MS4 permit establishes six minimum control measures that municipalities must comply with: 1) Public Education & Outreach; 2) Public Participation/Involvement; 3) Illicit Discharge Detection & Elimination; 4) Construction Site Runoff Control; 5) Post-Construction Runoff Control; 6) Pollution Prevention/Good Housekeeping (EPA, 2003b).

The currently active MS4 permit for most municipalities in Massachusetts was released in 2003. New Hampshire (NH) was issued a MS4 draft permit in February of 2013. The requirements for the 2013 NH draft permit are far more extensive than those in the active 2003 MA permit. Stormwater officials believe that the 2013 NH draft permit is a strong indicator of the contents of the upcoming MA permit. As some municipalities are struggling to comply with the current 2003 MA permit, the comprehensive requirements of the 2013 NH draft permit will pose a challenge to many towns and cities across Massachusetts.

Methodology

The overall goal of this project was to improve stormwater management programs (SWMPs) in Central Massachusetts municipalities. We worked with the Massachusetts Department of Environmental Protection (MassDEP) to help the towns of Auburn, Holden, and Upton prepare for upcoming MS4 permit requirements. In order to successfully achieve our goal, we completed the following objectives: 1) assess the current success of municipalities' stormwater management programs; 2) act as an informational resource to municipalities on stormwater management; 3) assist municipalities with mapping and delineation of catchment areas, and 4) create a catchment priority ranking database.

In order to complete our objectives, our team analyzed both the 2003 MA permit and the 2013 NH draft permit, along with the stormwater management documents of Auburn, Holden, and Upton. We also interviewed several municipal stormwater officials, municipal employees whose responsibility it is to manage a town's stormwater program. The position of stormwater official varies within each town. Throughout our project, we worked with Assistant Town Engineer in Auburn, Senior Civil Engineer in Holden, and the Director of Public Works Department in Upton. Additionally, we interviewed officials from the MassDEP, US EPA, and Central Massachusetts Regional Stormwater Coalition (CMRSWC). Through document analysis, interviews, and training sessions, we were able to assess compliance with the 2003 MA permit for Auburn, Holden, and Upton, while also serving as an educational resource to them on stormwater management. Additionally, we assisted the three towns by recording Global Positioning System (GPS) locations of their stormwater infrastructure. For our final objective, our team developed a database that has the capacity to priority rank catchment areas based on criteria found in the 2013 NH draft permit. A catchment area is a portion of land that drains to one outfall, incorporating all the catch-basins, manholes and piping within the area. After interviewing municipal officials, we incorporated their feedback within the database.

Key Findings & Recommendations

Our team formed a number of findings and recommendations after compiling and analyzing the data collected throughout our study.

Annual Reports Are Not an Accurate Representation of Permit Compliance

When analyzing each municipality's compliance with the 2003 MA MS4 permit, we found that the 2013 annual reports were not an accurate representation of the subject town's permit

compliance. Municipalities submit an annual report to the US EPA summarizing their stormwater management programs. Often times municipalities either under- or over- state their procedures because there is no template to follow when completing the annual report. To help with this, we recommend that the US EPA develop a standardized reporting form explicitly stating all of the requirements to ensure that municipalities correctly report their SWMPs.

Municipal Concern with Time, Manpower and Funds

Throughout the interviews we conducted with municipal stormwater officials, a common trend appeared. The granularity, that is the level of detail, of the upcoming permit demands far more time, manpower and funding than municipalities are capable of providing. The officials felt that the upcoming permit was very specific and will be a major challenge for municipalities to overcome. We recommend that for future permits, the US EPA make incremental changes to stormwater regulations so as to not overwhelm the municipalities and give them the greatest chance of success in their stormwater programs.

No Uniformity in Municipal Stormwater Management Programs

While working with stormwater officials from the different municipalities of the CMRSWC, our team found little uniformity in municipal stormwater management programs. Every official that we interviewed had a different knowledge set and a unique interpretation of permit requirements. Our team also observed that there is no specially designated position, within a municipality, for stormwater management. We recommend that municipalities regionalize in order to collaborate efforts and resources to further their SWMPs. We also recommend that the US EPA mandate a yearly stormwater training for municipal stormwater officials in order to ensure that municipalities understand what they need to do to fully comply with the MS4 permit.

Priority Ranking Process is Difficult and Confusing

While studying the Catchment Area Priority Ranking requirement within the 2013 NH draft permit, we found that the priority ranking process is difficult and confusing to interpret. We recommend that the US EPA clarify this requirement within the upcoming MA MS4 permit by explicitly defining the categories for ranking and criteria used for prioritizing. In order to assist municipalities with fulfilling the priority ranking requirement of the new Massachusetts permit, our team developed the Catchment Area Priority Ranking System (CAPRS) Database. We recommend that a future WPI student research, or other independent research team conduct a pilot test of the CAPRS Database to evaluate its functionality and effectiveness.

Conclusion

Stormwater pollution is a relatively new environmental issue that is rapidly gaining traction in the plans of local governments. Many municipalities are more accepting of stormwater regulations and are working together to improve regional stormwater management. However, the problem of stormwater is vast and will require a great deal of time and effort to resolve.

Although municipalities need to improve their stormwater management programs, the difficulty of this task must be acknowledged and municipalities cannot be overwhelmed with regulations.

If municipalities are given proper assistance, great strides can be made to improve the health of our rivers, lakes and streams in years to come.

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List of Acronyms

BMP:	Best Management Practice
CAPRS:	Catchment Area Priority Ranking System
CIC:	Community Innovation Challenge
CWA:	Clean Water Act
CMRSWC:	Central Massachusetts Regional Stormwater Coalition
FWPCA:	Federal Water Pollution Control Act
GIS:	Global Information System
GPS:	Global Positioning System
IDDE:	Illicit Discharge Detection & Elimination
MA:	Massachusetts
MassDEP:	Massachusetts Department of Environmental Protection
MS4:	Municipal Separate Stormwater Sewer System
MySQL:	My Structured Query Language
NH:	New Hampshire
NPDES:	National Pollutant Discharge Elimination System
PHP:	PHP: Hypertext Preprocessor

SWMP: Stormwater Management Program

US EPA: United States Environmental Protection Agency

WPI: Worcester Polytechnic Institute

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Section 1.0 Introduction

"[B]orn in a water-rich environment, we have never really learned how important water is to us. We understand it, but we do not respect it" (Ashworth, 1982, p. 26). A lack of respect for the finite source of water will have detrimental effects for mankind. In many corners of the earth, human beings have struggled with keeping water sources clean and useable. At the forefront of water pollution, stormwater runoff is the greatest threat to clean water in the United States (Swamikannu et al., 2003).

The United States Environmental Protection Agency (US EPA) defines stormwater runoff as precipitation from rain or snowmelt that flows over land or impervious surfaces, like driveways and streets (EPA, 2003a). Stormwater runoff becomes an environmental threat when it flows and picks up numerous types of pollutants, such as sediments, oils, or fertilizers. The resulting contaminated water subsequently enters local stormwater sewer systems and is released into surface water bodies, causing great harm to the environment.

Many people do not realize that some of the most ordinary tasks can have adverse effects on local bodies of water. An activity as simple as washing a car can eventually have a lasting effect on the local ecosystem. Chemicals from soaps flow down driveways, enter the nearest storm drain and are released into the local river. These harmful chemicals can damage water quality and the health of many life forms that depend on the river (EPA, 2003a).

A well-known and ongoing water quality issue in Massachusetts is the health of the Charles River. Stormwater pollution in the Charles River Watershed is "a chief culprit in dramatic algae blooms... that have plagued the river in recent years" (EPA, 2013b). The US EPA believes that phosphorus levels caused by stormwater runoff must be reduced by 54% to restore the Charles

River to a healthy state (EPA, 2013b). Stormwater pollution in water bodies like the Charles River threaten their capability for recreational use and degrade fish habitat and aesthetics. Scenarios like this have led to a growing realization of the need to manage and regulate stormwater runoff.

In 1990, the US EPA created the Municipal Separate Storm Sewer Systems (MS4) Permit to address this problem (EPA, 2005b). In order to regulate stormwater pollution, the MS4 permit establishes minimum control measures that municipalities must meet to comply with the permit. Initially, the permit only applied to large, urbanized cities. However, as the need to manage more sources of stormwater runoff grew, the US EPA expanded the permit to include smaller municipalities in 1999 (EPA, 2005b).

Though the municipalities are required to follow the minimum control measures established by the US EPA, many towns and cities struggle to fully comply with all of the requirements laid out in the MS4 permit. Municipalities face funding challenges, lack of manpower, and time constraints. Also, many municipal employees may not have a complete understanding of the control measures in the permit or how to fully comply with them. Although the US EPA had good intentions in leaving the permit language open to interpretation, the vagueness of the requirements further compounds the municipal lack of understanding. The US EPA has the primary enforcement power over compliance of MS4 permits while the Massachusetts Department of Environmental Protection (MassDEP) serves as an aid to the municipalities. Furthermore, the MassDEP acts as a liaison between the US EPA and the municipalities.

In collaboration with Worcester Polytechnic Institute (WPI), the MassDEP developed a project to assist three Central Massachusetts municipalities in compliance with the six MS4 control measures. The goal of our project was to improve stormwater management programs of

municipalities within Central Massachusetts. Specifically, our team worked with the towns of Auburn, Holden, and Upton. Through interviews with municipal and analysis of past municipal MS4 annual reports, we assessed each municipalities' current stormwater management program and their level of compliance with the 2003 MA MS4 permit. For each municipality, we served as an informational resource and assisted in the mapping of stormwater infrastructure using Global Positioning Systems. Lastly, we developed an interactive database that automatically priority ranks catchment areas when criteria is entered.

Our report includes the following chapters. In chapter two we examine stormwater pollution, provide a brief history of stormwater regulation, and explain the specifics of the recent MS4 permits. In chapter three, we describe our approach for gaining information about the municipalities' MS4 compliance as well as our methods for improving stormwater management programs. In chapter four, we provide an analysis of our findings and recommendations. Upon the completion of this project, we hope to have left a meaningful impact in Central Massachusetts stormwater management programs.

Section 2.0 Literature Review

Stormwater runoff looks like a simple flow of clean, natural rainwater that pours into drains on the street and eventually back into the nearby surface water. This runoff is the result of precipitation from rain or snowmelt that flows over land or impervious surfaces (EPA, 2003a). As stormwater flows across impervious pavement towards a surface water body or storm drain, any trash, salt, pesticides, debris and/or chemicals on the road are swept along with it. Contrary to wastewater, which is filtered at specialized treatment plants, stormwater flows directly into a surface body of water without treatment. This means that any pollution that is collected by the stormwater runoff is emptied directly into streams, lakes, rivers, and eventually oceans.

The seriousness of stormwater pollution has been under scrutiny for a few decades. There is no clear answer to the problem of stormwater pollution, and most existing regulations are still evolving as more is learned about its effects (Goonetilleke, Thomas, Ginn, & Gilbert, 2005). The most recent effort to mitigate the stormwater problem is regulation by the United States Environmental Protection Agency (US EPA) of municipal separate storm sewer systems (MS4) under the federal Clean Water Act (CWA) via a discharge permit. This MS4 permit establishes several requirements that municipalities must follow in order to effectively manage their stormwater runoff. Our project, with the assistance of the Worcester Regional Office of the Massachusetts Department of Environmental Protection (MassDEP), focuses on improving stormwater management programs (SWMP) in Central Massachusetts municipalities.

In this chapter, we begin by taking a deeper look at what stormwater runoff really is and how it gets polluted. In section two, we examine the progression of stormwater regulations that have

culminated into the MS4 permit. In the third section, we analyze the control measures established in the MS4 permit. In the final section, we explore different methods to improve municipal permit compliance.

Section 2.1 Stormwater

What is stormwater? To most, it is natural rainwater that falls and flows into drains which empty out into larger bodies of water. However, stormwater is not that simple. As seen in Figure 2, urbanization has complicated the journey of stormwater and its effects on the environment (Ohio EPA, n.d.).

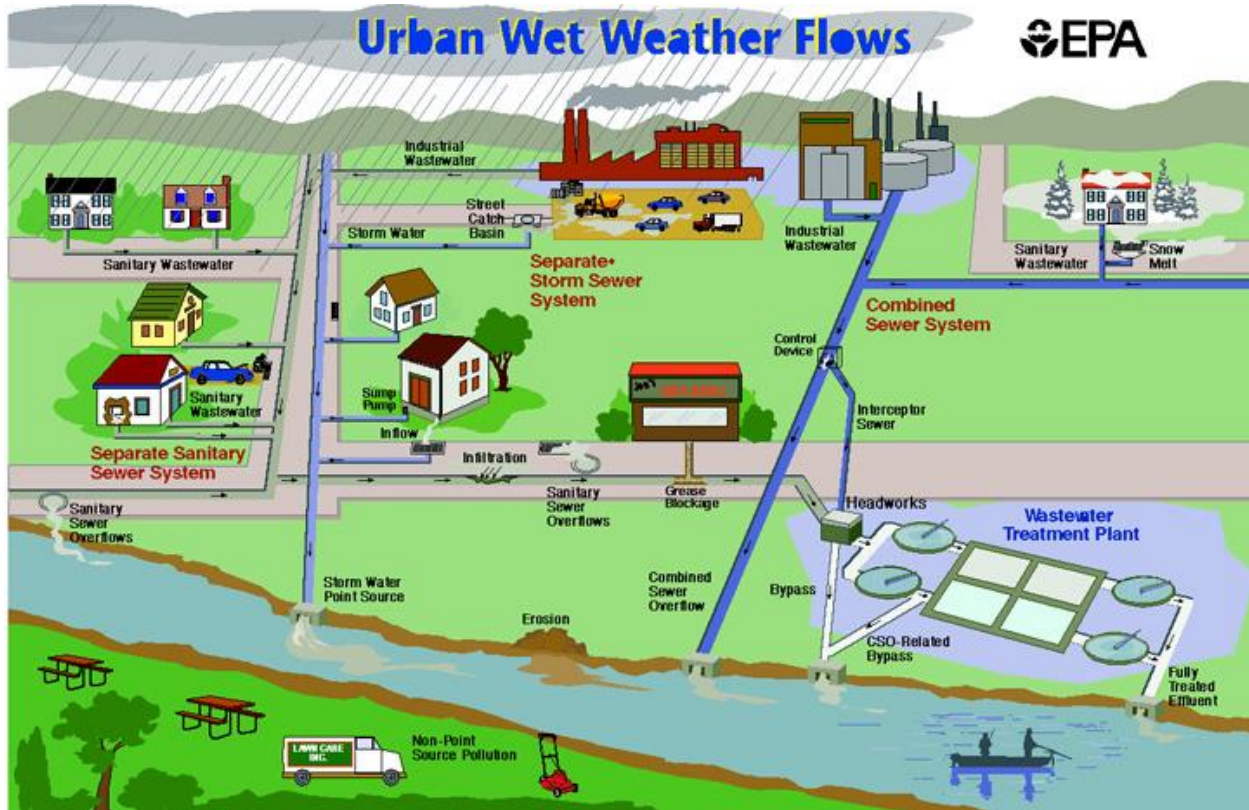


Figure 2 - An Example of a Municipal Separate Stormwater Sewer System (MS4)
Retrieved from: http://www.epa.ohio.gov/portals/35/cso/wet_weather_flow_graphic.jpg

In rural areas, stormwater can naturally penetrate into the ground and filter into the underground flow of groundwater. However, urbanization has increased the amount of surfaces that are impervious, meaning water cannot penetrate them. Therefore, many urbanized areas have catch

basins that collect this runoff water and reroute it, via underground piping, directly into rivers, streams, ponds, lakes, and oceans. The point at which regulatable stormwater is discharged is called an outfall. Hundreds of outfalls can sometimes lead into to a single river or other body of water. The presence of numerous catch basins and outfalls in urbanized areas results in intricate stormwater management systems.

Some larger municipalities have combined stormwater and wastewater systems. Combined systems are rare as most municipalities have separate stormwater sewer systems. Treating stormwater runoff alongside wastewater is not an option as it is not practical to filter such vast amounts of water in a timely and cost-efficient fashion. “A single large rain in Los Angeles produces as much stormwater runoff as [some of the] largest treatment plants [in California] can purify in an entire month” (Stenstrom, 2004, p. 1). For more perspective, a one-acre parking lot will produce about 27,000 gallons of stormwater runoff after only one inch of rain (King County Stormwater Services, 2013). Why is this a problem? Whatever flows into catch basins often ends up in a body of water harming the quality of the water and subsequently many life forms that depend on that water source. While one outfall in a river may not be a serious threat to the water quality, having a high concentration of outfalls emptying into a river can yield major environmental consequences.

