Phase II MS4 Pilot:
Central Massachusetts Stormwater Management

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

Submitted by:
Alexander Barat
Randy Chin
William Feraco

Submitted to:
Prof. Corey Denenberg Dehner

In Cooperation with
Fredrick Civian, Stella Tamul, and Cheryl Poirer of the Department of Environmental Protection

December 13th, 2012
Abstract
Stormwater runoff pollution is a serious problem in municipalities. The goal of this project was to promote communication between the Massachusetts Department of Environmental Protection and the Central Massachusetts Regional Stormwater Coalition by facilitating increased understanding of the MS4 permit, assessing the current state of municipality MS4 compliance and assess the feasibility of the implementation of the Zoho database.

Acknowledgements
At the culmination of this project, we would like to firstly thank the Massachusetts Department of Environmental Protection for sponsoring this joint venture. We would particularly like to thank Fred Civian, Stella Tamul, and Cheryl Poirier for guiding us every step of the way, and providing invaluable knowledge concerning the MS4 permit and stormwater runoff. Carissa Lord, the bi-state stormwater coordinator, also gave us guidance before we went out mapping for the municipalities.

We would also like to thank Deb Cohen and Gina Snyder of the Environmental Protection Agency for providing our project group with the Garmin Oregon 450 GPS units that we used during catch basin and outfall mapping. PeopleGIS also provided us use of the Leica tablet system along with a training session at Tata & Howard’s office, and for that we would like to extend our thanks. Helen Pottle and Aubrey Strause were also incredibly important individuals to this project, as they acted as our liaison to the 13 municipalities involved with the Community Innovation Challenge grant.

More thanks are in order for Shrewsbury, Holden, and Charlton as these towns allowed us to sit down with their engineers and conservation agents to discuss their MS4 permitting information. Bradford Stone of Shrewsbury, John Woodsmall and Isabel McCauley of Holden, and
Todd Girard of Charlton were the individuals that took time out of their days to speak with us, and we would like to thank them.

Finally, we would like to thank our project advisor, Professor Corey Denenberg Dehner, for her constant support, guidance, and critiques, which have helped our project reach its full potential.
### List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADS</td>
<td>Advanced Drainage System</td>
</tr>
<tr>
<td>BMP</td>
<td>Best Management Practice</td>
</tr>
<tr>
<td>CIC</td>
<td>Community Innovation Challenge</td>
</tr>
<tr>
<td>CMRSC</td>
<td>Central Massachusetts Regional Stormwater Coalition</td>
</tr>
<tr>
<td>DPW</td>
<td>Department of Public Works</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>GIS</td>
<td>Global Information System</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>IDDE</td>
<td>Illicit Discharge Detection and Elimination</td>
</tr>
<tr>
<td>IQP</td>
<td>Interactive Qualifying Project</td>
</tr>
<tr>
<td>ISW</td>
<td>Interstate South-Flowing Watershed</td>
</tr>
<tr>
<td>LID</td>
<td>Low Impact Development</td>
</tr>
<tr>
<td>MassDEP</td>
<td>Massachusetts Department of Environmental Protection</td>
</tr>
<tr>
<td>MS4</td>
<td>Municipal Separate Storm Sewer System</td>
</tr>
<tr>
<td>MTS</td>
<td>Maine Technical Source</td>
</tr>
<tr>
<td>MW</td>
<td>Merrimack Watershed</td>
</tr>
<tr>
<td>NASS</td>
<td>National Agricultural Statistics Service</td>
</tr>
<tr>
<td>NCW</td>
<td>Northern Coastal Watershed</td>
</tr>
<tr>
<td>NOAA</td>
<td>National Oceanic and Atmospheric Administration</td>
</tr>
<tr>
<td>NOI</td>
<td>Notice of Intent</td>
</tr>
<tr>
<td>NPDES</td>
<td>National Pollutant Discharge Elimination System</td>
</tr>
<tr>
<td>RTK</td>
<td>Real Time Kinematic</td>
</tr>
<tr>
<td>SCW</td>
<td>Southern Coastal Watershed</td>
</tr>
<tr>
<td>SWMP</td>
<td>Stormwater Management Plan</td>
</tr>
<tr>
<td>SWPPP</td>
<td>Stormwater Pollution Prevention Plan</td>
</tr>
</tbody>
</table>
TMDL: Total Maximum Daily Load
WPI: Worcester Polytechnic Institute
# Table of Contents

Abstract ................................................................................................................................. i

Acknowledgements .............................................................................................................. i

List of Acronyms .................................................................................................................... iii

1.0 Executive Summary ........................................................................................................ viii

1.1 Introduction .................................................................................................................... viii

1.2 Methodology .................................................................................................................. x

1.3 Findings/Discussion ....................................................................................................... xi

1.3.1 Garmin v. Leica .......................................................................................................... xii

1.3.2 MS4 Permit Compliance ............................................................................................ xiii

1.3.3 Post Construction Stormwater Management ............................................................... xiii

1.3.4 Funding ....................................................................................................................... xiii

1.3.5 Statewide Illicit Discharge Detection and Elimination Program .................................... xiv

1.3.6 Utility of the Zoho Database ..................................................................................... xiv

1.4 Recommendations/Conclusions ................................................................................... xv

2.0 Introduction ..................................................................................................................... 1

3.0 Background .................................................................................................................... 5

3.1 Impact of Stormwater Run Off ...................................................................................... 7

3.2 Point and Non-point Source Pollution ......................................................................... 8

3.3 MS4 Permitting .............................................................................................................. 9

3.3.1 Outcomes .................................................................................................................. 12

3.3.2 Implementation ......................................................................................................... 16

3.3.3 Role of the MassDEP in MS4 Permit Compliance ..................................................... 19

3.3.4 Obstacles to MS4 compliance ................................................................................ 19

3.4 Community Innovation Challenge Grant .................................................................... 20

3.5 Zoho Database ............................................................................................................. 20

4.0 Methodology ................................................................................................................... 22

4.1 Introduction ................................................................................................................... 22

4.2 Research Design .......................................................................................................... 23

4.2.1 Concepts .................................................................................................................. 23

4.2.2 Variables ................................................................................................................... 24
List of Figures

Figure 1: Regulated Municipalities in Massachusetts .................................................................11
Figure 2: Relationship Between Percent Watershed Imperviousness and Environmental Quality ....16
Figure 3: Effects of Impervious Surface on River Quality ...........................................................17
Figure 4: Operationalization Rubric ............................................................................................24
Figure 5: Covered Catch Basin ....................................................................................................30
Figure 6: Outfall Examples ..........................................................................................................31
Figure 7: Potential Illicit Discharge ..............................................................................................32
Figure 8: Garmin Oregon 450 .....................................................................................................34
Figure 9: Comparison of Leica and Garmin .................................................................................37
Figure 10: MS4 Compliance Based on Annual Reports ...............................................................38
1.0 Executive Summary