Section 2.1.1 Stormwater Pollution

“Stormwater runoff occurs when precipitation from rain or snowmelt flows over... impervious surfaces like driveways, sidewalks, and streets [preventing the] stormwater from naturally soaking into the ground” (EPA, 2003a). By forcing the stormwater to flow over impervious surfaces as opposed to penetrating the ground, stormwater runoff collects debris and contaminants along its path to the water source (Robert, 2007). Runoff conveyance systems were

originally created “to remove water from roads and walkways as rapidly and efficiently as possible” (Committee, 2008, p. 25). There is an additional component to the transportation of stormwater that was not taken into consideration in the original construction plans – and that is pollution. Any waste that is thrown on the ground, from cigarette butts to plastic bottles, has the chance to end up in stormwater. Chemicals from daily public use can also be hazardous; pesticides, cleaning solutions, and automotive fluids pose significant risks to the quality of stormwater runoff (Shivani, Vibhor, Bansal, & Siby, 2013). In Washington State, it is estimated that almost one-third of water pollution is the result of stormwater runoff (King County Stormwater Services, 2013). This pollution can be significantly reduced through natural means. By restoring the water infiltration capacity of the land back to its porous, pre-urbanized state, water quality can improve naturally (Frazer, 2005). Porous surfaces, like the natural ground cover shown in Figure 3, allow the water to filter slowly into the ground removing most harmful pollutants from the water (EPA, 2003a). From the figure, it is easy to see that urbanized areas

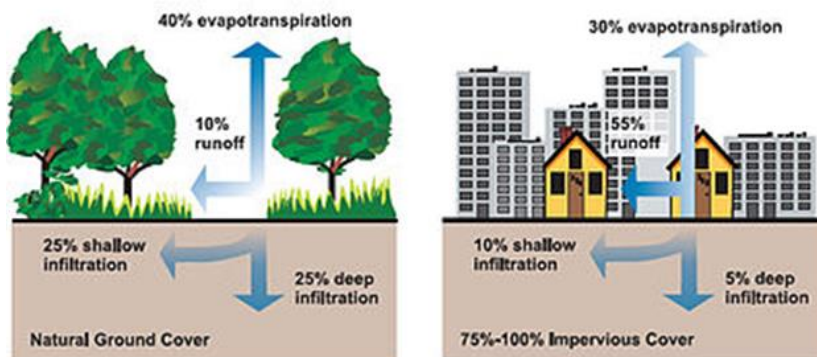


Figure 3 - Rural vs. Urban Path of Stormwater
 Retrieved from: http://www.epa.gov/npdes/pubs/nps_urban-facts_final.pdf

with impervious cover result in more than five times the amount of runoff than in areas of natural ground cover.

A study, conducted in 1993 by environmental specialists John P. Masterson and Roger T.

Bannerman in Milwaukee County, Wisconsin, examined the differences in pollution levels between urban, rural, and hybrid areas. Table 1 (below) identifies key streams, the percentage of rural or urban area surrounding them, and length in miles. The reference stream was a

“nonurbanized location in the Mauthe Lake subwatershed of the East Branch of the Milwaukee River...” (Masterson & Bannerman, 1994).

Table 1 - List of Streams from Areas of Varying Urbanization

Stream	% Rural	% Urban	Length (miles)
Non-urbanized	100	0	16.3
Oak Creek	52	48	13.1
Kinnickinnic River	0	100	24.8
Wilson Park Creek	0	100	11.2

Retrieved from: <http://www.cws.msu.edu/documents/masterson.pdf>

Throughout the study, the United States Geological Survey took samples from the river water, bottom sediment, whole fish tissue, whole crayfish tissue, and the nearby habitat (Masterson & Bannerman, 1994). Though the data was interesting, the bottom sediment analysis proved to be the most compelling and reliable data set. Table 2 contains select information from the bottom sediment analysis (Masterson & Bannerman, 1994). The last column is the US EPA criteria that defines a heavily polluted stream with 100% urban land use.

Table 2 - Comparison of Pollution in Bottom Sediment

Compound	Non – urbanized	Oak	Kinnickinnic	Wilson Park	US EPA Criteria
Lead (mg/kg)	8.45	12	68	92	>60
Oil and Grease (mg/kg)	425	3200	1200	2000	>2000

Units are milligrams of pollution per kilogram of sediment
 Retrieved from: <http://www.cws.msu.edu/documents/masterson.pdf>

The 1993 study found that the non-urbanized area, composed of 100% rural land usage, had considerably lower amounts of lead, oil, and grease. Meanwhile, values for lead increased proportionally with the amount of urbanization. Both Kinnickinnic River and Wilson Park creek,

each 100% urbanized, were found to exceed the criteria for heavily polluted streams. Oil and grease followed a similar pattern with the exception of Oak Creek having the most and Kinnickinnic River having the second least. Oak Creek's high amount of oil and grease could be a result of different types of urban land use. Similarly, a team of engineers conducting a case study in India found that "pollutant concentrations vary considerably with land use pattern which indicates that pollutant distribution in the stormwater is highly influenced by the surrounding land use type" (Shivani et al., 2013). Oak Creek is an example of an area with only 48% urbanization that violates US EPA criteria defined for a stream with 100% urbanization. Regardless of the amount of urbanization in an area, stormwater pollution poses a significant impact on water quality if left unaddressed. For most other compounds examined in the study, the non-urbanized stream contained fewer pollutants than the more urbanized areas. Masterson & Bannerman conclude that "the biological integrity of urban streams is at risk due to stormwater discharges" (Masterson & Bannerman, 1994). Studies like this contribute to the growing evidence supporting mandatory stormwater pollution mitigation and regulatory oversight.

Section 2.2 The Clean Water Act and Its Origins

The Federal Water Pollution Control Act (FWPCA) of 1948 was the first major US law to address water pollution and authorized federal agencies to support water quality research, encourage new technology projects, and provide loans for treatment plants. However, in its original form, the law did not give federal agencies the authority to regulate or enforce measures to control the pollution that entered US waters (Pralhad, Clagett, & Hoagland, 2007). Over 20 years later, the US environmental movement of the 1960s and early 1970s helped spark the creation of the US EPA in 1970. This was shortly followed by the 1972 amendments to the

FWPCA, which is largely responsible for creating the modern day command and control water quality statute, commonly known as the Clean Water Act (CWA).

In general, the CWA established the basic structure for regulating the discharge of pollutants into US surface waters and gave the US EPA the authority to implement pollution control programs. The CWA embodies a federal-state partnership: federal guidelines, objectives, and limits are set by the US EPA, while the states largely administer and enforce the CWA programs with significant technical and financial assistance from the federal government (EPA, 2012c).

The main goal of the CWA is to maintain the “chemical, physical, and biological integrity” of US waters by eliminating the release of harmful pollutants into surface water bodies (EPA, 1977). To accomplish this, the 1972 amendments to the CWA established the National Pollutant Discharge Elimination System (NPDES), essentially a program that regulates the amount of allowable pollutant discharges into a surface water body and allows the US EPA to monitor the water quality of the receiving water body (Wagner, 2006). The NPDES program requires all municipal, industrial, and commercial facilities to implement specific pollution control technology and obtain NPDES permits to legally discharge pollutants into the waters of the US (Pralhad et al., 2007). The US EPA’s regulations that interpret the CWA are what eventually would lead to the creation of a permitting program for MS4s.

Section 2.2.1 Point Source and Nonpoint Source Pollution

The CWA and its subsequent amendments define specific types of pollution discharge mechanisms that need to be regulated under the NPDES program – two of which are point source pollution and nonpoint source pollution.

A point source is defined in the CWA as “any discernible, confined and discrete conveyance,” including but not limited to things like pipes, ditches, and channels, from which pollutants are or

may be discharged (EPA, 1977). For example, pollution that exits a factory through a single pipe and discharges into a body of water constitutes a point source of pollution because all of the pollutants are exiting from an identifiable single point. Such discharges can be harmful to aquatic ecosystems, kill aquatic life, and contaminate drinking water (Oana et al., 2010).

Stormwater runoff that enters an MS4 is considered a regulatable point source because after entering the MS4, the stormwater will eventually exit the sewer from a single, identifiable outfall. Point sources of pollution are considered to be relatively easy to regulate because each point source is at a known location and the owner of the source can be identified. Conversely, a nonpoint source is anything not already defined by the statute or accompanying regulations as a point source (Oana et al., 2010).

Nonpoint source pollution, unlike point source pollution from industrial and sewage treatment plants, comes from many different sources that are difficult to identify and monitor (Oana et al., 2010). Stormwater runoff that does not flow into an MS4 is considered nonpoint source pollution and can include fertilizers from agricultural lands, oil and grease from roads, sediment from construction sites, and many other pollutants (EPA, 2013c, 2013e). An example of how nonpoint source pollution can cripple a body of water is the Bosque River Watershed in Texas. The river is surrounded by dairy farms. Despite only 30% of the surrounding land being impervious, the polluted runoff filled with the manure and fertilizers from the approximately 100 dairy farms has forced the US EPA to list the river as impaired. (Santhi et al., 2001)

Regulation of stormwater pollution that runs over land (a nonpoint source) is much more difficult to enforce than pollution that comes from an identifiable pipe outlet (a point source) (Wu, Lin, Bajpai, & Gang, 2008). Frederick Civian, Stormwater Coordinator for the MassDEP, provided a good example of the difficulties of nonpoint source pollution: a business owner with a parking

lot on his/her property may not be aware of everything that people are putting on the parking lot. (Civian, October 29, 2013) Patrons could be littering or leaving behind automotive fluids. The owner is not actively producing pollution or doing anything illegal. Therefore, it becomes difficult to tell the parking lot owner to stop producing polluted stormwater runoff when he/she is not actually responsible for producing the pollutants that end up in larger bodies of water.

In 1987, Congress amended the CWA to “address water quality impairment caused by nonpoint sources” (Pralhad et al., 2007). These amendments created a new federal program that provides money to states, tribes, and territories for the development of programs to reduce pollution from unregulated, nonpoint sources (EPA, 2012c). The amendments also expanded the NPDES program to include discharges of stormwater from construction activities, industrial activities, and MS4s (Pralhad et al., 2007).

Section 402 of the CWA mandates that MS4 owners must obtain a NPDES permit. The disposal of any known stormwater discharge is illegal before obtaining a proper NPDES permit (EPA, 1977). This requirement was established to track stormwater runoff to reduce the amount of pollution contaminating bodies of water (EPA, 2005b). Although stormwater runoff originates from nonpoint sources, the collection and discharge of stormwater from MS4 outfalls into water bodies is considered a point source discharge (Harrop, 2001). The 1987 amendments to the CWA attempt to address nonpoint source pollution by subjugating MS4 outfalls to the NPDES permit as point sources of pollution. The NPDES program allows for issuance of system- or jurisdiction-wide permits, which alleviates the difficulty of permitting every discharge point, of which a large MS4 may have hundreds (Harrop, 2001).

By 1990, the US EPA had issued the first MS4 permits through the NPDES permit program to different cities and towns all over the country to help regulate pollution from nonpoint

sources. The focus of our project was to help municipalities in Central Massachusetts manage and fulfill the requirements presented by these MS4 permits.

Section 2.3 MS4 Permits

A Municipal Separate Storm Sewer System, or MS4, is a system designed to capture, transport

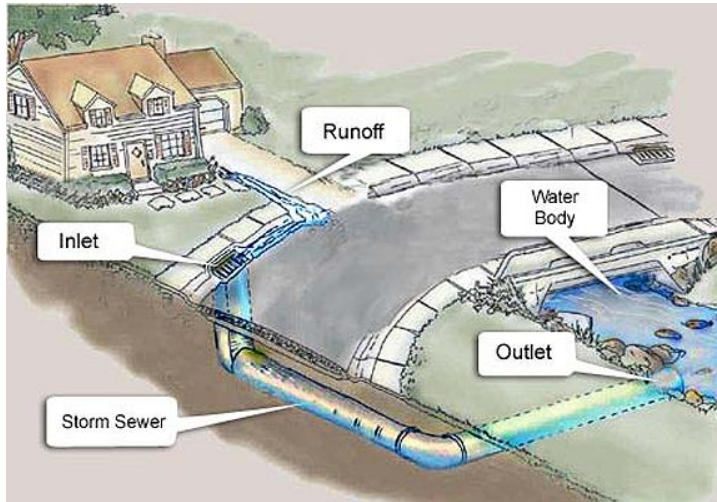


Figure 4 - A Simplified Example of a MS4

Retrieved from: http://www.deldot.gov/stormwater/images2/drain_full.jpg

and displace stormwater into larger bodies of waters of the United States. An MS4 is owned by the state, city, or other public entity and importantly, is not a component of a sewage treatment plant (EPA, 2013g, 2013i). Figure 4 shows a simplified

version of an MS4. Stormwater enters through an inlet, known as a catch basin, flows through underground pipes, and discharges through an outlet, known as an outfall, into a larger body of water (Delaware Department of Transportation, n.d.).

There are two types of MS4 Permits: Phase I and Phase II. The Phase I permit was established in 1990 by the US EPA (EPA, 2005b). The development of the Phase I permit mandated the use of the NPDES permit for medium and large cities housing populations of 100,000 or more (EPA, 2005b). As of July 2013, there are two MS4s in Massachusetts falling under this category, Boston and Worcester (EPA, 2013e). The US EPA published the NPDES Phase II Small MS4 Permit in 1999, requiring small MS4s both inside and outside of urbanized areas and small

construction sites to obtain a NPDES permit (EPA, 2013g). As of 2012, 238 systems are regulated by the current 2003 Massachusetts Phase II permit (EPA, 2012a).

Section 2.3.1 Six Minimum Control Measures

The MS4 Permit Program defines six minimum control measures that municipalities must incorporate into their SWMPs. According to the US EPA, the implementation of all six measures are expected to result in significant reductions of pollutants discharged into surface water bodies (EPA, 2005b). Municipalities must develop and implement different best management practices (BMPs) in order to fulfill the requirements of each of these control measures. “A stormwater BMP is a cost-effective strategy, measure, or engineered structural control designed to control the quantity and improve the quality of stormwater” (Harrop, 2001).

The six minimum control measures are:

- 1.) Public Education & Outreach
- 2.) Public Participation/Involvement
- 3.) Illicit Discharge Detection & Elimination
- 4.) Construction Site Runoff Control
- 5.) Post-Construction Runoff Control
- 6.) Pollution Prevention/Good Housekeeping (EPA, 2013g)

Public Education and Outreach requires municipalities to develop and implement a plan to educate the public on the negative impacts of stormwater runoff. Since stormwater runoff is generated from dispersed land surfaces – pavement, yards, driveways, and roofs – “efforts to control stormwater pollution must consider individual, household, and public behaviors” in order to thoroughly control pollution from these sources (EPA, 2012b). The US EPA suggests BMPs such as the creation of pamphlets and websites that will educate town residents on topics such as littering, disposing of trashing, and changing motor oil (EPA, 2012b).

Public Participation/Involvement mandates that municipalities provide opportunities for the general public to assist in the reduction of stormwater pollution. The goal of public involvement is to build on community capital – the wealth of interested citizens and groups – to spread the message on preventing stormwater pollution and to run group activities that restore and protect local water resources. This measure suggests BMPs such as the establishment of positions on local stormwater management panels and the creation of initiatives like volunteer monitoring programs and storm drain stenciling (EPA, 2012b).

The Illicit Discharge Detection & Elimination (IDDE) measure requires the utilization of a system to identify and eliminate illicit discharges to the storm sewer system (Treadway, Reese, & Noel, 2000). Under Federal regulations, an illicit discharge is defined as “any discharge to an MS4 that is not composed entirely of storm water” (EPA, 2005a, p. 1). This regulation has exceptions, including discharges resulting from NPDES-permitted industrial sources and discharges resulting from fire-fighting activities. Figure 5 shows wash water from a



Figure 5 - Potential Illicit Discharge
Retrieved from:
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=3

commercial car wash flowing into a storm drain, which is considered an illicit discharge because the wash water contains chemicals and is therefore, not composed entirely of storm water (EPA, 2012b). Unlike wastewater which flows through a treatment plant, stormwater and any illicit discharge flows through an MS4 and directly into a larger body of water without treatment. One illicit discharge BMP suggests municipalities map out their entire storm sewer system (EPA, 2012b).

Construction Site Runoff Control calls for the development of an erosion and sediment control plan for construction activities disturbing one or more acres of land (Treadway et al.,

2000). Once sediments from construction sites have reached larger bodies of water, they can



Figure 6 - Poorly Maintained Construction Site

Retrieved from:
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=4

“reduce the amount of sunlight reaching aquatic plants, clog fish gills, smother aquatic habitat and spawning areas, and impede navigation” (EPA, 2012b). Figure 6 shows a poorly managed construction site that is discharging sediment in their stormwater runoff. The measure suggests BMPs such

as the establishment of erosion and sediment control plans along with procedures to review and inspect construction site plans (EPA, 2012b).

Post-Construction Runoff Control involves “developing, implementing, and enforcing a program to address discharges of post-construction stormwater runoff from new development and redevelopment areas” (EPA, 2005b). As the world continues to develop and urbanize, the amount of impervious surfaces covering the Earth increases as well.

A study conducted by a group of researchers at Colorado State University estimated that between 2000 and 2030, there will be a 36% increase in impervious surfaces in the United States (Theobald, Goetz, Norman, & Jantz, 2009). Therefore, it is important for construction sites to consider BMP’s that reduce the effects of impervious surfaces on stormwater runoff. Some of these practices include using porous concrete and building infiltration islands in parking



Figure 7 - An Infiltration Island in a Parking Lot

Retrieved from:
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=5

lots. Porous concrete allows stormwater to infiltrate the ground underneath. Infiltration islands are strips of land used to break up the continuity of impervious surfaces. An example of an infiltration island can be seen in Figure 7 (above) (EPA, 2012b).

Pollution Prevention/Good Housekeeping mandates the creation of a plan to reduce or eliminate the pollutant runoff resulting from municipal operations. These municipal operations include winter road maintenance, road repairs, landscaping, and more (EPA, 2012b). A mandatory component of this control measure is the training of staff in prevention methods such as catch basin cleaning and street sweeping (EPA, 2005b).

The US EPA requires each municipality to submit an annual report which demonstrates how well the municipality has adhered to the requirements of the MS4 permit. The annual report requires municipalities to self-report on the BMPs used in their SWMPs along with any issues of non-compliance (Harrop, 2001). There are five columns in the annual report: description of the BMP, department responsible for the BMP, measurable goals for the completion of the BMP, progress on goals, and planned activities for BMP.

Section 2.3.2 Permits in Massachusetts

The circumstances surrounding MS4 permits in Massachusetts are complex due to the fact that the US EPA issues permits for the state. Most other states have the authority to issue their own individual MS4 permits (MassDEP, 2013). The active Phase II permit for Massachusetts was issued on May 1st, 2003. The CWA limits the term of the permit to five years unless the issuer agrees to extend the permit (EPA, 1977). The first permit year of the 2003 MA permit ended on April 30th, 2004. Due to extenuating circumstances, the 2003 MA permit term was extended past five years. In 2010, the US EPA released a new draft permit. The typical process for a draft

permit involves notifying the public of the draft permit and allowing for public comment on the permit particulars. After this period, the draft permit can be reissued with changes based on the public feedback (MassDEP, 2013). However, the 2010 draft permit was abandoned in 2011 due to heavy disapproval from municipalities on the increased specificity of the draft permit (EPA, 2013f). Frederick Civian of the MassDEP expects the US EPA to release an updated permit by mid-2014 (Civian, October 29, 2013).

The US EPA has recently released the 2013 New Hampshire (NH) Small MS4 Draft General Permit. Frederick Civian, along with many others, believes that this draft permit serves as a strong indicator of what will be included in the upcoming Massachusetts permit (Civian, October 29, 2013).

Section 2.3.2.1 Illicit Discharge Detection and Elimination

The 2013 NH draft permit has far more detailed control measure requirements when compared to the active 2003 MA permit (EPA, 2003b) (78FR27964). Specifically, the third control measure, IDDE, has been drastically expanded. For example, the 2003 MA permit requires only outfalls and receiving waters to be mapped, while the 2013 NH draft permit requires municipalities to delineate their catchment areas, meaning that the interconnections between all catch basins and outfalls must be mapped out, including pipes and manholes (78FR27964). “A catchment is defined as the area that drains an individual development site to its first intersection with [an outfall]” (Center for Watershed Protection, 1998). After delineating all catchment areas, the 2013 NH draft permit requires municipalities to priority rank the catchment areas based on their potential for illicit discharge. The ranking is based on numerous factors, including chemical levels, usage of receiving waters, and density of runoff generating sites. The 2003 permit mandated priority ranking of areas but provided no criteria for doing so. Accurate ranking will

allow municipalities to prioritize the screening and investigation of catchment areas (EPA, 2013a).

Additionally, the standards for outfall interconnection screenings/samplings and catchment investigations have been raised. In the 2003 permit, only the planned procedures for screenings and investigations are required in the annual report. The 2013 NH draft permit requires proper documentation and reporting of each of the inspections and investigations conducted in the permit year. Inspections and investigations also have more criteria to determine if further action is needed on the subject outfall or catchment area (78FR27964). The US EPA created a document summarizing the changes between the 2003 MA general MS4 permit and the 2013 NH draft permit as a resource to municipalities (EPA, 2013h). Similarly, the MassDEP has been trying to provide resources to municipalities, when possible, as they are preparing for the upcoming Massachusetts permit.

Section 2.3.3 The Role of the MassDEP

While the MassDEP plays a major role in the compliance process of the MS4 permits, the US EPA has the primary authority for issuing and enforcing all NPDES permits in Massachusetts (EPA, 2013i). The MassDEP has the option to co-issue these permits with the US EPA, giving them some power to enforce the permit requirements. However, despite its budgetary constraints, the MassDEP currently acts as a liaison for the municipalities and the US EPA to help facilitate municipal compliance with the MS4 permits.

Section 2.3.4 Issues with Compliance

Although the MassDEP works to serve as a resource for Massachusetts municipalities, many still face issues with MS4 permit compliance. The ambiguous language used in defining standards for specific MS4 permit requirements can be challenging for municipalities to interpret (Barat,

Chin, and Feraco 2012). For example, certain good housekeeping practices defined in the permit specify how often facilities should be inspected, but give no specific guidelines for the inspection (Wagner, 2006).

The MS4 permit system application uses a “performance based” regulatory approach, which means that municipalities are given a lot of freedom to develop their own BMPs as long as requirements are fulfilled (EPA, 2005b). However, this lack of guidance means that municipalities must put more time and resources into developing a SWMP that fits each of their situations. Furthermore, many communities do not have the funds and resources available to implement the extensive programs required by the MS4 permit (Andreen, 2004). In response to the 2010 draft MS4 requirements, Adam Gaudette, Administrator for the Town of Spencer, MA stated that, "Fitting new requirements in budgets has been difficult, if not impossible" (Spencer, 2012).

The lack of resources in certain municipalities leads to many difficulties when trying to fulfill all of the MS4 permit requirements. For example, a town may not have the manpower to survey and inspect construction sites or clean catch basins. Additionally, towns may lack the personnel to develop different public education and involvement programs from scratch (Bates, Butcher, Gillespie, & Holbrook, 2002).

The US EPA enforces compliance with the MS4 requirements by heavily fining towns that demonstrate weak programs. For example, the city of Gardner, MA was fined \$60,000 by the US EPA in 2008 for failure to comply with the 2003 MS4 permit requirements (Spencer, 2012). The extensive funds required to implement stormwater mitigation practices is one of the core obstacles to municipal compliance. The fines for noncompliance create an additional burden on the already limited budgets of the municipalities.

Section 2.3.5 Central Massachusetts Regional Stormwater Coalition (CMRSWC)

In order to provide financial assistance to municipalities, a statewide grant program was developed in 2012, titled the Community Innovation Challenge (CIC) Grant. This grant program provides funding opportunities for the 351 cities and towns in the Commonwealth of Massachusetts, while encouraging innovation and municipal collaboration between neighboring communities (Massachusetts, 2013a). Thirteen communities within Central Massachusetts created the Central Massachusetts Regional Stormwater Coalition (CMRSWC) and applied for funds. In 2012, these municipalities received \$310,000 to complete a project titled “Regionalizing Municipal Storm Water Management in Central Massachusetts through Collaborative Education, Data Management, and Policy Development”. In 2013, the coalition received an additional \$115,000 for their renewed grant application with the addition of seventeen new municipalities.

In a combined effort of resources, these communities were able to design improved stormwater management systems and educate the public on the issue of stormwater. The CMRSWC works with two consultant companies: Verdant Water and Tata & Howard. The municipalities hold monthly steering committee meetings to discuss future plans for the coalition, as well as an annual training session to educate municipal officials on the most current methods for stormwater management. The CIC grant also allowed the CMRSWC to purchase Global Positioning System (GPS) surveying equipment for their communal use to assist with the mapping requirements of the current and upcoming MA MS4 permits (Massachusetts, 2013b). The coalition invested in two Leica GPS units to be used on a rotating schedule between all the municipalities. Although these units are very expensive, they are extremely accurate in recording locations. In addition to the Leica units, the coalition purchased an Asus tablet for each of the municipalities. The Asus tablet is a smaller, less expensive unit that is also less accurate than the

Leica tablet. Both tablets function as a mobile computer for fieldwork. The CMRSWC works with PeopleGIS, a global information systems consultant company that connects GPS locations recorded with the tablets to interactive maps. PeopleGIS has also set up inspection forms for catch basins and outfalls that can be completed using either of the units. Through the collaboration of resources, the CMRSWC helps to improve the stormwater management programs of the 30 municipalities within Central Massachusetts.

Section 2.4 Improving Stormwater Management

With constraints on resources, some municipalities struggle to comply with the six control measures. The MassDEP believes that providing additional assistance to the municipalities will improve their SWMPs. To aid these municipalities with MS4 compliance, the MassDEP has collaborated with Worcester Polytechnic Institute (WPI) students to help improve SWMPs throughout Central Massachusetts.

Section 2.4.1 Past Projects

In early 2012, a team of WPI students created a database on Zoho, an online data management service (Abdelfattah, Gagnon, and Koumbaros 2012). The database was designed to help municipalities organize all of their tracking data and other information needed to comply with the 2010 draft MA MS4 permit. The purpose of the Zoho database was to assist municipalities with storing all of the necessary data for the US EPA annual report.

Later in 2012, a second team of WPI students was tasked with aiding the municipalities with compliance. These students assisted the towns of Charlton, Shrewsbury, Dudley, and Millbury with the GPS mapping of outfalls (Barat et al., 2012). This team also helped explain the MS4 permits to city engineers who were unfamiliar with the 2010 draft MS4 permit requirements and

attempted to identify certain issues with the permits that were especially problematic for these municipalities. (Barat et al., 2012).

One issue identified was that entering data into the annual report was problematic and taxing on town employees. The municipalities lacked the personnel to repeatedly enter data into different reports and desired an easier method to file the annual report. Municipalities also struggled to create an effective education plan for residents. The municipalities believed that the US EPA should supply a standardized plan. This would reduce the additional effort required by the municipal employees to create such a plan (Barat et al., 2012).

Also, there are several instances of vague wording in the permits that confused municipalities. For example, it was unclear when wet-weather water quality sampling should be taken – during the wet weather or after (Barat et al., 2012). This team worked to increase municipal understanding of the draft 2010 MS4 permit while also assisting municipalities to improve their SWMPs.

Section 2.4.2 Current Project

As a new permit will be issued for Massachusetts in 2014, our project focused on preparing Central Massachusetts municipalities for the extensive, upcoming requirements. With the already existent strain on resources, municipalities will be hard-pressed to meet all the new requirements. To help with this issue, the MassDEP in conjunction with Central Massachusetts municipalities gave six additional WPI students the opportunity to continue improving stormwater management programs in the region. Both teams worked with the 2013 NH draft permit to gain a better understanding of what the new MA permit might consist of. Our team worked with the three municipalities which are part of the Central Massachusetts Regional

Stormwater Coalition: Auburn, Holden, and Upton. Our project focused specifically on the upcoming requirements listed in the IDDE control measure.

Section 3.0 Methodology

The overall goal of this project was to improve stormwater management programs (SWMP) in municipalities within Central Massachusetts. We worked with the Massachusetts Department of Environmental Protection (MassDEP) to help the towns of Auburn, Holden, and Upton prepare for upcoming MS4 permit requirements. In order to successfully complete our goal, we achieved the following objectives: 1) assess the current success of municipalities' stormwater management programs; 2) act as an informational resource to municipalities on stormwater management; 3) assist municipalities with mapping and delineation of catchment areas, and 4) create a catchment priority ranking database.

In this chapter, we describe our methodological approach to accomplishing the project goal and four project objectives. In sections 3.1 to 3.4 we talk about each objective and the tasks completed to achieve them.

Section 3.1 Objective 1: Assess Stormwater Management Programs of Auburn, Holden, and Upton

Our first objective was to assess the current success of the included municipalities' stormwater management programs. The United States Environmental Protection Agency (US EPA) describes six different minimum control measures that each municipality must fulfill in order to comply with the Clean Water Act (CWA). The minimum control measures are:

1. Public Education and Outreach
2. Public Participation/Involvement
3. Illicit Discharge Detection and Elimination (IDDE)
4. Construction Site Runoff Control
5. Post-Construction Runoff Control

6. Pollution Prevention/Good Housekeeping (EPA, 2003c)

In order to gain a full understanding of the active requirements that municipalities must meet under each control measure, our team examined the 2003 Massachusetts general permit. While analyzing the permit, we compiled notes of the requirements to serve as convenient reference while assessing the SWMPs of the municipalities.

Each municipality has its own environmental conditions and stormwater problems that must be taken into consideration. To effectively assess each individual SWMP, our team conducted content analysis of each municipality's 2013 annual report- the stormwater management reporting method required by the US EPA. This type of self-reported, in-depth data featured in an annual report provided us with a strong starting point in understanding which best management practices (BMPs) a municipality has utilized to meet the requirements of each control measure since the beginning of the permit term. Also, conducting content analysis of each 2013 annual report involved few resources and only required our time working on the project (Berg & Lune, 2012, p. 375). For each of the three annual reports we analyzed, we created a spreadsheet detailing which permit requirements were clearly met by the BMPs listed in the annual reports.

Analysis of the annual reports provided us with broad areas of compliance but did not identify specific obstacles that municipalities encountered (Kinney Engineering, 2013). For example, if a municipality did not have the manpower to implement a public education program, the annual report will only tell us that there was no educational program and will not describe whether there were circumstances that caused that lack of a program or whether it was a municipal oversight. For this reason, we also conducted interviews with municipal employees.

The MassDEP scheduled days that our team spent in Holden, Auburn, and Upton. Our team was also provided with the contact information of a stormwater official in each of the towns. In the town of Holden, we interviewed Isabel McCauley, Senior Civil Engineer and the leading manager of stormwater. Through Isabel McCauley's recommendation, we interviewed John Woodsmall, the Director of the Department of Public Works for Holden. In the town of Auburn, we interviewed Joanna Paquin, the Assistant Town Engineer. Lastly, we interviewed Jeffrey Thompson, the Director of the Department of Public Works for the town of Upton.

Municipal employees were the primary source of information because they work with stormwater management on a daily basis and are familiar with any issues a municipality has with permit compliance. These interviews were semi-standardized, meaning that we were able to probe far beyond the prepared questions depending on the needed detail of response (Berg & Lune, 2012, p. 110). The ability to ask questions throughout the interview allowed our team to fully understand the problems each municipality may have had with permit compliance. During interviews, we asked about any requirements that were not clearly met in the previously analyzed annual report. After assessing the municipality's compliance with the 2003 permit, we asked about their thoughts on the 2013 New Hampshire (NH) draft permit and their plans for dealing with the upcoming Massachusetts (MA) permit (See Appendix A for interview questions). Through interviews and content analysis, our team gained a comprehensive understanding of each municipality's SWMP and subsequently compiled a spreadsheet of requirements met from the 2003 MA MS4 permit. The spreadsheet includes two columns: information gained from annual reports and information gained from interviews. In Chapter Four, we describe our findings on each towns' current compliance status.

Each municipality's compliance was an indicator of their preparedness for the upcoming MA permit. During our interviews with municipal employees, we asked about any concerns they have with the 2013 NH draft permit and how prepared their towns would be if it was implemented in Massachusetts. The findings that we compiled from this objective provided the MassDEP and US EPA a sample of common trends in Central Massachusetts municipal compliance with the MS4 permit.