1.1 Introduction
Over the seven-week duration of this Interactive Qualifying Project (IQP), we, three undergraduate junior level Worcester Polytechnic Institute (WPI) students, worked to improve communication between the Central Massachusetts Department of Environmental Protection (MassDEP) and 13 municipalities within the Central Massachusetts region as well as improve the overall understanding of the MS4 stormwater permit to promote municipality compliance. These 13 municipalities, Auburn, Charlton, Dudley, Holden, Leicester, Millbury, Oxford, Paxton, Shrewsbury, Spencer, Sturbridge, Webster, and West Boylston applied jointly for and were awarded a Community Innovation Challenge (CIC) Grant. Together, these municipalities make up the Central Massachusetts Regional Stormwater Coalition (CMRSC). The goal of this stormwater coalition is to develop communication within the 13 communities and work together to comply with both the current 2003 and the draft 2010 MS4 permit through education and training to yield a more cost-effective and efficient means of stormwater management. The EPA requires all of these municipalities to be regulated as Phase II communities. This means that the populations of these towns are less than 100,000, and that their MS4 system is classified as ‘small’ (EPA, 2012).

In order to promote communication between the MassDEP and the 13 municipalities, a previous IQP selected an online database, which allows municipalities to directly input the relevant information from their annual reports regarding the six minimum control measures. The goal of our IQP was to improve this existing Zoho database and begin the MS4 system mapping process in order to allow the municipalities to make progress towards full compliance with the draft MS4 permit as well as create a better sense of communication between the municipalities and the MassDEP.
Ever since mankind has organized into towns and villages, access to clean water has been a primary objective for survival. William Andreen, professor of law at the University Of Alabama School Of Law, notes in his paper concerning the effectiveness of the Clean Water Act that the early stages of the statute dealt with single discharges. However, it was largely ineffective dealing with non-point source pollution (Andreen, 2004). Thusly, in 1972, Congress reorganized and greatly expanded the Federal Water Pollution Control Act. The 1972 amendments, in addition to giving the statute more bite and enforcement mechanisms than its lesser predecessor, created a regulatory framework, the National Pollutant Discharge Elimination System (NPDES), for limiting pollutant discharges into America’s surface waters from point sources. The 1972 amendments also recognized the inherent problem with nonpoint source pollution (EPA, 2012). In order for an individual, company or operator to legally discharge into a regulated body of water, they must apply to the Environmental Protection Agency (EPA) or state regulatory agency, for a NPDES permit.

Since its introduction in 1972, the EPA had begun to realize the ineffectiveness of the NPDES permit. Consequently, in 2003 the EPA enacted a stormwater specific regulatory permit system. After seven years of the permit’s existence, the EPA began drafting a 2010 Municipal Separate Storm Sewer System (MS4) permit that would detail methods of stormwater management and control. The draft 2010 MS4 permit details the minimum control measures that the EPA proposes to require of municipalities for dealing with stormwater pollution. These six minimum control measures are:
(1) Public Education/Outreach
(2) Public Involvement/Participation
(3) Illicit Discharge Detection and Elimination
(4) Construction Site Runoff Control
(5) Post Construction Runoff Control
(6) Pollution Prevention/Good House-Keeping (EPA, 2010)

The EPA hopes these control measures will provide guidance to and appropriate regulation of the municipalities by detailing specific parameters for stormwater control. Even so, many municipalities fear they will struggle with MS4 compliance. Factors such as lack of manpower, monetary resources, GIS expertise, knowledge of the permit itself and how to properly document town activities all contribute to the large potential non-compliance with the permit once it is finalized.

1.2 Methodology
To efficiently accomplish the goals set out at the inception of our IQP, which included comparing the Leica and Garmin GPS (Global Positioning System) devices, expediting the implementation of the Zoho database, and gauge municipality understanding and compliance with the MS4 permit, we executed the following steps. During the initial stages of our IQP, we took part in multiple training courses on the logistics of the MS4 permit, GIS training, Garmin GPS unit training, a Low Impact Development (LID) workshop, and Leica Tablet GPS training which prepared our group for fieldwork and interviews with the municipalities of the CMRSC. After these training sessions, we met with Carissa Lord, Bi-state Municipal Stormwater Coordinator, and Fred Civian, MassDEP’s Stormwater Coordinator, who gave us guidance on how to efficiently manage our time and expectations for assistance with the communities.
Upon the conclusion of our trainings, we began outreaching to Shrewsbury, Dudley, Millbury and Charlton town employees to aid them in GPS mapping their outfalls and catch basins while simultaneously generating feedback on two different GPS units: the Garmin Oregon 450 and the Leica CS25 Tablet. This fieldwork gave us the opportunity to connect with the municipal employees, see firsthand the physical state of the municipality’s MS4 system and assess how well the systems complied with the draft MS4 permit.

In order to aid the municipalities in complying with the MS4 Permit and facilitating communication between the MassDEP and the 13 CIC municipalities, we interviewed and surveyed employees of the municipalities, who regularly deal with the MS4 system and permit regulation. Our survey was intended to act as a precursor to our interview questions, though are response rate was abysmal, yielding a 15% return rate. Once we sat down with the municipalities, we broke up our interview into three distinct topics. The first topic was the municipalities’ opinion on the stringency or vagueness that the 2003 and 2010 MS4 permit draft regulations present. The conversation then shifted to how each municipality complied or did not comply with the six minimum control measures in both the 2003 and 2010 MS4 permit. Finally we discussed the Zoho database developed by MassDEP and the previous IQP team which aimed to give the municipalities a structured application and means of reporting their town’s compliance with the six MS4 permit control measures. After we gathered the necessary information, we used it to improve the functionality of the Zoho database and provide the MassDEP with information to help them understand what compliance issues the 13 included municipalities faced.

1.3 Findings/Discussion
Over the course of this project, we came to several conclusions pertaining to the pros and cons of the Garmin and Leica GPS units, municipality opinion on the current and draft MS4 permits, and the potential feasibility of the Zoho database.
1.3.1 Garmin v. Leica

As we conducted GPS mapping with Shrewsbury, Dudley, Millbury, and Charlton, we were able to generate useful feedback on the two types of GPS mapping units, the Garmin Oregon 450 unit and the Leica CS25 Tablet unit. We found when using the Garmin unit that the triangulation to fix our location took roughly one minute with an error parameter of 2-5 meters. The mapped point had to be named manually which our group found to be tedious. For future users attempting to locate the mapped outfalls, we concluded that finding them would be difficult without previous knowledge of the town’s roadways due to the non-uniformity of the reference labeling of the mapped points. Another drawback of the Garmin unit is its lack of post processing capabilities.

Post processing refers to the steps taken, after waypoints are created, to superimpose them onto an orthographic map. In order to superimpose the mapped points on to an orthographic map, we had to use Garmin’s Basecamp software.

Conversely, the Leica unit was more accurate, but more time consuming than the Garmin. In order to gather a fixed location, the tablet had to boot up, connect to AT&T wireless data internet and establish a Bluetooth connection to the Leica GG02 GPS antenna. This entire process took roughly 20 minutes. It took about 10 more minutes to obtain an initial fixed location. With the unit fully operational, the catch basin and outfall forms were generated by PeopleGIS, a third party company that developed forms which are to be filled out and submitted at every mapped catch basin or outfall while in the field. These forms contain information pertaining to the MS4 permit regarding catch basin and outfall inspection. We found the precision of the Leica unit to be within 2-4 centimeters of accuracy and that once submitted, the forms contained all of the necessary post processing information. These onsite forms eliminated the need for additional post processing after field work was completed, unlike the Garmin where post processing was necessary.
1.3.2 MS4 Permit Compliance

Our interviews with the municipalities provided us with a great deal of information about potential compliance issues as well as what municipalities may need in order to be in full compliance when the final permit is issued. One of the areas that the municipality employees we sat down with focused on in the MS4 permit was Public Education. They believed that the EPA is asking too much of them in individually developing and implementing a Public Education program. They suggested that either the MassDEP or EPA develop a model Public Education program that the municipalities could just implement and distribute rather than allocating scarce municipal resources to developing an education program. Also, the municipality employees believed that the stormwater educational outreach program would draw more attention if it were developed by a respected source like the EPA rather than individual municipalities.

1.3.3 Post Construction Stormwater Management

Another control measure the municipalities had a potential issue with was Post Construction Stormwater Management. The municipalities did not have much trouble in developing a regulatory bylaw, but they struggled with implementation and guidance from the EPA. We noticed that certain municipalities found it very difficult to obtain any form of EPA follow up on stormwater management issues. We also realized that most municipalities felt that post construction best management practices (BMP), methods of stormwater management that mitigate the adverse effects of construction development and redevelopment through their implementation are not difficult to design, but the cost of implementation often discourages effort to put them into use (MRSC, 2012).

1.3.4 Funding

Municipalities also noted the difficulty in maintaining their MS4 system up to the permit’s requirements. While keeping a perfectly maintained MS4 system would be beneficial to the environment, it is much too costly to keep up such a high level of maintenance on a municipalities’ small budget. One example was the annual cleaning of catch basins. While the issue is important,
the increase of urban development and roadways makes it difficult for municipalities to clean the hundreds of new catch basins along with the existing ones with the limited resources they have. In addition, the new 2010 draft permit requirements are much stricter than the previous permit, adding burden to the already strapped financial budget and workload of municipal employees.

1.3.5 Statewide Illicit Discharge Detection and Elimination Program
Finally, we observed that the municipalities would benefit greatly if the EPA created a statewide Illicit Discharge Detection and Elimination program template, which would allow the municipalities to know exactly what is necessary to have in their IDDE program. This would promote widespread compliance and understanding of the requirements. The municipalities found that some of the requirements of the IDDE program, outlined in the MS4 permit, were so vague as to render them useless. For example, the draft permit requires MS4 operators to conduct wet weather sampling. However, it is not clear when the samples should be taken, during first flush of the storm, within three hours, within twenty four hours, etc. Unclear requirements such as this would be resolved if EPA provided MS4 operators with an IDDE program template.

1.3.6 Utility of the Zoho Database
The implementation of the Zoho database will allow the participating municipalities to gauge where they lie in terms of MS4 compliance and promote communication with the MassDEP. When conversing with municipalities on their thoughts of the Zoho database and its control measure specific applications, they felt as though its greatest use was the ability to provide the town with a structured way of filling out their annual reports throughout the year as information is collected. Bradford Stone, town engineer of Shrewsbury, helped revise the Construction, Post Construction and Good Housekeeping forms on the Zoho database in order for site specific information to be uploaded into it. The thoughts and critiques of the Zoho database allowed us conclude that the database could be an effective tool for the municipalities to input information pertaining to their
annual reports. However, municipalities do not want the implementation of the Zoho database to add work to their yearly efforts. Therefore it is important for the DEP and future IQP’s to create a simple means of exporting the municipal data directly into an annual report format so that the municipal employees do not have to complete an annual report with the same information residing in the database.

1.4 Recommendations/Conclusions
The results of data collection gave us invaluable information pertaining to the municipalities’ MS4 permit understanding and compliance techniques. We relayed this information back to the MassDEP in order to improve its role in assisting the Phase II municipalities and further development of the Zoho database. We have the following recommendations, which we believe will improve municipal compliance with the anticipated revised MS4 permit.

- EPA to implement the use of the Leica tablet in conducting outfall and catch basin mapping as the standard for mapping for the MS4 permit
- MassDEP to facilitate the development of a workshop to train municipalities on the use of the Leica tablet and how to fill out the PeopleGIS catch basin and outfall forms
- EPA or MassDEP to develop a public education program on stormwater that municipalities can implement to raise awareness in their communities as opposed to the individual municipalities developing their own program
- EPA or MassDEP to develop an IDDE program template that clearly states what they expect in terms of full compliance for the municipalities to implement and cater specifically to their municipal needs
• Municipalities want more frequent communication with and guidance from the EPA and MassDEP on issues that arise in Post Construction regulations

• EPA needs to reassess the feasibility of municipality compliance with good housekeeping permit requirements

• Future IQP groups should continue to improve the Zoho database so it can be effectively utilized by municipalities and export relevant data to municipal annual reports

With stormwater posing so many significant repercussions to our communities, the lack of awareness of the issue is staggering. During the course of this project we were able to gather information that led to recommendations that could help bridge communication between the EPA, MassDEP, and municipalities. This communication will strengthen the efforts of the municipalities to comply with the MS4 permit and raise the standards in stormwater management. We believe that the implementation of the Zoho database, with municipal feedback taken into account will promote a structured and progressive way of filling out the NPDES stormwater annual report while also encouraging oversight from the MassDEP and EPA.
2.0 Introduction

“Access to safe water is a fundamental human need and, therefore, a basic human right. Contaminated water jeopardizes both the physical and social health of all people. It is an affront to human dignity” (Annan, Secretary-General Kofi, 2001). Truer words concerning the innate human need for clean water have not ever been spoken. Secretary-General Kofi Annan released this statement on March 12, 2001 discussing World Water Day and how, for most of the world, clean drinking water is still an enormous uncertainty.