Section 3.2 Objective 2: Serve as an Informational Resource for Municipal Employees

In order to assist municipalities on compliance with the MS4 permit, we served as a source of information to municipal employees in the towns of Holden, Upton, and Auburn. To be an effective aid, we immersed ourselves in the field of stormwater.

As we had already examined the 2003 MA general permit, we now had to review the IDDE section of the 2013 New Hampshire (NH) draft permit as our project only required an understanding of the IDDE portion of the upcoming permit. We met with Frederick Civian and Cheryl Poirier, stormwater experts at the MassDEP, to further analyze the IDDE section of the 2013 NH draft permit.

One of the most time consuming tasks of the IDDE section is completing the mapping of stormwater infrastructure. We assisted municipalities with this requirement while conducting fieldwork within each town. While working in the town of Auburn, Joanna Paquin, Assistant Town Engineer, trained us on the Leica tablet, a Global Positioning System (GPS) unit used for mapping stormwater infrastructure. In the town of Upton, we worked with Aubrey Strause, a stormwater consultant who manages the Central Massachusetts Regional Stormwater Coalition (CMRSWC). In the field, she demonstrated a more hands-on application of stormwater concepts,

including the practical use of different stormwater mitigation BMPs. She also trained us on how to use the PeopleGIS forms for outfall and catch-basin inspections. These forms are used by all 30 towns in the coalition to keep track of the health of their stormwater infrastructure.

Additionally, we attended the CMRSWC training, an annual congregation of municipal employees from the 30 municipalities of the coalition to receive training on the newest stormwater regulations and practices. At the training, we became more familiar with the PeopleGIS system and the Asus and Leica tablets.

Using this background knowledge, we were amply prepared should any mapping or compliance related questions arise. Although municipal employees did not have prepared questions for us, we were able to address most issues that arose during the time we spent with them. Information we provided included specifics of the six minimum control measures of both the active 2003 Massachusetts permit and the 2013 NH draft permit, different BMPs, and usage of the tablets. Serving as a convenient source of information on the MS4 permit helped conserve time in the busy schedules of municipal employees.

By serving as a resource of information to the three municipalities, we were able to answer questions municipal employees had on the MS4 permit while also facilitating the exchange of information between different municipalities.

Section 3.3 Objective 3: Assist Municipalities with Mapping and Delineation of Catchment Areas

As part of the third control measure of the 2003 MA permit, Illicit Discharge Detection & Elimination, municipalities must map the locations of all outfalls. The 2013 NH draft permit also requires the delineation of catchment areas, meaning that catch basins, manholes, pipes, flow of water, and interconnections between MS4s need to be documented (78FR27964). Knowing the

exact locations of catch basins, outfalls, and the path of flow allows a municipality to more easily identify where stormwater pollution is originating. With this information, municipalities can better mitigate stormwater pollution.

Although mapping out MS4s is an important step in managing stormwater runoff, it is also a time consuming and repetitive process. Many municipal engineers and public works employees do not have the time to map out all of the catch basins and outfalls in their municipality. To reduce the workload of municipal employees, we worked with Holden, Upton, and Auburn to complete the mapping of catch basins, outfalls, and flow paths in each municipality.

The Central Massachusetts Regional Stormwater Coalition allowed us to use their two Leica tablets when mapping. According to Aubrey Strause, the CMRSWC chose the Leica because it is more accurate than the Garmin unit – the other system the coalition considered – and is able to automatically collect GPS data. The Leica tablet has significantly less error in its GPS readings and provides dependable elevation information. However, most municipalities do not own their own Leica tablet. The two tablets the coalition owns are lent out to the 30 municipalities of the coalition on a rotating schedule. On some of the days we mapped for municipalities, the Leica tablets were unavailable.

For these occasions, we used the MassDEP's Trimble GPS unit or a town's Asus tablet. Whether we used the Leica, Trimble, or Asus unit, our objective was to help prepare municipalities for the newer and more extensive mapping requirements of the upcoming MS4 permit by mapping outfalls, catch basins, and flow directions for municipalities.

Section 3.4 Objective 4: Create a Catchment Priority Ranking Database

Our final objective was to create an interactive database that would help municipalities rank their catchment areas as part of the IDDE control measure of the 2013 NH draft permit. Initially, our

objective was to improve the Zoho database that had been previously created by WPI students. Zoho is an interactive database that was designed to help municipalities organize all of their stormwater tracking data and other information needed for the US EPA annual report. However, municipalities do not currently utilize the database to store stormwater management information because they did not want to adopt a new method of storing MS4 data that would replace their current storage system. We interviewed Isabel McCauley of Holden, Charlton's Conservation Agent Todd Girard, and Frederick Civian of the MassDEP in order to understand why municipalities have chosen not to use the Zoho database for storing and managing their stormwater data.

In collaboration with the MassDEP, we determined that creating a new more specific database would be more beneficial to municipalities than trying to further improve the Zoho database. While analyzing the 2013 NH draft permit, we found that the IDDE section had significantly more technical and complex requirements. As a result, our team compiled a document comparing the IDDE requirements of the 2013 NH draft permit and the 2003 MA general permit. Although the US EPA developed their own comparison document, we designed the comparison chart to focus solely on the IDDE section of the permits in simplified language (EPA, 2013d).

In collaboration with the MassDEP, our team also decided to create a new database to help municipalities with the catchment area priority ranking requirement of the IDDE control measure in the 2013 NH draft permit. By accurately ranking the catchment areas based on the criteria listed in the permit, the municipalities will be aware of which areas need to be inspected more frequently. The 2013 NH draft permit requires that each catchment area be ranked based on criteria listed in the permit. However, it can be very time-consuming for municipal employees to

actively consider each ranking criterion when prioritizing catchment areas. The database facilitates the priority ranking process for municipal employees by automatically considering each criterion.

In order to help determine which database infrastructure to use, we conducted research on the different programming language options available. We also received suggestions from Craig Shue, Ph.D., a computer science professor at Worcester Polytechnic Institute. Once we decided on the basic infrastructure for the database, we began asking municipal employees what sorts of issues they anticipated with the new requirement of having a catchment area priority ranking system. During these interviews, we also asked municipal employees for different suggestions and features that they thought would be helpful to incorporate into the database. We received many useful points of advice from several different municipalities that we did not originally think of ourselves and gradually added these new features throughout the course of the project. The goal of the database is to simplify the complexities of a priority ranking system as much as possible for municipal employees.

Lastly, one of the largest tasks we faced throughout the development of the database was interpreting the permit's catchment ranking requirements. In order to have the database automatically carry out this process, we first needed to understand the requirements ourselves. Unfortunately, the priority ranking portion of the 2013 NH draft permit is confusing when describing the process for how to properly rank a catchment area. After reading through this portion of the permit several times and meeting with MassDEP officials, we did not grasp a full understanding of the priority ranking process. We also met with our advisor, Corey Dehner, Ph.D. & J.D., to discuss the language of the permit. Despite the help we received, the process was still unclear to us, so, with the assistance of our sponsor, we decided to reach out to Newton

Tedder, the MS4 permit writer for US EPA Region 1(New England). Newton Tedder provided valuable information for fully understanding the priority ranking process that will be detailed in the upcoming MA general MS4 permit. He explained the process using a flow sheet created by the US EPA (EPA, 2013d). With the help of this document, we created our own flow sheet to supplement the database. In chapter four we further discuss the assistance we received from Newton Tedder and the priority ranking process.

Section 3.5 Conclusion

Stormwater runoff is a growing environmental problem and needs to be properly managed to reduce pollution and ensure the safety of aquatic ecosystems. The main research goal of our project was to improve Central Massachusetts municipality SWMPs. By working with the MassDEP and Central Massachusetts municipalities, we aimed to prepare municipalities for the upcoming MA general MS4 permit and add our discoveries to the ongoing efforts against stormwater pollution.

Section 4.0 Findings and Recommendations

Throughout the completion of research, interviews, and fieldwork, our team developed findings and recommendations to help improve Central Massachusetts stormwater management. Speaking with municipal employees gave us a strong understanding of municipal compliance with the active 2003 Massachusetts (MA) MS4 permit and the different stormwater management programs (SWMPs) within various municipalities. In anticipation of the upcoming MA MS4 permit, our team examined the 2013 New Hampshire (NH) draft MS4 permit and discussed the requirements with MassDEP and other stormwater officials. We analyzed municipal concerns about the future MS4 permit requirements and assisted municipal employees by creating a priority ranking database and by mapping stormwater infrastructure. After immersing ourselves in the field of stormwater management, we developed findings and recommendations that provide valuable first-hand insight into the challenges municipalities face with the upcoming permit.

In this findings chapter, we introduce multiple findings that arose from our data collection and fieldwork and relevant recommendations. In Section 4.1, we analyze Holden, Auburn, and Upton's compliance with the 2003 MA MS4 permit and each of their 2013 annual reports. In Section 4.2 we discuss municipal concerns when preparing for the upcoming permit and trends we observed. We explain our analysis of the overall municipal understanding of stormwater management and regional collaboration in Section 4.3. We detail the development of the Catchment Area Priority Ranking System (CAPRS) Database, as well as an examination of the Catchment Area Priority Ranking requirement in Section 4.4. In Section 4.5, we compare the various types of mapping equipment we used throughout our fieldwork.

Section 4.1 Municipal Compliance with 2003 Massachusetts MS4 General Permit

Central Massachusetts' municipalities have different levels of preparedness for the upcoming MS4 permit, and different approaches to compliance with the active 2003 MA MS4 permit.

Since the upcoming permit is presumed to be far more specific and complex than the current permit, assessing compliance with the easier 2003 permit will be a clear indication of a town's ability to adapt to the new permit requirements. If a town fulfills all of the requirements of the 2003 permit, that town will be more likely to have the infrastructure in place to complete the additional requirements of the upcoming permit. Our team assessed the stormwater programs of Auburn, Upton, and Holden, Massachusetts.

Despite the fact that all three towns are located in Central Massachusetts and are members of the Central Massachusetts Regional Stormwater Coalition (CMRSWC), they have diverse land usage characteristics as illustrated in Table 3, below. Our team analyzed the land use maps and statistics for each of the three towns. Although Auburn is the smallest of the three towns, it is the most urbanized with 17.03% of its land being classified as impervious surface by the United States Environmental Protection Agency (US EPA) Region 1 Global Information System (GIS) Center (EPA, 2010a). Conversely, Upton is a mainly residential town, meaning that there is very little industrial and commercial land usage - only 6.5% of its land is classified as impervious (EPA, 2010c). Finally, Holden is the largest of the three towns we are working with in terms of square miles; however, the majority of its 36.33 total square miles is completely un-urbanized. Holden falls in between Auburn and Upton with 7.04% of its land classified as impervious surface (EPA, 2010b). Refer to Table 3 for a comparison of the three subject towns land use and impervious surface area (Bureau, 2013).

Table 3 - Land Usage Statistics

	Auburn	Upton	Holden
Total Square Miles	16.45	21.8	36.33
Impervious Square Miles	2.8	1.42	2.56
% Impervious	17.03%	6.5%	7.04%
Population	16,188	7,542	17,346
Population Density (per square mile)	984	346	477

The first step we took in assessing each town’s stormwater program was to examine the town’s 2013 annual stormwater report. Each town’s annual report contained a list of best management practices (BMPs) that the town has implemented since the beginning of the 2003 permit term. The annual reports also specified different BMPs that each town plans to carry out in the near future. Analyzing the annual reports of Holden, Auburn, and Upton gave us an initial understanding of the effectiveness of the respective SWMPs.

Section 4.1.1 Finding 1: Annual Reports Are Not an Accurate Representation of Permit Compliance

In the opening pages of the annual reports, each town summarized the overall compliance with the 2003 MS4 permit. Holden and Auburn each claimed that they were fully compliant. To assess each town’s compliance, we created a spreadsheet listing all of the 2003 permit requirements and the relevant actions the town was taking to meet them (a blank example of our spreadsheets can be found in Appendix B). Upton acknowledged that its’ mapping and administrative components were not meeting the requirements. The town of Upton has not

completed the mapping of all of its outfalls. However, the town explained future plans to complete the mapping requirement using the coalition's mapping equipment. In May of 2012, Upton approved a stormwater management bylaw (Upton, 2013). The bylaw created a committee that is currently working on four projects to meet the requirements listed in the following control measures: Illicit Discharge Detection & Elimination, Construction Site Runoff Control, and Post-Construction Runoff Control. One example that is in progress is the creation of a stormwater management plan application, which is mandated under the Construction Site Runoff Control measure of the 2003 MA permit. It will be required for developers working on a site larger than one acre or conducting a project that will alter drainage in the area. The application will ensure that developers have taken stormwater management into consideration.

Though the towns of Holden and Auburn each reported compliance with the 2003 permit, when we examined their stormwater management plans in detail, we found some shortcomings. We found that several requirements were not being met by the BMPs or plans listed. Similarly, Upton had some provisions missing that they did not previously acknowledge.

While analyzing the annual report of each town, a major trend appeared. Towns were unclear in reporting their plans for Illicit Discharge Detection & Elimination (IDDE) and Pollution Prevention & Good Housekeeping in Municipal Operations. One specific example is that none of the annual reports mentioned the basic priority ranking requirement. Despite the absence of these details in the annual reports, all three towns thought they were compliant with these requirements of the permit.

Upon interviewing municipal officials in each of the towns, it became evident that a system was in place to meet the missing requirements but it had not been clearly explained in their annual reports. In Holden, we met with the Senior Civil Engineer, Isabel McCauley. We met with the

Assistant Town Engineer of Auburn, Joanna Paquin. In Upton, we met with the Director of Public Works, Jeff Thompson. All three towns had an IDDE packet completed by a hired consultant.

Each town's IDDE packet contained much of the information required by the permit. However, this information was not presented explicitly in the annual report, thereby making the town appear to be noncompliant with that specific requirement. This means that the US EPA, when evaluating the annual report, will not be able to see that each town has an IDDE packet that meets the requirement. Clearly, annual reports are not an accurate representation of a town's compliance with the 2003 MS4 permit, as not all procedures are being properly reported.

Section 4.1.2 Recommendation 1: US EPA Standardized Reporting Form

The lack of information presented in the annual report is partly due to the flexibility of the reporting procedures. Municipalities are free to enter whatever information they feel necessary to demonstrate compliance without any standardized organization. We recommend that the US EPA provides municipalities with additional guidance on MS4 compliance reporting in the form of a standardized reporting form. This form should state each requirement and have columns for the municipality to fill out their current and future plans for it. If all requirements are explicitly stated by this reporting form, annual reports will be easier for municipalities to complete and will likely be more accurate.

Section 4.1.3 Finding 2: Vagueness of 2003 Permit Requirements Makes It Hard to Assess Compliance

While assessing the stormwater programs of Holden, Auburn, and Upton, we found it difficult to interpret the necessary procedures a town must carry out to achieve compliance with the 2003 MA MS4 permit. The IDDE section is one good example of how difficult interpretation can be. The section requires municipalities to have "procedures to identify priority areas," and lists

several examples of areas that could be classified as priority areas, such as older areas of a city or drinking water resources (EPA, 2003b). This requirement leaves open for interpretation what “procedures” are necessary and what defines an “area.” The permit also does not specify a system of how the ranking of areas should be accomplished. Our team met with Newton Tedder, Region One (New England) permit writer of the US EPA, to discuss MS4 permit requirements. He informed us that the permit language of the 2003 MA permit was written intentionally vague to give each municipality flexibility in their compliance plans. This resulted in confusion among municipalities because the procedures necessary for compliance were not explicitly stated. For example, one of the provisions for the Public Education & Outreach requires municipalities to communicate with residents on the issue of stormwater. Stella Tamul of the MassDEP stated that a simple street sign would suffice, as there is no specific procedure required (Tamul, December 5, 2013).

Although it appeared as if Holden, Auburn, and Upton complied with most of the permit, the vagueness of the permit requirements made it difficult to determine if the three towns were fully compliant with the 2003 MA MS4 General Permit.

Section 4.2 Municipal Reactions to the Upcoming MA MS4 permit

The US EPA is expected to release a new MS4 permit for Massachusetts in 2014, however a release date has not been finalized. In order to prepare themselves for this upcoming permit, municipalities have been looking at the recently released 2013 NH draft permit as a guideline for what the anticipated Massachusetts permit will require. With a new permit expected to be released, we decided it was important to gauge the reactions of municipal employees to the 2013 NH draft permit.