One of, if not, the most important resources to civilization is water. Water is crucial to keeping societies running. The earliest civilizations searched out rivers, lakes, and other clean water sources to build communities as they recognized the importance of clean water as a resource and how these sources created fertile farming land. Civilizations such as the Akkadians, Babylonians, and Assyrians in Mesopotamia are just a few examples. These ancient people thrived as early civilizations due to their close proximity with the current day Tigris and Euphrates Rivers in Iraq (Darity Jr., William A. 2008).

Today, the importance of water can be seen when this vital resource is lacking. With the recent 2012 drought plaguing the United States, the farming and agricultural communities were severely impacted as water is crucial for the success of crops. By September 20th 2012, the National Agricultural Statistics Service (NASS) rated 50 percent of the crops in the United States as “poor to very poor” (United States Department of Agriculture, 2012). The NASS also estimated that corn production would be down 27.5 percent, soybean production down 7 percent and sorghum production down 24 percent from May 2012 to November 2012 (United States Department of Agriculture, 2012).
Moreover, the world’s clean, freshwater sources are in short supply. Planet Earth contains roughly 332,500,000 cubic miles of water volume. Only 8,404,000 cubic miles of that total water volume is fresh water and 5,773,000 cubic miles of freshwater is trapped in glaciers, ice caps, and permanent snow. This means that fresh water makes up a mere 2.5 percent of the world’s total water and 68.7 percent of the freshwater on Earth is trapped in the form of ice and therefore unusable by humans (United States Geological Survey, 2012). This staggering statistic provides a scientific backing for the necessity to keep our freshwater sources clean and drinkable. However, water was not always a protected natural resource.

Pollutants in large bodies of water contaminate community drinking water as well as swimmable and fishable water. In 1948, brought on by a yellow fever epidemic, Congress passed the Federal Water Pollution Control Act (FWPCA) to authorize the Surgeon General to create programs to eliminate and reduce pollution in surface water (Digest of Federal Resource Laws of Interest to the US Fish and Wildlife Service, 2012). A largely ineffective statute in 1948, the original FWPCA provided the framework for an overhaul of the statute in 1972 when Congress amended the Federal Water Pollution Control Act to create the enforceable surface water regulatory mechanism it is today. Among other things, these revisions detailed and regulated point source discharges by creating limits to the amount and type of allowable pollution that can be discharged into a regulated body of water (EPA, 2012).

An example of polluted freshwater and of the necessity for strict, enforceable regulations can be found in Boston Massachusetts. The Charles River, from Magazine Beach upstream to the Watertown Dam, is not swimmable half of the time (Boston Globe, 2005). An enormous contributing factor to the pollution in the Charles River, and other water sources across the country, is stormwater runoff. Stormwater runoff is incredibly difficult to prevent, as it is a type of non-point
source pollution. Non-point source pollution involves polluted water, from an unknown origin, infiltrating and contaminating current water sources. In 1994, in Milwaukee, Wisconsin over one hundred people died and thousands more became ill due to water contamination from a non-point source of pollution (Water Quality Act of 1994). These are just a few examples of the severity of non-point source pollution, and evidence to the fact that the strength of the Clean Water Act amendments was not adequate.

The United States Environmental Protection Agency defines stormwater runoff as “rainfall that does not evaporate or infiltrate the ground because of impervious land surfaces or a soil infiltration rate lower than rainfall intensity, but instead flows onto adjacent land or water bodies or is routed into a drain or sewer system” (EPA, 2012). Stormwater runoff is a type of non-point source pollution. The DEP defines non-point source pollution as pollutants that are picked up by excess rain water/ snow melt runoff and carried over surfaces which do not allow runoff infiltration into the ground. These pollutants can include naturally occurring nutrients and minerals as well as man-made fertilizers and automotive greases (Department of Environmental Protection, 2012). Non-point source pollution caused by runoff originates from non-discernible locations making it very difficult for municipalities to map and prevent.

To formally combat this issue, in 1990 the EPA passed the Phase I Municipal Separate Storm Sewer System (MS4) permit in order to create regulations to track stormwater runoff and reduce the amount of non-point source pollution. In 1999 the EPA redrafted the Phase I permits to include Phase II communities (communities with smaller MS4 systems). The Phase II permit’s most recent draft went out in 2010 and is currently out to the municipalities for public comment. After the public comment time period, the EPA will review the comments and potentially make further revisions. Each Phase II Massachusetts municipality has a responsibility to submit reports based on
the requirements of the MS4 permit. The MS4 permit plays a crucial role in minimizing the amount of pollutants that enter municipal drinking water sources.

Currently in Massachusetts, the Department of Environmental Protection is the liaison between the EPA and Phase II municipalities. While the MS4 permit creates specific regulations for municipalities to abide by, municipalities are having problems complying with these regulations. These problems are caused by three major issues: (1) lack of communication between the MassDEP and municipalities, (2) insufficient knowledge of permit requirements and (3) lack of resources to effectively comply with the guidelines of the MS4 permit. Currently, the MassDEP does not have an efficient means of tracking and documenting municipality compliance with the MS4 permit. This data collection gap makes it very difficult for the DEP to assist municipalities in compliance with and understanding of the MS4 permit. The DEP wants improved communication with the Phase II municipalities so they can better assist these cities and towns in their MS4 compliance and stormwater programs.

Our research question aimed to identify the major gaps in stormwater mapping, GPS tracking, EPA reporting and the level of compliance of Central Massachusetts municipalities with the Phase II MS4 permit. In order to attempt to answer our research question, we worked with the MassDEP, aiding them in the development of a database which tracks MS4 compliance and annual reporting. This included contact with each of the following 13 Central Massachusetts municipalities: Auburn, Charlton, Dudley, Holden, Leicester, Millbury, Oxford, Paxton, Shrewsbury, Spencer, Sturbridge, Webster, and West Boylston. We conducted our research using interviews and surveys. We then used this information to find where municipalities are lacking in their MS4 permit compliance and to improve the Zoho database, an online annual report tracking database, for
viewing by the MassDEP. We were able to effectively aid the MassDEP in further closing the gaps in communication between them and the 13 municipalities involved in the CIC grant.

3.0 Background

Do you remember the last major rainstorm in your area? Water flows along curbs downhill into the catch basins, carrying any chemicals, trash or other pollutants present on the road. Where does all of this now polluted rainwater go? While some infiltrates into the ground as it travels over grass and dirt, most of it flows directly into catch basins attached to the municipality’s stormwater system. Unlike sewer systems, stormwater systems do not go through any treatment plants to remove pollutants, chemicals and harmful bacteria, but rather flow directly into nearby bodies of water including rivers, streams and lakes. As the stormwater flows into these bodies of water, it carries the pollutants and trash, harming the nearby fresh water supplies. These pollutants and chemicals not only harm the drinking water for humans, but create uninhabitable conditions for the animals which live and utilize the streams, rivers and lakes. The Blackstone River, a 46 mile long river stretching from Worcester, Massachusetts to Pawtucket, Rhode Island presents a multitude of entry points for stormwater outfalls. While one outfall will not destroy an entire river, 46 miles of outfalls will pollute a body of water to the point that the Blackstone River reached “prior to 1970 where the only two species of fish that could survive in it were White Sucker Fish and Carp” (Blackstone River Coalition, 2008). The Blackstone was polluted not by chemical dumping but by a multitude of stormwater outfalls discharging polluted runoff into the river.

The Massachusetts Department of Environmental Protection (DEP) facilitates the implementation of Environmental Protection Agency (EPA) stormwater regulations. Municipal Separate Storm Sewer System permits, also known as MS4 permits are utilized to regulate stormwater runoff. There are three categories of MS4 systems. Large and medium (communities
with a population of 100,000 or more) MS4’s fall under the Phase I regulations (EPA, 2012). Phase II communities (population less than 50,000 or as determined by EPA) are regulated by separate criteria. The 2003 MS4 and 2010 draft MS4 permits detail criteria for Phase II communities. On May 1st 2003, the EPA Region 1 issued a MS4 permit to address and regulate stormwater runoff in Massachusetts (ENSR International, 2005). These permits raised awareness of stormwater runoff and led to implementation of stronger regulations. In 2010, in order to replace the expired 2003 permit, EPA Region 1 issued an availability notice for a newly drafted MS4 permit regulation (Federal Register, 2010). This newly drafted set of permits is separated into three separate general permits; one to establish a Notice of Intent (NOI), a second to cover the prohibitions and a third to regulate Best Management Practices (BMP) (Federal Register, 2010). With the drafting and logistics of the MS4 permit being undertaken by the EPA, the job of regulating the compliance of the MS4 permit falls with the MassDEP (Fred Civian, 9/26/12). The purpose of these permits is to build upon the previous MS4 regulations and implement a higher quality, more inclusive plan to deal with stormwater runoff.

In this chapter, we begin by introducing the logistics of stormwater runoff by discussing some statistical and factual data on the effects of stormwater runoff in urban areas. In section two we discuss point and non-point source pollution describing each of them individually as well as some differences between the two pollution sources. In section three we introduce MS4 permitting, its history as well as outcomes of the permit. The next section discusses the implementation of the MS4 permit. Thereafter we present the role of the MassDEP pertaining to MS4 permitting. We then discuss obstacles that municipalities face with complying to the permit. Next we introduce the Community Innovation Challenge Grant and its role with the Central Massachusetts Regional Stormwater Coalition. Lastly, we discuss the Zoho database and its feasibility as an annual reporting tool.
3.1 Impact of Stormwater Run Off

When an impervious surface is built to replace once natural land, 16 times more rainwater runs off into surrounding bodies of water (Watershed Action Alliance of Southeastern Massachusetts, 2008). Stormwater is a leading contributor to the pollution of clean water but not many people understand what stormwater is and how it pollutes bodies of water.

Stormwater runoff is precipitation that accumulates from rain and melted snow, flows over impervious surfaces (surfaces which do not allow the infiltration of water into the ground) and does not get absorbed by the ground (EPA, 2012). As of 2008, stormwater runoff was responsible for 60% of all water pollution in Massachusetts (Watershed Action Alliance of Southeastern Massachusetts, 2008). In order for the EPA to regulate stormwater pollution, they laid out some basic guidelines in section 305(b) of the Clean Water Act to maintain fishable and swimmable areas. To maintain a fishable body of water locally, Massachusetts established limits for dissolved oxygen, pH, and temperature (314 CMR 4.00 et seq, 2012). To maintain a swimmable environment, Massachusetts established a limit on the amount of bacteria present in the body of water (314 CMR 4.00 et seq., 2012). “High bacterial concentrations in stormwater runoff from agricultural and urban areas are a leading cause in the failures to meet designated use criteria [minimum water quality conditions set by the EPA]” (Borst, Selvakumar, 2003). Michael Borst, a chemical engineer for the Urban Watershed Management Branch of the EPA, analyzed a sample of stormwater taken from a storm sewer drain in a residential area of Monmouth County, NJ. Borst discovered high levels of Staphylococcus aureus (Staph infection) and Pseudomonas aeruginosa (fatal to immunocompromised individuals) in the urban stormwater runoff (Borst, Selvakumar, 2003). Another source of pollution to freshwater within Massachusetts is high amounts of dissolved organic carbon which denigrates the quality of surface water. The Department of Environmental, Earth and Ocean Sciences at University of Massachusetts Boston conducted a study to determine the correlation of
dissolved organic carbon flow, which contributes to surface water acidification, with impervious surfaces in urban areas (Tian, 2012). The study measured the amounts of dissolved organic carbon in streams and the impervious surfaces bordering them within the south east region of Boston (Tian, 2012). The studies determined that the higher amounts of impervious surfaces led to higher amounts of dissolved organic carbon pollutants. These high amounts of pollutants found in urban stormwater runoff negatively impact the water quality of receiving water bodies (EPA, 2012). Once the stormwater is sampled, detecting pollutants is straightforward; the difficulty arises in discerning the origin of the stormwater and its point of contact with the pollutants (EPA, 2012).

3.2 Point and Non-point Source Pollution
In years past, pollution was thought of as large corporations and factories discharging their harmful chemical waste into pristine rivers and lakes, but currently, society faces a type of pollution much more difficult to regulate and manage; non-point source pollution. In order for municipalities to address the issue of stormwater, they first must understand non-point source pollution and its harmful potential if unregulated.

The EPA defines non-point source pollution as pollution caused by snowmelt and rain water traveling over the ground, picking up natural and man-made pollutants, and discharging them into bodies of water (EPA, 2012). The removal of trees, fields and other natural surfaces for the urbanization of a community decreases the surface area that can absorb stormwater and allow it to naturally enter the ground and slowly trickle into bodies of water, constantly recharging them (ENSR International, 2005). The prevalent issue with stormwater runoff is that the pollutants carried with the stormwater are sediments, toxic chemicals from motor vehicles, pesticides from gardens, road salts, heavy metals from motor vehicles, and thermal pollution from rooftops (EPA, 2012). These pollutants congregate in the stormwater runoff and then flow into bodies of water.
The origins of stormwater runoff are difficult to locate because any impervious surface is a potential source of polluted runoff.