Section 4.2.1 Finding 3: Municipalities Are Lacking Time, Manpower, and Funds

From our interviews, we identified common concerns that all three towns shared. The towns all struggled with having enough resources to meet all of the new permit requirements. The granularity, that is the level of detail and specificity, of the 2013 NH draft permit demands far more time, manpower, and funding than municipalities are capable of providing. The requirements of the NH draft permit are drastically more extensive and detailed than those in the 2003 MA MS4 general permit. For example, when comparing the two permits, our team noted that the IDDE section went from being one page in length in the 2003 MA permit to being twelve pages in the 2013 NH draft permit.

Isabel McCauley, Senior Civil Engineer in Holden, MA, expressed concern about the number of detailed requirements in the 2013 NH draft MS4 permit (McCauley, November 12, 2013). For example, Isabel McCauley was particularly troubled with the mapping portion of the IDDE section of the NH draft permit. The new mapping provisions require towns to not only map outfalls as stated in the current permit, but also to map catch basins, catchment areas, and direction of flow. Isabel McCauley believes these new requirements will be difficult to complete within the two year time period mandated by the permit. Similarly, Joanna Paquin, Assistant Town Engineer in Auburn, MA, believed that delineating and mapping catchment areas would pose a problem for municipalities (Paquin, November 14, 2013) . Her reasoning was that most municipalities do not have a large enough staff to be able to dedicate time solely to stormwater management.

While we were mapping catch basins, outfalls, and catchment areas for the three municipalities, these issues with time became prevalent. In Holden, it took us an entire day to delineate one catchment area - Industrial Drive, a street with only industrial businesses. Figure 8 shows a map

depicting a neighborhood of Holden that we delineated. The water in this area is flowing to the bottom right corner of the map.



Figure 8 - Map of Delineated Portion of Holden

In Upton, catch basin and outfall mapping for two small suburban neighborhoods took us approximately four hours to complete. We mapped 87 catch basins and outfalls. Municipal employees with many responsibilities outside of stormwater management will not have the time to delineate the numerous catchment areas within their municipality, especially if the municipality is understaffed and has not already mapped most of its MS4 infrastructure. The amount of infrastructure varies greatly depending on the municipality. The number and size of catchment areas depend the number of outfalls within a municipality.

Another example is the development of a maintenance schedule for municipal infrastructures such as parks and roadway drainage systems, which is required under the 2003 MA Pollution Prevention & Good Housekeeping in Municipal Operations control measure. Through interviews, we determined that all three towns had some form of a schedule to maintain the stormwater infrastructure. However when discussing specifics of the schedule, it was evident that

the three towns were not adhering to the schedules they had made. The main reasoning for this was a lack of manpower. Isabel McCauley stated that Holden plans to have each catch basin cleaned at least twice every year (McCauley, November 12, 2013). However, she also noted that this often is not possible because of Holden's small workforce. These public works employees have several other duties to other departments and cannot devote all of their time to catch basin cleaning, as it is not as urgent as other tasks. Joanna Paquin told us that Auburn only had their catch basins cleaned when extra money was left in the budget (Paquin, November 14, 2013). Auburn would hire the overstretched public works employees on weekends as overtime. However, it is unlikely to have money left in the budget every year.

The maintenance requirement is only a single provision within one of the six control measures. With municipal resources being strained for just the mapping and maintenance of catch basins, the more extensive provisions of the upcoming permit such as priority ranking, outfall screenings, and public education programs will only overtax the time, manpower, and funding a municipality has available.

Section 4.2.2 Finding 4: Municipalities are Dependent on Environmental Consultants
Holden, Auburn, and Upton all used environmental consultants in the past to help complete their SWMPs. We found that all three municipalities needed assistance to comply with the 2003 MA MS4 permit requirements due to a lack of manpower and time. Each town received a packet detailing their IDDE plan as well as a map of the identified outfalls from their hired consultant. By hiring an environmental consultant, a municipality is relieved of a great deal of work that is required by the 2003 MS4 permit.

Although consultants can be a valuable resource, municipalities can become dependent on them to maintain their SWMPs. Municipal employees become less active in stormwater management

when consultants are utilized. Since the permit requirements are being completed by the consultant, municipalities focus on other projects and, as a result, overlook the importance of continually engaging in stormwater management activities. As the municipal officials become less involved, the municipality’s stormwater management program does not move forward after the completion of the consultant’s work. Therefore, the need for a consultant returns when new requirements are mandated, creating a cyclical effect. All of the employees we interviewed stated that, often times, consultants are expensive to hire. Isabel McCauley informed us that Holden’s process to gain funding for hiring consultants is a difficult one, which included presenting in front the town’s board (McCauley, November 12, 2013). This process is similar in other towns and does not guarantee funding after completion. A summary of the advantages and disadvantages of hiring an environmental consultant can be seen in Table 4 below.

Municipalities, without the resources to complete the permit requirements on their own, rely on funds to hire consultants.

Table 4 - Advantages and Disadvantages of Utilizing Environmental Consultants

Advantages	Disadvantages
Time Efficient	Expensive
Relieves Work From Municipal Employees	Municipal Employees Become Less Involved in Stormwater Management

Section 4.2.3 Recommendation 2: Incremental Changes to Stormwater Regulations
 Our experiences in Holden, Auburn, and Upton, as well as our time at the CMRSWC training, allowed us to gain a partial view into the overall state of Central Massachusetts SWMPs. We observed that municipalities generally had a positive attitude, meaning that they were not

resistant towards advancing stormwater regulations. Our interview with Jeffrey Thompson, Director of Public Works in Upton, MA, affirmed our observation. He stated that the town of Upton was fulfilling the requirements of the permit not just for compliance reasons (Thompson, November 21, 2013). He believes that stormwater and mapping information will be valuable to Upton's Department of Public Works and that completing the requirements will be beneficial to municipalities. For example, if a sewage pipe breaks, the public works employees of the municipality will be able to easily identify areas of stormwater infrastructure that may be affected. This would help contain the spread of pollutants. Although the work that the upcoming permit mandates will have a positive effect in cleaning municipal stormwater, the challenges that the permit will present may have a negative effect on the attitude of municipalities.

Overwhelming the municipalities with regulations that require extensive resources to fulfill will damage both the municipality's and the residents' initiative to have cleaner stormwater. The 2013 NH draft permit has expanded greatly on all six of the control measures in the 2003 MA permit.

With insight from John Woodsmall, Director of Public Works in Holden, MA, we recommend that new permits should either greatly expand on a few control measures or slightly expand on all of the control measures (Woodsmall, November 12, 2013). Smaller changes to the permits are more likely to be accepted by the public and officially issued as general permits. One downside is that multiple permits with smaller changes will have to be issued more frequently. This means that more time and effort would be required to create additional permits. However, we believe that more progress would be made in stormwater management as more municipalities would be willing to take the steps necessary to comply with the smaller changes, as opposed to major changes that are often rejected in the draft stage. By making incremental changes to the current

permit, it allows a municipality to more easily adapt to the permit conditions without straining its resources.

Section 4.3 Serving as an Informational Resource to Municipalities

Our second objective was to serve as an informational resource to municipalities. During our time within each town, we exchanged information such as BMPs and thoughts about the new requirements. While exchanging information amongst municipalities, we made observations regarding the overall knowledge of stormwater officials and the utility of regionalization.

Section 4.3.1 Finding 5: No Uniformity in Municipal Stormwater Management Programs

Between our interactions with employees from Upton, Holden, and Auburn and employees from other towns we have encountered through the coalition meetings, we found that there is no uniformity in municipal SWMPs. There is a disparity in the interpretations of the differences between the current 2003 MA permit and the more recent draft permits – 2010 in MA and 2013 in NH - as well as a disparity in the best way to comply with each requirement. We observed that there is no specially designated position, within a municipality, for stormwater management. For example, in Holden, the primary manager of stormwater is Senior Civil Engineer, Isabel McCauley, where in Auburn, the role of stormwater management is given to the Assistant Town Engineer, Joanna Paquin. Furthermore, in Upton, the role of stormwater management falls under the Director of the Department of Public Works, Jeff Thompson. This inconsistency makes it difficult to clearly define the roles and responsibilities of a stormwater official, considering stormwater is just one of the many components of their positions.

The stormwater officials we worked with had varying levels of knowledge on the topic of stormwater and the MS4 permit regulations. The differing levels of knowledge can be attributed to the varied backgrounds of each individual and their unique interpretations of the permit

requirements. For example, each municipality had different views on conducting public education. In their annual report, Upton emphasized brochures and signage as well as a collection plan for household hazardous waste. Meanwhile, Holden showed an extensive visual aid program by providing educational documentaries and advertisement on their town's local access cable station. While Auburn had smaller-scale educational programming, it also published a quarterly article in the local newspaper. All of these methods achieve compliance, even though they have varying levels of effectiveness.

Another example of non-uniformity became evident while our team was completing outfall inspections with Aubrey Strause, CMRSWC's stormwater consultant and owner of Verdant Water, in Upton (Strause, November 18, 2013). While completing an inspection form on PeopleGIS using the Asus tablet, we learned about a common misconception that all outfalls are just pipes. Aubrey explained to us that swales are also considered outfalls. A swale is a redirection of the flow of stormwater to reduce flow speeds and promote infiltration (Davis, 2005). She told us that many municipalities still only consider outfalls to be pipes. Aubrey also informed us about the "lack of awareness of municipal officials about what constitutes an illicit discharge"(Strause, November 18, 2013). Examples like these prove that there is much disparity in the levels of stormwater knowledge among stormwater officials.

Section 4.3.2 Recommendation 3: Regionalization

We recommend that municipalities regionalize to share information and assist each other in their stormwater management. Regionalization is a partnership developed between municipalities to achieve a common goal (Strause, December 5, 2013). After observing the operations of the CMRSWC, we found that knowledge and resources can be more easily shared through town

collaboration. There are many benefits to regionalization, including the alliance of efforts, funds, and resources to assist in the management of stormwater.

Jeff Thompson of Upton described the benefits of regionalization when he stated that it does not take ten times the effort to manage ten times the area (Thompson, November 21, 2013). Through collaboration, municipalities can learn from each other and share BMPs in order to more easily improve their SWMPs. One example of this collaboration was our experience with the Asus tablet. While working in Upton with Aubrey Strause, our team was able to learn about various features on the Asus Tablet, including the tablet's ability to GPS map a point while completing an inspection form. During our second visit to Holden, we were able to show this feature to Isabel McCauley. Although she was the first municipal employee to show our team how to fill out a catch-basin inspection form on the tablet, she was unaware of the tablet's ability to map.

In order to educate stormwater officials within the CMRSWC, the coalition organizes an annual training. This year, the town of Holden offered to host the event, which included a presentation from Jim Esterbrook of PeopleGIS and training on the Leica units. The training sessions were recorded for any municipal officials of the coalition who were not able to attend the event. At the training we attended, US EPA and MassDEP officials were present, providing municipal officials the opportunity to discuss any concerns regarding the upcoming permit. This exemplifies the benefits of collaborating efforts and resources to further the management of stormwater in a region.

Aubrey Strause informed our team that by documenting municipal cooperation and partnerships, municipalities can improve the chance of receiving funding from outside grants (Strause, December 5, 2013). For example, after receiving funds from the Community Innovation Challenge (CIC) grant in 2012, the CMRSWC was able to purchase two Leica units to share

amongst the group on a rotating schedule. (Massachusetts, 2013b)The municipalities of the coalition were able to conserve money as opposed to purchasing their own equipment, as one unit cost \$13,500 and the other \$10,500 (Strause, December 5, 2013). There are also additional fees for subscription to the GPS network, wireless internet service, and extra batteries. Now municipalities have access to advanced mapping equipment that they may not have had access to without regionalization.

Although there are numerous benefits to regionalization, we recognize there are also drawbacks associated with this practice, including the additional time and effort required as well as the sometimes conflicting views on the best way to share resources and expenses. As an example, Frederick Civian stated that a small municipality might not want to contribute the same amount of funds as a larger town towards a shared expense (Civian, December 5th, 2013). It is also crucial that municipalities arrange consistent meetings and remain organized after regionalizing, requiring additional time and effort. In order to assist with the organizational aspect, the CMRSWC hired two consultants, Matt St. Pierre of Tata and Howard and Aubrey Strause of Verdant Waters. Despite the potential drawbacks, we believe that regionalization is a beneficial approach that municipalities should utilize to comply with the upcoming Massachusetts MS4 permit. The benefits and drawbacks of regionalization can be seen below in Table 5.

Table 5: Potential Benefits vs. Potential Drawbacks to Regionalization

Potential Benefits	Potential Drawbacks
Sharing of Information	Organization of Many Municipalities
Reduces Costs for Each Municipality	Conflicting Views on Best Ways to Share Costs
Sharing of Resources	Conflicting Views on Best Ways to Share Resources

Section 4.3.3 Recommendation 4: US EPA Yearly Stormwater Training

We recommend that the US EPA mandates a yearly stormwater training for all stormwater officials. The US EPA website offers several trainings on stormwater. However, many municipalities are unaware of the existence of or the value of these trainings. Due to the variation of background knowledge held by stormwater officials, it would be beneficial to mandate a yearly training to ensure that at least one official from every municipality has a full understanding of stormwater regulations. This training should include a breakdown of the permit requirements and should exhibit effective, modern BMPs. To be convenient and easy to manage, the training should be offered online. As municipal employees have varying schedules, it would not be feasible to ask an employee from every municipality to congregate for a training. By hosting it online, the training will be easily accessible as well as being inexpensive for the US EPA to maintain. With a new permit expected to be released, training will be very essential in helping municipalities understand the upcoming requirements.

Our group developed a comparison chart that can be used as an example of information in the suggested training. It acts as an easy-to-read comparison between the IDDE requirements of the 2003 MA permit and the 2013 NH draft permit (See the comparison chart in Appendix C).

Placing both sets of requirements side by side encourages municipalities to be more active with the IDDE control measure by illustrating the extensiveness of the new IDDE requirements. Subsequently, the chart shows the extra effort that will be necessary to comply. The permit language is simplified and less technical in the comparison chart. Mandating an educational training will help ensure that municipalities are prepared for the upcoming permit.

Section 4.4 Catchment Area Priority Ranking System (CAPRS) Database

As stated previously, the 2013 NH draft permit is far more extensive than the active 2003 MA permit. The addition of new requirements means that municipalities have more information that needs to be recorded and stored. For example, municipalities have to manage a more intensive inspection schedule, a map of delineated catchment areas, and other new requirements. Past Interactive Qualifying Projects (IQPs) by Worcester Polytechnic Institute (WPI) students attempted to address the issue of data management with a Zoho database. The two student groups based the database off the 2010 MA draft permit. The Zoho database established an infrastructure for municipalities to input and store all of their stormwater data (Barat, Chin, and Feraco, 2012).

Section 4.4.1 Finding 6: Municipalities Found the Zoho Database too Broad to be Useful

We found that Zoho database was not being used in any of the three municipalities to manage their stormwater data. Both Frederick Civian of the MassDEP and Todd Girard, conservation agent for the town of Charlton, MA, shared the same views as to why municipalities did not adopt the Zoho database - it was too broad (Civian, November 10, 2013; Girard, November 20, 2013) . The database attempted to compile all stormwater management information required in annual reports for a municipality as opposed to effectively managing one or two permit requirements. Frederick Civian explained that municipalities did not want to “reinvent the wheel” since most already had a system in place to store their stormwater management data

(Civian, November 10, 2013). Isabel McCauley of Holden believed the database could have been more user-friendly by allowing officials to edit previously stored entries (McCauley, November 12, 2013).

The MassDEP wanted to develop a tool to assist municipalities in meeting the upcoming permit requirements. As a result of this finding, our team decided to create a database with a more narrow focus. The database is solely devoted to helping towns complete the catchment area priority ranking requirement of the upcoming MA permit, which will be modeled after the 2013 NH draft permit's provision.

Section 4.4.2 Finding 7: Priority Ranking Process is Difficult and Confusing

The 2013 NH draft permit requires a catchment area priority ranking system far more detailed than in the 2003 MA permit. The active permit only requires the identification of priority areas, which are defined as areas suspected of having illicit discharges. After delineating their catchment areas, the 2013 NH draft permit requires municipalities to categorize each area into one of the following four categories - Excluded Catchments, Problem Catchments, High Priority Catchments, and Low Priority Catchments – using a list of criteria that is stated in the permit (78FR27964). However, the permit does not clearly define the process a municipal employee would have to follow in order to accurately rank catchment areas.