Unlike non-point source pollution, point source pollution can be traced to a specific location. Many companies and factories dispose of their chemical and pollutant waste by discharging it into surface waters using pipes (NOAA, 2008). This means that the contaminants are being deposited into bodies of water through a specific source, hence garnering the name point source. Thus, determining the areas where the pollutants are deposited from a point source is much easier to locate than non-point source pollution where the locations are more difficult to discern due to the vast area of runoff locations.

Increased non-point source runoff can be attributed to the expansion of impervious surfaces due to urban development. As impervious surfaces expand, the rate of non-point source pollution grows thereby increasing pollution levels of surrounding surface water bodies. This relationship between impervious surfaces and water quality has led the EPA to categorize streams in a watershed, the area of land where all the water collects and goes into the same surface body of water (EPA, 2012), with 25 % or more of its land covered by impervious surfaces, to be so impaired that they are not suitable for restoration (Millar, 2012). The extensive research on the impact of stormwater runoff has led the EPA to implement an MS4 permit to regulate stormwater runoff and discharge.

### 3.3 MS4 Permitting

An MS4 is a system which collects stormwater through the use of sewer piping, various drainage techniques, and treatment plants (EPA Administered Permit Programs: The National Pollutant Discharge Elimination System, 2011). MS4s are owned by a state, a municipality or any public entity that releases stormwater into bodies of water within the United States (EPA, 2012). The MS4 permit originated from Congress’ 1972 Federal Water Pollution Control Act amendments,
also known as the Clean Water Act (CWA). These amendments created the surface water regulatory infrastructure we have in the United States today. The present day CWA regulates point source discharges using a permit system, specifically the National Pollutant Discharge Elimination System (NPDES) (Federal Register, 2010). More specifically, the CWA gives the EPA the authority to set measurable enforceable limits on individuals who wish to discharge pollutants. Without the proper NPDES Permit, any known discharge is considered illegal (EPA, 2012). With regards to stormwater discharging, the CWA requires facilities to implement a stormwater pollution prevention plan (SWPPP) which identifies and removes potential sources of pollution that will negatively impact the quality of stormwater runoff (EPA, 2010).

In 1990, the EPA publicized the original Phase 1 regulations dealing with MS4’s. This Phase I MS4 permit required cities or counties with a population of 100,000 citizens or more to apply for a NPDES permit for their stormwater discharge (EPA, 2012). In 1999, the EPA implemented the Phase II regulations of MS4 permitting. These regulations required smaller MS4’s in urban areas to apply for the NPDES permit by March 10, 2003. This permit expired on December 9, 2007 (Federal Register, 2010). The recently drafted 2010 MS4 permit regulates the Phase II communities, MS4 systems both in and outside of urbanized areas which are designated by the permitting authority. Like Phase I municipalities, Phase II communities must apply for a NPDES permit to cover their stormwater discharge (EPA, 2012).

Within Massachusetts there are four watersheds that are regulated by Phase II guidelines. These watersheds are (1) Merrimack Watershed (MW), (2) Interstate South-Flowing Watershed (ISW), (3) Northern Coastal Watershed (NCW), and (4) Southern Coastal Watershed (SCW). Within these four watersheds lie 239 of the total 351 municipalities that make up Massachusetts (See Figure 1) (EPA, Regulated Communities in Massachusetts, 2012). The newly drafted 2010 MS4 permit for
Phase II communities builds upon the EPA’s Phase I implementations by requiring members of small MS4 systems, including construction sites within the municipality, to implement plans to control and eliminate stormwater runoff pollution through the use of NPDES permits (EPA, Office of Water, 2005).

Figure 1: Regulated Municipalities in Massachusetts
Retrieved From: http://www.epa.gov/region1/npdes/stormwater/ma/MA_PermitType.pdf

The MS4 permit is broken down into six sections. Part 1 consists of general regulations such as a requirement to submit a Notice of Intent to both the EPA and the Mass DEP, following all necessary rules of the Endangered Species Act and the National Register of Historic Properties requirements (EPA Summary of Permit Requirements, 2010). Part 2 “Non-Numeric Effluent Limitations” defines the time constraints which stormwater controls must be implemented within.
This section includes the implementation of the stormwater management plan as well as the six minimum control measures implemented to prevent and reduce contamination due to stormwater runoff (EPA Summary of Permit Requirements, 2010). Part 3 “Outfall Monitoring Program” discusses the implementation of an outfall monitoring program, a program which involves conducting various dry weather, field and wet weather screenings of MS4 connections and outfall pipes discharging into bodies of water. These tests are conducted to analyze the pollutant content in the discharge (EPA Summary of Permit Requirements, 2010). Part 5 “Program Evaluation, Record Keeping and Reporting” requires regulated municipalities to maintain all of the MS4 related records including an overall self-assessment review of municipality compliance with the permit, an assessment of the selected BMP’s, and an assessment of compliance with the six minimum control measures (EPA Summary of Permit Requirements, 2010). The above requirements come together to make up the required annual report submitted by each Phase II municipality to the EPA. Part 6 “Requirements for State Non-Traditional MS4’s” requires municipalities to document and submit annual reports on properties as well as green infrastructure facilities owned and operated by Massachusetts (EPA Summary of Permit Requirements, 2010). For a more in depth summary of a potential 2010MS4 permit, refer to the EPA website\(^1\). With these regulations in place, the EPA and MassDEP hope to reduce the devastating impact of stormwater on the Commonwealth’s waterways.

### 3.3.1 Outcomes

The responsibility of the administration of the NPDES stormwater permit program in Massachusetts falls under the EPA in conjunction with the Massachusetts state environmental agency (EPA, 2012). The EPA drafts, and implements the permit (EPA, 2012). The MS4 permit outlines many regulations for municipalities to follow in order to effectively deal with stormwater runoff. In this section, we will discuss the six minimum control measures of the MS4 permit and

\(^1\) [http://www.epa.gov/region1/npdes/stormwater/ma/SummaryPermitRequirements.pdf](http://www.epa.gov/region1/npdes/stormwater/ma/SummaryPermitRequirements.pdf)
EPA issued guidelines pertaining to the implementation of green infrastructure in new development and redevelopment.