To fully understand the ranking process and incorporate it into the database, we arranged time with MassDEP officials to decipher the correct way to rank catchment areas. Despite spending several hours analyzing the permit, we were unable to clearly define the proper procedure for ranking a catchment area. For example, we found it was difficult to differentiate a Problem Catchment from a High Priority Catchment. In the permit, the definitions of the two terms are

very similar. Additionally, the course of action needed to address each of the two types of catchments are not clearly distinguished in the 2013 NH draft permit.

With the assistance of our sponsors at the MassDEP, we were able to arrange a meeting with Newton Tedder, US EPA MS4 permit writer, to resolve our confusion. He provided us with valuable insight to the priority ranking requirements, which enabled us to implement the ranking procedure within the database.

Newton Tedder explained to us that some of the criteria were left intentionally vague to provide municipalities with some decision-making power in the ranking process (Tedder, December 3, 2013). This was not completely clear in the permit and caused a great deal of confusion among our team and with the officials with whom we discussed the permit. Newton Tedder defined the criteria thresholds for how to rank a catchment area into the appropriate category. He also pointed out which criteria should be used for inter-category prioritizing (Tedder, December 3, 2013).

As a result of our discussion with Tedder, we were able to define the four categories and understand the criteria. An Excluded Catchment is defined as a catchment with no potential for illicit discharges, meaning that no screening or investigating is required. As an example, the permit lists parks or undeveloped green space as Excluded Catchments. (78FR27964).

Catchments with known or suspected contributions of illicit discharges based on existing information are classified as Problem Catchments (78FR27964). A catchment area is considered a High Priority Catchment if it discharges to an area of concern to public health such as beaches, recreational areas, and drinking water supplies; or inspections indicate the presence of illicit discharges. Any catchment area where olfactory/visual or water sampling inspections indicate the presence of sewer input, the catchment should be placed at the top of the high priority

category and scheduled for further investigation. The water sampling inspections will be compared to the threshold explicitly listed in the permit. A catchment is low priority if it does not fall into any other categories. However, low priority catchments are still to be ranked within the category using the criteria listed in the permit. A brief overview of each category can be seen below in Table 6.

Table 6 - Four Catchment Area Ranking Categories

Catchment Categories	Description
Excluded Catchment	Areas with no potential for illicit discharge
Problem Catchment	Areas with a known history of illicit discharges or areas where a municipality feels a need to address immediately
High Priority Catchment	Areas determined to have a high potential for illicit discharge; these areas will be investigated after Problem Catchments have been completed
Low priority Catchment	Areas determined to have a low potential for illicit discharge

Using this information, we created a simplified flow chart that municipalities can utilize when priority ranking catchment areas (See Appendix D for flow chart).

Another example of confusing language in the permit is the difference between “screening” and “investigating” in the ranking process. The permit says Problem Catchments must be investigated while High Priority Catchments must undergo further screening. However, Newton Tedder clarified that Problem Catchments are those that need immediate attention while High Priority Catchments are those where illicit discharges are suspected due to smell, but have not

been scheduled for further investigation (Tedder, December 3, 2013). Although the processes are defined separately in the permit, the similarity in wording can cause confusion among readers.

The last aspect of the ranking system that we found unclear was the difference between ranking criteria that is used for direct categorization and criteria that are used for prioritizing within a category. There is a number of criteria that are listed within the permit that are not given specific thresholds or direction. For example, the permit requires the permittee to consider the density of aging septic systems in the ranking process (78FR27964). However, the only information the permit provides is that septic systems thirty years or older in residential areas have a high potential for illicit discharge. Should this criterion be used to categorize a catchment into High Priority? How is it used to prioritize within a category? These sort of questions make it difficult to determine a way to incorporate certain criteria into the ranking process.

Section 4.4.3 Recommendation 5: Make Priority Ranking Section Clear and Easily Understood
This priority ranking process is one of the most time-consuming and extensive requirements in the 2013 NH draft permit. Therefore, we recommend that the US EPA clarifies the priority ranking process within the upcoming Massachusetts MS4 permit. First, a clarification in the naming and purpose of catchment categories would be helpful. Instinctually, the phrase “high priority” has a more urgent connotation than “problem.” However, the permit indicates that Problem Catchments should be addressed before High Priority Catchments. Changing the word High/Low “priority” to High/Low “concern” would clarify the ambiguity of the category names.

Also, we suggest that the US EPA differentiate which ranking criteria are meant to directly categorize catchment areas into one of the four rankings and which are meant for inter-category prioritizing. It is unclear where the thresholds for each category end and where ranking within

each category begins. By clarifying the categories and the ranking process within each category, this section of the permit will become more clear and understandable for municipal employees.

Our final recommendation for the priority ranking requirement is to clean up some of the confusing language throughout the section in the permit. Technical jargon makes it difficult for municipalities to fully understand what they need to do to comply. For example, the permit says that if screening indicates sewer input based on olfactory evidence, rank the catchment at the top of High Priority (78FR27964). It would be much clearer if the individual criterion said, “if the permittee smells sewage, then the catchment should not only be ranked as high priority but be placed at the top of high priority.” Additionally, the permit states that Problem Catchments should be investigated while High Priority Catchments need to be screened (78FR27964). Investigations are supposed to address and attempt to resolve the illicit discharge situation. Screenings involve additional sampling and monitoring the health of the catchment. Replacing the term “investigating” with the word “rectifying” may make the difference in these processes more discernible. Examples of confusing language and our suggestions to replace the phrasing can be seen below in Table 7. More straightforward language like the examples provided would go a long way in helping all parties understand the proper way to rank catchment areas.

Table 7 - Suggested Permit Language

Original Permit Language	Suggested Permit Language
High and Low “Priority” Catchments	High and Low “Concern” Catchments
“Any catchment where screening indicates sewer input based on olfactory/visual evidence shall be ranked at the top of the High Priority Catchments category.”	“If the permittee smells sewage, then the catchment should not only be ranked as high priority but be placed at the top of high concern.”
“Investigating”	“Rectifying”

Section 4.4.4 Finding 8: Development of the CAPRS Database

To assist municipalities with fulfilling the complex priority ranking requirement, our team developed a database that solely focuses on automatically ranking catchment areas. Once catchment areas have been delineated, municipalities can enter information about each catchment into the database and will receive a suggested ranking for each one. Through collaboration with municipal and MassDEP officials during the development process, we identified certain features that would optimize the functionality while keeping the database a user-friendly system.

Initially, we met with Craig Shue, computer science professor at WPI, to help determine a practical database infrastructure to utilize. Professor Shue suggested that we use PHP: Hypertext Preprocessor (PHP) along with My Structured Query Language (MySQL) for a number of reasons: 1) PHP and MySQL are open source, meaning that it would be totally free of cost for our team and municipalities to use; 2) they are known for being extremely easy to learn and implement; 3) they are widely used in websites and web servers across the world; 4) they give us the ability to create a database with a user interface; and 5) they give the option for running the

database on a server so that multiple computers/users can access the database. A downside to choosing PHP and MySQL was that we would have to independently develop the database ourselves within the seven weeks we were given of the project term.

After interviewing Newton Tedder, we were able to determine an appropriate method for the database to calculate priority rank recommendations for each catchment area. To add a catchment area to the database, a user is first presented with a form to fill out about the catchment. A screenshot of this form can be seen in Figure 9.

Page 3 of 3 - High or Low Priority Catchment

The form below will give you a recommendation as to whether the catchment area should be ranked as a High or Low Priority Catchment. It will A High Priority Catchment is a catchment area that has a high probability of containing illicit discharges and should be subject to further screening

A catchment area should be ranked as High Priority if the total priority score calculated from the questions below is at least **40 points**.

* required field

Table to Store in: *

Catchment Area ID: * *Catchment Area IDs must be unique within a single table.*

*If any of the following 6 questions are answered as "Yes" then the catchment area should automatically be ranked as a **High Priority Catchment**.*

Catchment area screening indicates evidence of sewer input:

- Do sampling results indicate ammonia levels greater than 0.5 mg/l? (200 points)
 Yes No Not Sure
- Do sampling results indicate surfactants levels greater than 0.25 mg/l? (200 points)
 Yes No Not Sure
- Do sampling results indicate bacteria levels greater than the water quality criteria applicable to the receiving water? (200 points)
 Yes No Not Sure
- Do sampling results indicate detectable levels of chlorine? (200 points)
 Yes No Not Sure
- Is there any olfactory (smell) or visual evidence of sewer input in the catchment area? (200 points)
 Yes No Not Sure

Does the catchment area discharge to an area of concern to public health due to proximity of public beaches, recreational areas, drinking water supply?
 Yes No Not Sure

Figure 9 - Screenshot of CAPRS Database priority ranking form.

Completing the form is a three step process of answering different questions about the catchment: page one determines if the catchment is an Excluded Catchment (process ends if the catchment is Excluded); page two determines if the catchment is a Problem Catchment; and page three determines whether the catchment is a High or Low Priority Catchment while also calculating the priority ranking within each category (except Excluded Catchments). At the end of the form, the user will be presented with a recommendation as to which category the catchment should be ranked in based on the answers in the form. Once the user chooses a category and submits the form, the information entered about the catchment will be stored in the database for later viewing and management. The catchment area entries can only be accessed by anyone with access to the computer that the database is being run on, who we anticipate to only be employees within the municipality.

The database facilitates the process for ranking catchment areas within each category. Once the user views the recommended categorization at the end of the form, he/she will also be presented with a ranking score for the catchment area. This score is a number that will be used to sort catchments within each category when they are assessed at a later date. We developed a scoring system for the database by analyzing the requirements in the 2013 NH draft permit and discussing an appropriate algorithm with Newton Tedder and MassDEP employees. The permit defines a list of criteria that, if met in the catchment area, result in the catchment being ranked at the top of the High Priority category. If the catchment is not ranked as a Problem Catchment and one of these criterion are met, the database will automatically recommend that the catchment be ranked as High Priority and add 200 points to the total catchment score for every one of these criterion that are met. Adding the value of 200 points ensures that the catchment will be ranked at the top of its assigned category. If none of these criterion are met, the database uses several

other questions derived from criteria listed in the permit to determine a catchment's rank and score. In collaboration with the MassDEP, our team determined point values ranging from 10 to 20 for these remaining questions. If the sum of these question values is greater than or equal to 40, the database will recommend the catchment be ranked as High Priority; otherwise, it will recommend the catchment be ranked as Low Priority.

Another important feature of the database is the ability to store catchment areas for later viewing. After catchment area forms have been filled out and submitted to the database, the user can then view all of the catchment areas they have in the database. A user can either view all the catchments at once, or they can choose to view just the catchment areas ranked within a particular category.

Throughout the development process, we interviewed several municipal employees, showed them the database, and received useful feedback and suggestions. Isabel McCauley of Holden suggested that we enable users to edit catchment area information once it has already been entered into the database (McCauley, November 12, 2013). Todd Girard of Charlton gave us the idea for three new features to add to the database (Girard, November 20, 2013). First, he suggested that we track the history of each catchment area, meaning that if you change the category of a catchment, the history of changes can be later viewed. Todd Girard also suggested that we assign colors to categories, which would be displayed upon viewing rows in the database: Excluded Catchments are gray, Problem Catchments are red, High Priority Catchments are yellow, and Low Priority Catchments are green (Girard, November 20, 2013). Lastly, he suggested that we enable users to export tables to CSV files (Girard, November 20, 2013). The ability to export tables would allow municipal employees to transfer data into a Microsoft Excel

spreadsheet for further analysis or organization. All of these features were incorporated into the database.

The predominant suggestion we received from municipal employees was to keep the database simple. We incorporated that suggestion in every decision we made in creating the database. The process of maximizing the effectiveness of the database and all of its features is explained in our user guide (See Appendix E for a user guide describing how to install and operate the CAPRS Database).

Section 4.4.5 Recommendation 6: Pilot Test of CAPRS Database

Upon the completion of the initial version of the CAPRS Database, we recommend that a future research group conduct a pilot test of the database within municipalities of the CMRSWC. A pilot test would assess the overall functionality of the priority ranking system, detect bugs in the system or identify additions that need to be made. Municipal stormwater officials would have the opportunity to evaluate the integrity of the priority ranking scoring system and provide feedback for improvements. Incorporating suggestions from municipal stormwater officials from a pilot test of the database may optimize the functionality of the database.

Section 4.4.6 Recommendation 7: Incorporate Priority Ranking System into PeopleGIS Maps in the Future

We recommend that the Priority Ranking System be incorporated into PeopleGIS maps in the future. While speaking with Jim Esterbrook of PeopleGIS at the CMRSWC training in Holden, he informed us that a system for storing the priority ranking of catchment areas will likely be utilized in the PeopleGIS system in the future (Esterbrook, November 20, 2013). We suggest that PeopleGIS adopt a similar ranking system to the one our team outlined in our CAPRS Database. Although we understand that there may be compatibility issues that inhibit the use of the database within the PeopleGIS system, our priority ranking system can be used as a starting

point. By storing catchment area data into the PeopleGIS system, municipal officials will have convenient access to this information in one place.

Section 4.5 Mapping

In the 2003 MA permit, the IDDE control measure only required the mapping of outfalls and the receiving waters. The 2013 NH draft permit requires a more extensive map to be developed as it mandates the locations of catch basins, outfalls, receiving waters, pipes, manholes, interconnections with other MS4s, and municipally-owned stormwater treatment structures. It also requires the delineation of catchment areas - identifying the flow of water to the outfalls.

Section 4.5.1 Finding 9: Leica is better than Asus or Trimble

While completing our third objective, mapping stormwater infrastructure within Holden, Auburn, and Upton, we were able to use three different pieces of equipment to map our locations of catch-basins and outfalls. Upon the conclusion of our fieldwork, we determined that the Leica tablet is the most accurate device when compared to the Trimble and the Asus tablet. See Table 8 for a comparison between the GPS units based on different attributes. The Leica provides precise elevation measurements and is accurate within a few feet.

Table 8 - GPS Equipment Features Comparison Chart

	Trimble Unit	Leica Tablet	Asus Tablet
Technical Capability	Worst	Best	Moderate
Speed	Worst	Best (Tied)	Best (Tied)
Accuracy	Moderate	Best	Worst
Training required	Moderate	Worst	Best
Transportation	Best	Worst	Moderate

The two CMRSWC Leica tablets were not always available to us due to scheduling conflicts with other coalition towns and issues with the battery. Therefore, we often used the Trimble unit or the Asus tablet. The Trimble unit, owned by the MassDEP, was an older and slower unit, being from 2005. While the Trimble produced accurate latitude and longitude measurements, the unit was not always accurate with elevation points. Additionally, the Trimble unit often had difficulty retrieving satellite signal, resulting in a longer time period to map a point. The Trimble did not receive a strong signal during rain or under tree coverage.

In some cases, we used the Asus Tablet, which was provided by the CMRSWC to each of the municipalities. The Asus Tablet had variable levels of accuracy. One of the days we mapped in Upton, the accuracy range was within 60 meters. The other days we used the Asus Tablet, the accuracy range was within three meters. It was a very quick process to record with the Asus. An additional benefit to using the Leica tablet or the Asus tablet was the access to PeopleGIS forms.

With either of these units, the catch basin inspection form or the outfall inspection forms could be completed on site. The Trimble unit did not have this technological capability.

Since the Asus Tablet is a simple tablet computer, it does not require much training to use. The Leica and Trimble are specialized mapping instruments and are more complex. Additionally, the Leica tablet uses multiple software programs to record its locations, meaning that it requires more training than the Trimble unit.

A smaller, less important issue was the transportation of each unit. The Leica requires a stand and a satellite device making it cumbersome to move around. The Trimble and Asus units are much smaller and do not require as much effort to transport. The second team of WPI students working with the MassDEP also used the Leica tablet. They experienced battery issues with the Leica as it would not hold a charge for the length of time it displayed. This resulted in much shorter periods of mapping than was expected.

Section 4.5.2 Recommendation 8: Use Leica Unit to Map All Stormwater Infrastructure
We recommend that the Leica unit is used to map all stormwater infrastructure within a municipality. Although we were able to utilize the Trimble and the Asus tablet, we found that the Leica produced the highest quality results despite its shortcomings. The Leica was not the best in all categories, but our team identified accuracy as the most important aspect of mapping equipment. It was quick and provided accurate locations and elevation points. With access to PeopleGIS forms, it was also possible to perform dry and wet weather inspections of catch basins and outfalls. Although the Leica tablet is an expensive piece of equipment, it provides the best results of the three units we utilized.

Section 4.6 Summary of Recommendations

There are six recommendations that our team developed after the conclusion of our data collection and analysis. We believe our findings, as well as the following suggestions, will be beneficial to the US EPA, the MassDEP, the CMRSWC, and the municipalities of Central Massachusetts in improving stormwater management programs:

- Recommendation 1: US EPA Create Standardized Reporting Form
- Recommendation 2: US EPA Make Incremental Changes to Stormwater Regulations
- Recommendation 3: Municipalities Utilize Regionalization
- Recommendation 4: US EPA Mandate Yearly Stormwater Training
- Recommendation 5: US EPA Make Priority Ranking Section Clear and Easily Understandable
- Recommendation 6: Future Research Group Pilot Test CAPRS Database
- Recommendation 7: PeopleGIS Incorporate Priority Ranking System into Maps in the Future
- Recommendation 8: Use Leica Unit to Map All Stormwater Infrastructure

Section 5.0 Summary and Conclusion

Stormwater pollution is the leading cause of water body contamination (Swamikannu et al., 2003). Stormwater runoff is precipitation which flows over impervious surfaces, collects pollutants, and discharges untreated into a surface water body. Contaminated stormwater runoff has the potential to harm aquatic life, reduce the recreational usability of water bodies, and poses a danger to public health. The United States Environmental Protection Agency issues Municipal Separate Storm Sewer System (MS4) permits to regulate stormwater runoff.

Municipalities throughout Massachusetts currently adhere to the MS4 permit that was established in 2003; however a new MS4 is expected to be released in Massachusetts within the upcoming year. Throughout our project, our team analyzed the 2013 New Hampshire draft permit, as it is a strong indicator of the requirements that will be included in the upcoming MA MS4 permit. This upcoming MS4 permit is expected to contain more demanding and extensive requirements that municipalities must meet to comply with the permit.

Through research, interviews, and fieldwork, our team worked to improve stormwater management programs in Central Massachusetts by providing resources to help municipalities prepare for the upcoming Massachusetts MS4 permit. Specifically, we worked with the towns of Holden, Auburn, and Upton. Upon the completion of our study, we concluded that municipalities will need help to overcome the huge challenge of complying with the upcoming permit requirements. Although municipalities exhibited positive attitudes toward mitigating the impacts of stormwater runoff, they do not have the time, manpower, and funds required to be able to meet these extensive requirements.

Our team created a number of tools to help municipalities prepare for the upcoming permit. These tools include several documents to improve municipal understanding of the complex upcoming permit requirements as well as an interactive database to help municipalities organize and rank catchment areas based on their potential for illicit discharges. Stormwater is a fast-growing topic of concern in municipalities across Massachusetts. If municipalities are given proper assistance, great strides can be made to improve the health of our rivers, lakes and streams in years to come.

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Appendices

Appendix A – Sample Interview Questions

DEP2 - Interview Questions for Holden, MA

Interview questions will be primarily for Isabelle McCauley, Senior Civil Engineer for the Town of Holden.

We may also interview other Holden employees that we are directed to that may be knowledgeable on Holden's stormwater management program.

Preamble:

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting an interview of municipal (or MassDEP) employees to better understand the issues municipalities face when trying to comply with the Phase II MS4 permit. These results will help us identify areas in which we might provide assistance. This information will not be used to enforce penalties and will be used purely for educational purposes. Your participation is completely voluntary and you may withdraw at any time. If you prefer to remain anonymous, we are willing to exclude your name and personal information from any project reports or publications. This is a collaborative project between Massachusetts Department of Environmental Protection and WPI. If interested, a copy of our report can be provided at the conclusion of our study. Your participation is greatly appreciated.

Opening Questions:

1. How long have you been working with the town of Holden?
2. Can you describe your daily responsibilities?

2003 Permit Questions:

1. How well do you think your municipality complies with each of the six minimum control measures? (Specifically IDDE)

2. How extensive is Holden's GPS mapping of outfalls? Do they meet all mapping requirements listed in the 2003 permit? (Percentage of outfalls)
3. Can you tell us about the integrated mapping and inspection database that the Central Massachusetts Regional Stormwater Coalition created to manage mapping data? Does Holden utilize this database?
4. How successful do you feel Holden's current stormwater education/outreach program has been in informing residents and industries on the practices of stormwater management? Why?
5. Does Holden's current Illicit Discharge Detection and Elimination (IDDE) plan meet all of the IDDE requirements laid out in the 2003 permit?
6. How effective do you feel Holden's currently implemented Good Housekeeping BMPs are in reducing stormwater pollution? Please explain. Do they meet all requirements for Good Housekeeping from the 2003 permit?

2013 Draft New Hampshire General Permit (Throughout this part of the interview, we may need to explain and discuss some of the requirements in the new permit.)

1. Have you had the opportunity to review the new draft permit that was released for New Hampshire by the EPA in 2013?
2. Focusing on IDDE, there is a new catchment ranking system requirement based on amounts of pollutants and other factors. Do you think that it is feasible for towns to accomplish this task within a year? Does your town already have some sort of ranking system in place?
3. How useful do you think a program would be if it could automatically priority rank the catchments based on information entered by a municipal employee?

4. How feasible do you feel the mapping requirements in the 2013 permit are for municipalities?

Closing Questions:

1. Are there any other people that would be able to provide us with additional information on Holden's stormwater management program?
2. Can we use your name in our final report?
3. Would you like a copy of our final report once our research is complete?

Appendix B – Sample 2003 MS4 Permit Compliance Spreadsheet

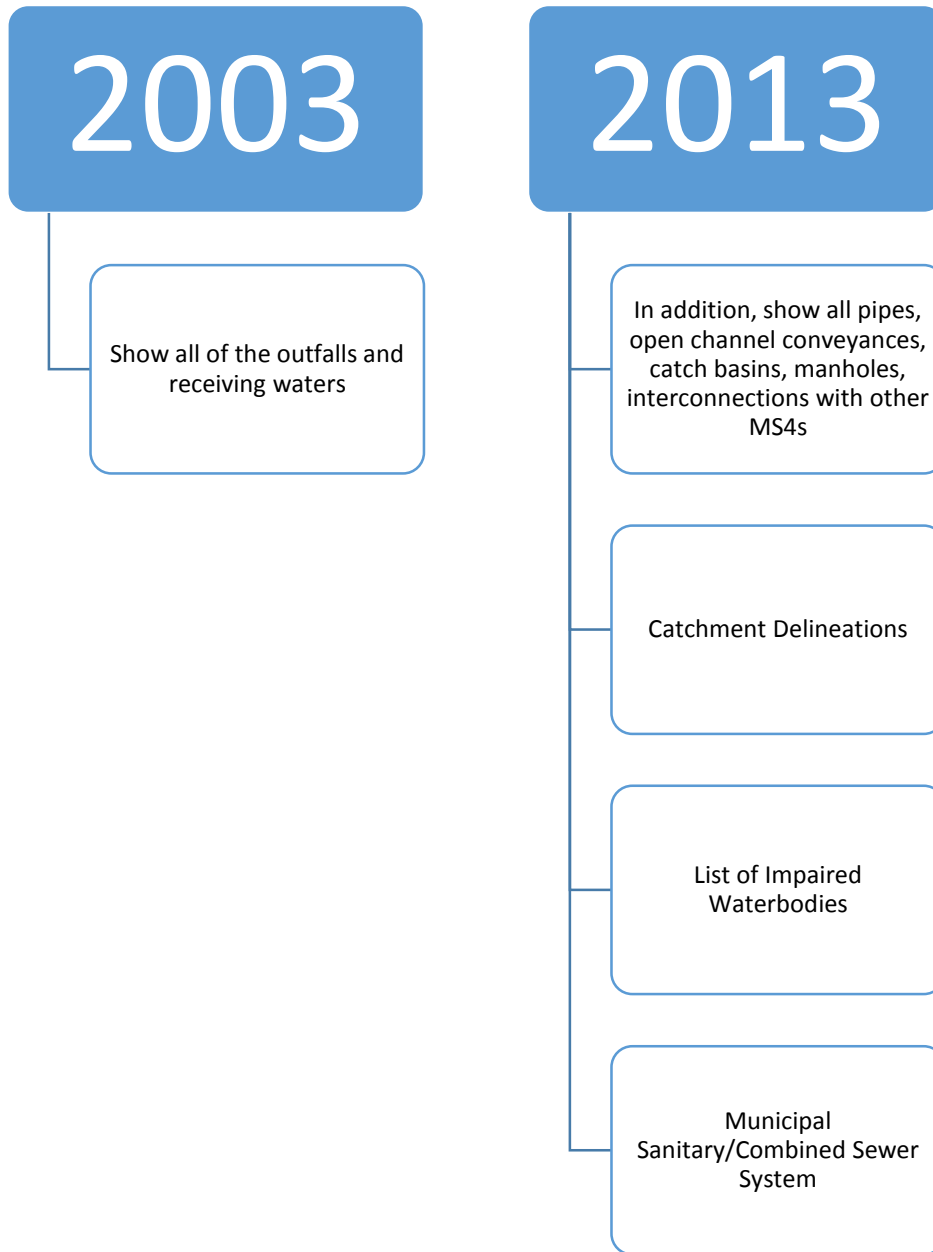
(Municipality), MA Compliance with 2003 MA MS4 Permit

Control Measure	Requirement	Comply?	Notes After Interviews
Public Education & Outreach	Implement an Education Program a)information regarding both industrial and residential activities b)coordination with local groups		
Public Involvement & Participation	Must provide opportunity for the public to participate in the implementation and review of the storm water management program.		
Illicit Discharge Detection & Elimination	Must develop, implement, and enforce a program to detect and eliminate illicit discharges.		
	Develop a Storm Sewer Map (outfalls and receiving waters)		
	Regulatory mechanism to prohibit non stormwater discharges		
	Procedure to identify priority areas		
	Procedure for locating illicit discharge		
	Procedure for locating source of discharge and removal of source		
	Procedure for documenting actions and evaluating impacts on the ms4		
	Must inform public employees, businesses, and the general public of hazards associated with illegal discharges and improper waste disposal.		
Construction Site Stormwater Runoff Control	Develop, implement, and enforce a program to reduce pollutants in any stormwater runoff from construction activities that result in land disturbance of 1 acre or greater		
	Regulatory mechanism to require sediment and erosion control		
	Sanctions to ensure compliance with program		
	Requirements for construction site operators to implement sediment & erosion control		
	Requirements for control of wastes		
	Procedures for site plan review which incorporates consideration of potential water quality impacts		
	Procedures for receipt and consideration of information submitted by the public		
	Procedures for inspections and enforcement of control measures		
Post Construction Stormwater Management in New Development & Redevelopment	Develop, implement, and enforce a program to address stormwater runoff from new development and re development projects that disturb greater than 1 acre		
	Regulatory mechanism to address post construction runoff from new development and redevelopment.		
	Procedures to ensure adequate long term operation and maintenance of BMP		

	Procedure to ensure that any controls that are put in place will prevent or minimize impacts to water quality		
Pollution Prevention & Good Housekeeping in Municipal Operations	Develop and implement a program with a goal of preventing and/or reducing pollutant runoff from municipal operations.		
	Employee Training		
	Maintenance activities for :parks and open space; fleet maintenance; building maintenance; new construction and land disturbance; and roadway drainage system maintenance; stormwater system maintenance		
	Develop schedules for municipal maintenance activities		
	Develop inspection procedures and schedules for long term structural controls		

Appendix C – 2003 MA MS4 General Permit vs. 2013 NH MS4 Draft Permit
Comparison Chart

System Mapping Comparison – Section 2.3.4.6

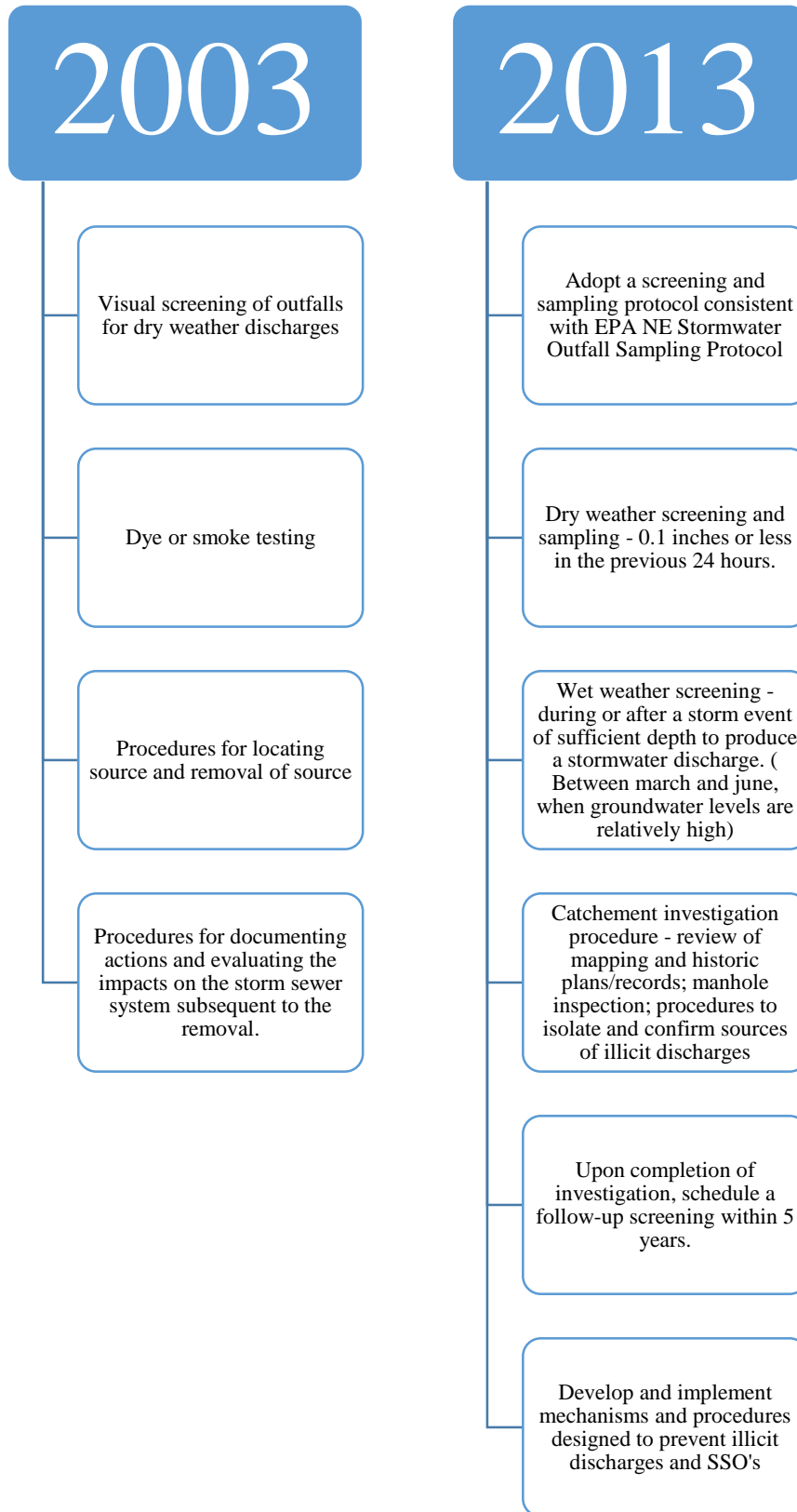


Additional elements to the 2013 permit:

Outfall Inventory – Section 2.3.4.7

Priority Ranking of Catchment Areas – Section 2.3.4.8

Screening Comparison – Section 2.3.4.8.d



Screening Comparison – Section 2.3.4.8.e

If outfall is inaccessible/submerged, first accessible point upstream should be tested.