An important section that the MS4 annual reports focus on are the six minimum control measures detailed MS4 permit. In order to fully comply with control measures, each municipality must produce a stormwater management plan which, in writing, demonstrates what will occur to fully meet the requirements of each individual control measure. The six 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 and
(6) Pollution Prevention/Good Housekeeping (EPA, 2010)

Public Education and Outreach requires that each Phase II municipality distribute at least two messages (pamphlet, bulletin board, website link, etc.) to the general public every year and include a description of them in the annual report to the EPA. Public Participation/Involvement requires each municipality to provide and document the general public’s opportunity to review and comment on the municipality’s stormwater management plan. Illicit Discharge Detection and Elimination details the required steps to develop a program to identify, diagnose and treat sources of illicit discharge. An illicit discharge is defined as any discharge, not covered by an NPDES permit, that is not composed of pure stormwater (EPA, 2012). Some of the steps necessary for an IDDE program are to maintain and eliminate storm sewer overflows, complete a map of the entire MS4 system including outfalls, create a hard copy of the IDDE program, effectively remove all illicit discharges and train municipal employees on the IDDE program. Construction Site Runoff Control requires that every construction site implements sediment and erosion control practices, create written procedures to detail the site’s sediment and erosion control practices and develop written
procedures for a site plan review. Stormwater Management in New Development and Redevelopment (post construction stormwater runoff control) requires the implementation of BMP’s to control and reduce stormwater runoff, include in the annual report any potential green infrastructure implementation and any retrofitted MS4 infrastructure (catch basin stenciling and labeling, etc.). The sixth and final control measure, Good House Keeping and Pollution Prevention for Permittee Owned Operation, requires every Phase II municipality to develop written procedures for all municipal activities, establish a program to repair and maintain MS4 infrastructure, clean MS4 catch basins and report on the number of miles of road swept. The EPA designed these control measures with the intention of giving municipalities guidelines and regulations to create a stormwater management program to reduce polluted stormwater runoff. The purpose of the stormwater management plan is to construct a foundation for further development of stormwater runoff prevention techniques as well as create an awareness of the runoff problem in the particular community. Through education, municipalities will have a greater understanding of the harmful effects of stormwater runoff on the environment and on potential drinking water sources, hopefully providing incentive to practice the green techniques offered in the plan.

The EPA hopes that implementation of these new Phase II MS4 permits will do more than just decrease stormwater runoff but increase the use of preventative stormwater infrastructure. “EPA has initiated a national rulemaking to establish a program to reduce stormwater discharges from newly developed and redeveloped sites and make other regulatory improvements to strengthen its stormwater program” (EPA, 2012). One of these regulatory improvements is the increased use of green infrastructure. Green infrastructure uses plants and soil to manage stormwater runoff through infiltration back into the ground, evapotranspiration (direct evaporation and transpiration through plant life), and the capturing and use of the stormwater itself (EPA Department of Water,
There are five elements of the stormwater program involving green infrastructure that the EPA suggests to guide the states in developing green BMPs.

(1) Implement policies regarding plumbing codes, landscaping requirements, construction sites and use of native plants through guidance manuals and other forms of education.

(2) Employ green infrastructure for capital improvement projects by working with facilities management and landscaping crews to have qualified people consistently implement this infrastructure in municipality projects.

(3) Allow time for training and devote resources to educating staff members, developers, and maintenance on green infrastructure in order for the concept to be prolific within the municipality.

(4) Establish a maintenance tracking system which assures that the maintenance on the green infrastructure entities is properly executed thereby allowing the entities to function at their highest potential. This tracking system should consist of a database with the capability to track not only maintenance but geographic information within the municipality as well.

(5) Incentivize green infrastructure by offering developers bonuses, discounted fees and/or tax credits (EPA Department of Water, 2012). The use of green infrastructure will not only aid in the reduction of runoff, but will provide an environmentally friendly approach to pollution control within municipalities.

In addition to detailing guidelines to mitigate stormwater runoff, the EPA hopes that the six minimum control measures along with the green infrastructure guidelines will reduce stormwater runoff through the implementation of BMPs and public awareness (EPA Department of Water, 2012).
3.3.2 Implementation

In a constantly increasing urbanized country, the effects of growing areas of impervious surface force the EPA to create tactics to combat the negative effects of larger volumes of stormwater runoff. The following section contains examples of various methods of stormwater prevention and management techniques that the EPA has enacted in several areas across the state.

The percentage land area constructed of impervious surfaces in municipalities is directly related to the overall pollutant levels of local streams and water supplies (See Figure 2).

![Figure 2: Relationship Between Percent Watershed Imperviousness and Environmental Quality](http://nemo.uconn.edu/tools/impervious_surfaces/pdfs/Sleavin_etal_2000.pdf)

If a city or town is covered in as little as ten percent impervious surface, stream quality is drastically impacted (See Figure 3).
Normally, in wet weather conditions, 50% of rain water soaks into the ground, 40% is used by trees and other vegetation while only 10% runs off into nearby rivers and streams (Flinker, 2010). As impervious surface increases, the percentages of where rainwater travels drastically changes. For example, one acre of paved parking lot produces 16 times more runoff directly into streams and rivers than a forest area of comparable size (Flinker, 2010). This increase volume and rate of flow into the rivers causes negative hydrologic, biological, physical and water quality impacts. These negative impacts include but are not limited to increased runoff volume, decreased river base flow, enlargement of the river channel, reduced fish, aquatic insect, amphibian and wetland plant diversity and increased sediment/nutrient concentrations (Flinker, 2010). In heavily urbanized areas, up to 50% of rainfall runs directly into nearby streams and bodies of water due to impervious surfaces (Frazer, 2005). In order to reduce the effects of impervious surfaces on stormwater runoff, the EPA
has begun to take measures to convert impervious surfaces into functioning areas of stormwater collection and distribution into the ground water. This conversion occurs with the addition of stormwater best management practices. These functioning areas prevent the stormwater from flowing into vital streams and other water sources.

Some of the EPA’s methods to combat stormwater runoff can be as simple as having a section of curb removed from a parking lot to adding a location for water to run out off of the impervious surface and into a bioretention cell, or as complicated and expensive as a roof garden. Other approaches to stormwater runoff management that the EPA has started to adopt include permeable pavers (pavement that allows rain water to soak through the surface into the ground below), rain gardens, underground retention basins (large basins underground which collect runoff and allow it to permeate back into the ground water), and constructed stormwater wetlands (EPA, 2012). These techniques share a common goal, to redirect or collect stormwater and prevent it from infiltrating valuable water supplies such as streams or wells. See Appendix 4 for an example of a stormwater BMP, the EPA green roof in Boston, MA.