Catchment Investigation Procedure:

- 1) Identify and record presence of any of the following specific **System Vulnerability factors** (in annual reports):
 - a. History of SSOs
 - b. Sewer pump/lift stations, siphons, is known sanitary sewer restrictions
 - c. Inadequate sanitary level of service
 - d. Common or twin-invert manholes serving storm and sanitary sewer alignments
 - e. Crossings of storm and sanitary sewer alignments
 - f. Sanitary sewer alignments known or suspected to have been constructed with an underdrain system
 - g. Sanitary sewer infrastructure defects
 - h. Areas formerly served by combined sewer systems
 - i. Infrastructure greater than 40 years old in medium and densely developed areas
 - j. Widespread code-required septic system upgrades required
 - k. History of multiple Board of Health actions addressing widespread septic system failures
- 2) Manhole Inspections Methodology:
 - a. **Dry weather inspections** – key junction manholes opened and inspected for visual and olfactory evidence of illicit connections. If flow is observed – sample for ammonia, chlorine, and surfactants. If illicit discharges are detected, flag the manhole for further investigation.
 - b. **Wet weather inspections** – inspect and sample to the extent necessary to determine whether wet weather-induced high flows in sanitary sewers or high groundwaters in areas served by septic systems result in discharges of sanitary flow to the MS4. Conduct at least one wet weather screening and sampling for any catchment where one or more system vulnerability factors are present.

Newly Introduced in the 2013 Draft NH Permit

Section 2.3.4.2

Upon detection of illicit discharges – identify and notify all responsible parties

If removal of discharge within 30 days of identification is not possible – establish a schedule for its elimination and report dates of identification and schedule for removal in annual report.

Section 2.3.4.3

If the non-stormwater discharges listed in part 1.4 are significant contributors of pollutants to the MS4, then try to reduce their impact or eliminate them entirely.

Section 2.3.4.4

Discharges from SSOs to the MS4 are prohibited. Identify all known location where SSOs have discharged to the MS4 **within the previous five years. Within 120 days of the effective date of the permit, develop an inventory of all identified SSO's indicating (include this info as part of SWMP and update annually):**

Location ; Indicate whether discharge entered surface water directly or entered MS4 ; Date and time of each known SSO occurrence ; Estimated volume of occurrence ; Description of occurrence indicating known or suspected cause ; Mitigation and corrective measures completed with dates implemented ; Mitigation and corrective measures planned with implementation schedules

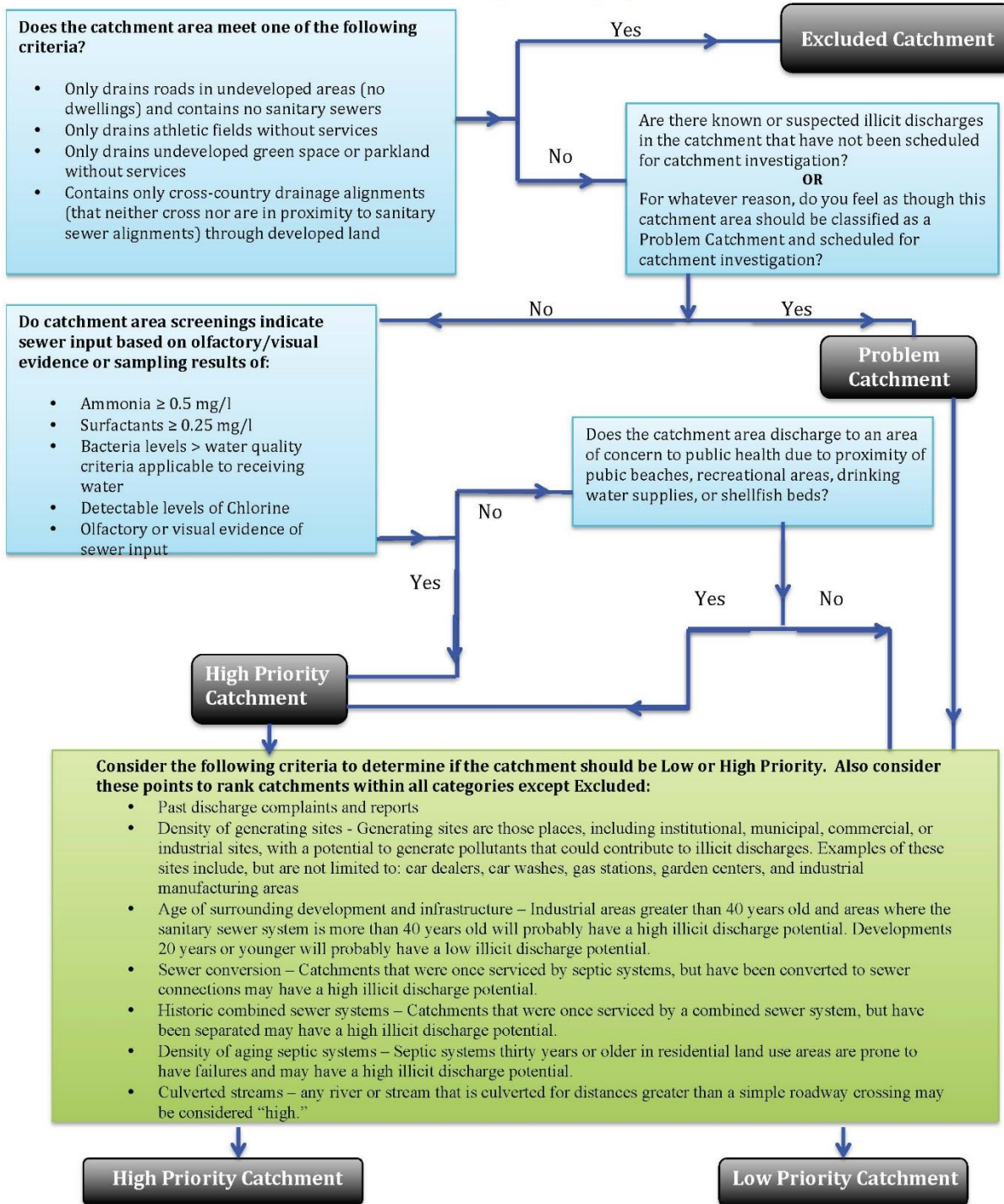
Upon becoming aware of a SSO discharge to the MS4, provide oral notice to EPA **within 24 hours**. Provide written notice to EPA and MassDEP **within five days**.

Section 2.3.4.5

When developing new components of IDDE program, be sure to continue implementation of existing IDDE program required by the 2003 permit.

Appendix D – Catchment Area Priority Ranking System Flow Chart

Catchment Area Priority Ranking System Flow Chart



XAMPP Installation

1. In order to install the CAPRS database, you must first install an XAMPP server/database, which CAPRS will run on. Use one of the two following XAMPP installers, which are both found in the folder that this user guide came with, in order to install XAMPP:
 - a. If you are using Windows 7 or 8, select the installer named *xampp-win32-7-installer*.
 - b. If you are using earlier versions of Windows, such as Windows XP or Windows Vista, select the installer named *xampp-win32-xp-installer*.

Note: XAMPP will install an Apache server and MySQL database on your computer. If you already have similar infrastructure in place, feel free to skip the XAMPP installation steps.

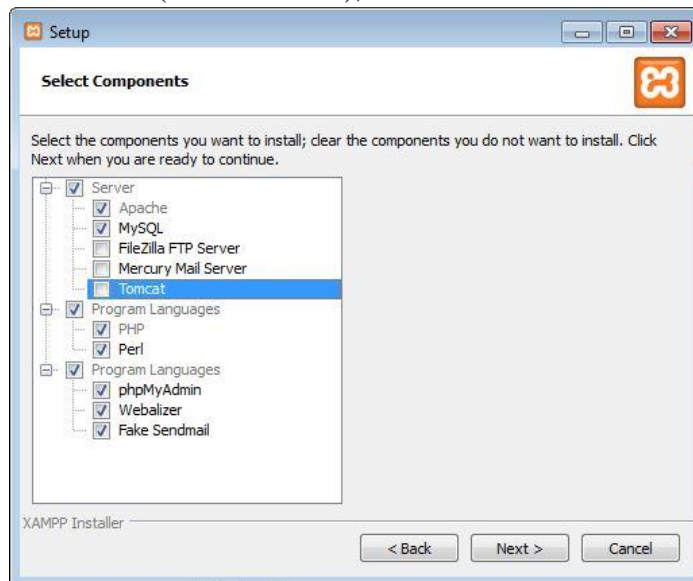
Note: These Windows installers can also be downloaded at:

<http://www.apachefriends.org/en/xampp-windows.html>.

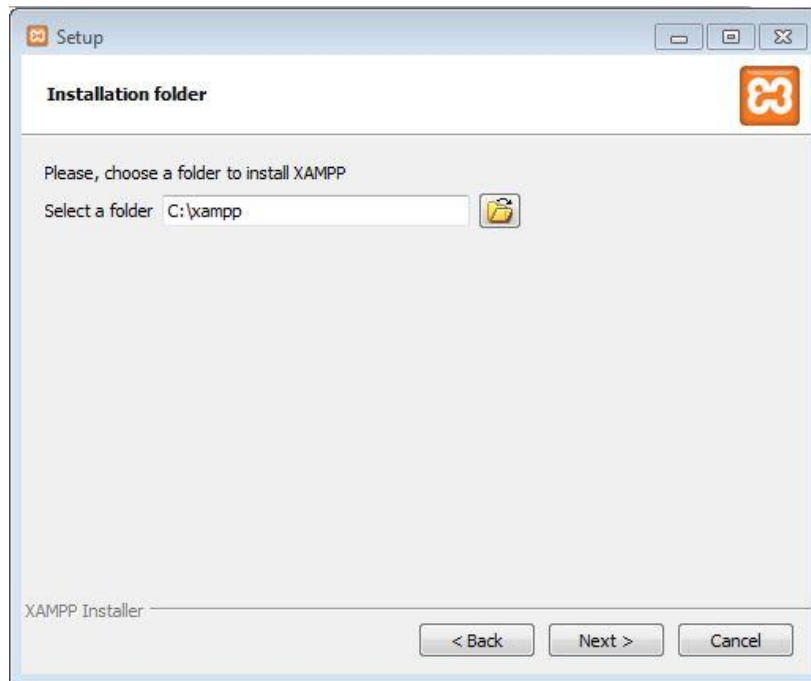
Note: Mac users can download an XAMPP installer at:

<http://www.apachefriends.org/en/xampp-macosx.html>.

2. In order to finish installation of XAMPP, complete all of the steps of the XAMPP Setup Wizard:
 - a. In step 1 of the Setup Wizard, uncheck the fields *FileZilla FTP Server*, *Mercury Mail Server*, and *Tomcat* (as seen below), and click *Next*.



- b. In step 2, use the default folder location (`C:\xampp`) when selecting a destination to install the XAMPP software. If you choose a different folder location, certain features of the database will not be functional.



- c. In step 3, uncheck the *Learn more about BitNami for XAMPP* field and click *Next*.



- d. In step 4, simply click *Next* and the XAMPP installation process will complete.

3. Now you must move the CAPRS files into your new XAMPP server. In the folder that this user guide came with, copy the sub-folder named *CAPRS* into the following location on your computer:

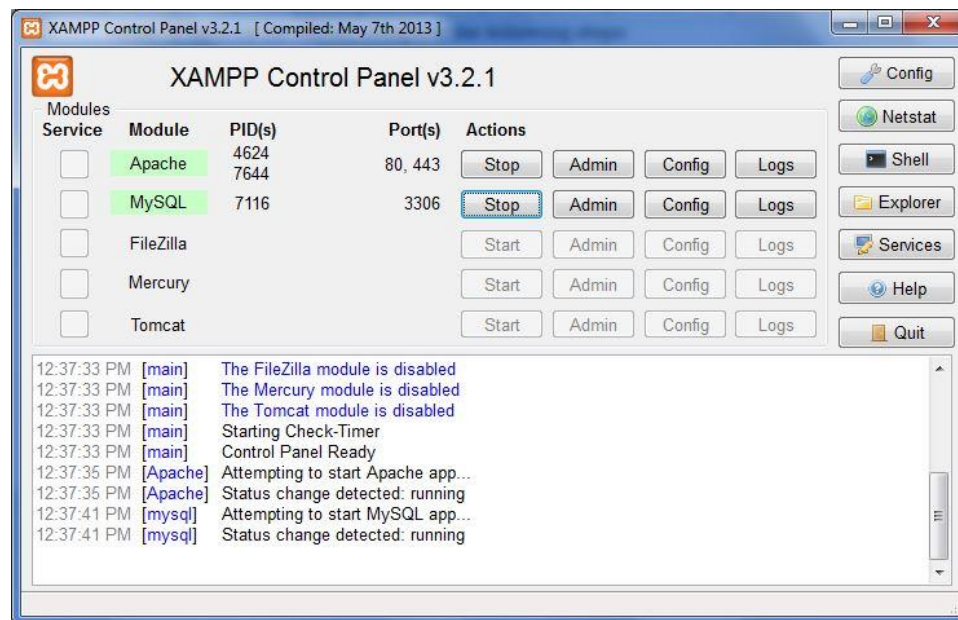
C:\xampp\htdocs

The folder named *CAPRS* that you just copied contains all of the code needed to run the CAPRS database. Placing this folder into *C:\xampp\htdocs* will allow your new XAMPP server to run the CAPRS database.

XAMPP Control Panel

In order to begin using the CAPRS database, you need to turn on the XAMPP server. In order to turn on the server, complete the following steps:

1. Open the XAMPP Control Panel, which was just installed on your computer.
2. As seen below, turn on the Apache server and MySQL database by clicking the *Start* button to the right of each.



Once properly turned on, you will see the words *Apache* and *MySQL* highlighted in green.

CAPRS Database

Installation

All interactions with the CAPRS database are done through a web browser. In order to begin using the CAPRS database, you need to install CAPRS onto your new MySQL database. This can be easily done by entering the following URL into your web browser:

<http://localhost/CAPRS/installation.php>

Once this webpage opens, click the *Complete Installation* button, and your CAPRS database will be ready to go!

Homepage

Use the following URL to get to the CAPRS database homepage:

<http://localhost/CAPRS/homepage.php>

Note: Feel free to save this URL under your favorites in your web browser for easy access to the database.

Add a Table

In order to store catchment areas into the database, you first need to create tables to store them in. Tables can be created by clicking on the *Add a Table* tab in the menu bar. Feel free to create as many tables as you would like for your own organizational purposes. You could have one table store all of your catchment areas, or spread them out among many tables.

Add a Catchment Area

In order to add a catchment area to the database, click on the *Add a Catchment* tab in the menu bar. This will bring you to the form used to calculate a catchment's priority rank and score.

For every catchment area you add to the database, you must choose a table and catchment ID. Catchment IDs must be unique within a particular table.

If the catchment area is not an Excluded Catchment, the last page of the form can be used to calculate category recommendations and priority scores. This can be done by clicking the *Calculate Rank* button at the bottom of the form:

Priority Rank:

[Return to Homepage](#)

Clicking the *Calculate Rank* button will not actually store the catchment area in your database, it will simply provide you with a recommendation as to how you should rank your catchment area based on the input you have already entered into the form. Once you have decided which rank you want to assign your catchment area, click the *Submit* button, and your catchment area will be stored in the database.

Viewing Catchment Areas

In order to view the catchment areas that you have stored in the database, click on the *View Catchment Areas* tab in the menu bar.

Table: Priority Rank:

Once you have reached the catchment viewing interface, you must select a table and (optionally) a particular category to view. Selecting a certain category to view will only display the catchment areas that are ranked under this category. Click *Go* to view your query.

Once you are viewing a table, clicking on the ID of a catchment area will allow you to edit or delete the catchment area.

Also, clicking the *Export Table* button will allow you to export the table that is currently being viewed into a CSV file that you can then save onto your computer.

Accessing CAPRS from Remote Computers

One of the nice features of the CAPRS database is that anybody within the same local Internet network as you can also access the database. In other words, people in the same office or

building as your computer can access your CAPRS database. This allows fellow colleagues to use the CAPRS database without having to install anything on their computers.

Recall how the URLs you have been using to access the CAPRS database include the word *localhost* in them (i.e. <http://localhost/CAPRS/homepage.php>). In order for someone else to access your CAPRS database, he/she must replace the word *localhost* with your computer's IP address when entering the URL into a web browser. For example, if your machine's IP address is 123.456.789.1, then a user must enter the following URL into his/her web browser to access your CAPRS database:

<http://123.456.789.1/CAPRS/homepage.php>

There are a number of ways to figure out your computer's IP address. Here is how Microsoft describes finding your computer's IP address on Windows 7: <http://windows.microsoft.com/en-us/windows/find-computers-ip-address#1TC=windows-7>.

Note: In order to have someone else access your CAPRS database, your Apache server and MySQL database must both be switched on through the XAMPP Control Panel as previously described in this user guide.

Note: Your computer's IP address will change if you physically enter another network. Only people within the same network as your computer can access the database.