The USEPA has detailed best management practices for municipalities to counteract the impact of excessive stormwater runoff. Best management practices (BMPs) “assist private property owners in estimating both the cost and pollution reduction impact of various mitigation measures” (Mondaq Business Briefing, 2008). BMPs are based on the six categories that make up the Phase II control measures as defined in section 3.3.1 outcomes; (1) Public Education, (2) Public Involvement, (3) Illicit Discharge Detection and Elimination, (4) Construction, (5) Post Construction and (6) Pollution Prevention/Good Housekeeping (EPA, National Menu of Stormwater Best Management Practices, 2012). One example of a BMP proposed by the EPA as a pollution prevention measure is
the elimination of curbs and gutters\textsuperscript{2}. Since curbs and gutters promote a quick flow, they do not allow the stormwater to permeate back into the ground, increasing the amount of runoff and pollution (EPA, 2012). While these BMPs are implemented by some municipalities and have been since 2003, the majority of Massachusetts municipalities have not put any BMPs into action (Klosterman, 2012).

3.3.3 Role of the MassDEP in MS4 Permit Compliance

With the EPA in the process of issuing their draft revisions of the MS4 Permit to Phase II municipalities, the MassDEP acts as a liaison between those cities and towns, which fall under the jurisdiction of the permits and the EPA. The MassDEP assumes the role of assisting the Phase II municipalities in their compliance with the MS4 permit. While the MassDEP does not regulate the MS4 permit like the EPA, they provide guidance in the form of educating on the contents of the permit and providing possible solutions to non-compliance with the six minimum control measures detailed in the permit (MassDEP, 2012).

3.3.4 Obstacles to MS4 compliance

One of the underlying issues facing successful and widespread implementation of MS4 permits is the lack of communication between the various municipalities and the EPA. The MassDEP has been attempting to act as liaison between these two entities to resolve this communication gap. Some municipalities are worried that if they fully disclose information concerning their stormwater runoff systems, they might get fined. This fear is strong in smaller municipalities that may not have the financial means or man power to implement compliant MS4s as Fred Civian, Phase II coordinator, with the MassDEP laments. Additionally, municipalities such as Uxbridge, MA have put draft stormwater management plans to a public vote and have had them rejected; this occurred even though the potential plan was a “barebones reflection of the EPA’s

\textsuperscript{2} An extensive discussion of stormwater Best Management Practices is outside the scope of this project. However for additional information on this subject please visit: \url{http://cfpub.epa.gov/npdes/stormwater/menuofbmps/}
requirement” (Spencer, 2012). In other words, many municipalities may have strong opinions about how they wish to handle stormwater issues and may feel strongly about changing their ways in order to effectively comply with MS4 permit requirements. With the municipalities lacking resources to fully comply with potential regulations of the upcoming MS4 permit, they began communicating with each other in order to collaborate funding.

3.4 Community Innovation Challenge Grant
The Community Innovation Challenge (CIC) Grant is a statewide grant program which attempts to provide incentives to local government to maintain local services within Massachusetts (Massachusetts Executive Office of Administration and Finance, 2012). In 2012, 13 municipalities within Central Massachusetts applied for funding from the CIC Grant Program and received $310,000 for a project titled “Regionalizing Municipal Stormwater Management in Central Massachusetts through Collaborative Education, Data Management, and Policy Development” (Office of the Governor of Massachusetts, 2012). These 13 municipalities make up what is called the Central Massachusetts Regional Stormwater Coalition. This project is based upon the realization that a collaborative effort, through education and training, would yield a more cost effective and efficient means to control stormwater runoff rather than each municipality individually trying to combat stormwater (CMRSC, 2012). For example, the 13 municipalities have used a portion of the grant money to purchase two Leica GPS units to complete their MS4 system and outfall mapping, as required by the MS4 permit. This is just one example of the many ways the CIC grant is assisting the Central Massachusetts Regional Stormwater Coalition in effectively controlling stormwater and complying with the MS4 permit.

3.5 Zoho Database
In order to parse through all of the information gathered from the MS4 permits, the Mass DEP needs a database to compile the municipality specific stormwater information in an organized
manner. The Zoho database is a program that stores all of the information and displays it in an easy to use manner and forgoes the complexity involved with database programming. Zoho implements a drag and drop interface that allows users to input their MS4 permits and upload them for the other users to view. This allows municipalities and DEP employees to collaborate on the uploaded information and communicate. What makes Zoho coveted is the simplicity associated with navigating through the database and the ease of organizing the information of MS4 permitting in order for other municipalities to have a reference from. Overall, Zoho database provides MassDEP with a proper medium in which to take all the information from MS4 permitting and organize it for users to use effectively. The Zoho database along with the implementation of the MS4 permit, if executed properly, will have a positive impact on the issue of stormwater runoff.

When using a third party database for information input of such magnitude as a municipality’s annual report, one wants to research as much background information about said database as possible. According to an independent review published on CRM Software’s website (crmsearch.com) the Zoho database is a relatively easy to use and inexpensive option for data input for municipality annual reports; however, the database as a whole is fairly new and untested and therefore faces much competition from more established competitors (CRM Search, 2012). Other case studies document nothing but high praise for the database from companies such as NASSCOM, Oxfam America, K. Hovnanian Homes, and SoluChem LLC (Zoho Creator, 2011). These case studies, however, may provide only one side of the story. All four case studies fail to mention any possible shortcomings of the database, or suggestions for improvement for Zoho Creator. Moreover, the studies are all available from the Zoho Creator website, implying a biased selection of posted reviews. Even so, the case studies highlight aspects of the database that would be beneficial to the municipalities which make up the Central Massachusetts Regional Stormwater Coalition. The Zoho Creator made an intuitively easy way to develop application forms with the use
of drag and drop fields. This allows the development of the forms to be created to reflect exactly how users would see the forms. Therefore, these applications could be tailored and modified to reflect the parameters that are detailed in the MS4 permit.

In this background, we identified the prevalent issues that stormwater runoff presents and how difficult it is for municipalities to locate and manage it. The EPA implemented the MS4 permit in order to not only reduce stormwater runoff but to illustrate and require a stronger stormwater runoff prevention infrastructure within each municipality. In the following chapter, with guidance from the Massachusetts Department of Environmental Protection, our project group locates trends in lack of compliance with the MS4 permit and the feasibility of the implementation of the Zoho database based on firsthand information and input obtained from town employees.

4.0 Methodology

4.1 Introduction

The goal of this project was to promote communication between the MassDEP and the CMRSC by identifying and addressing gaps in stormwater system mapping, EPA NPDES annual reporting and MS4 permit compliance for 13 municipalities in Central Massachusetts. In order to successfully complete this goal, we had several objectives. The main objectives were to: 1) improve the Zoho database and to facilitate its usage, 2) gather information regarding municipality specific MS4 permit critiques and 3) compare the usability of the Garmin Oregon 450 against the Leica CS25 tablet for municipal MS4 GPS mapping.

In this chapter, we begin by introducing the general scope of the methodology including justification for the research question that guided our project. Next we operationalize our research question, identifying our concepts and variables. In the following section we detail our methodology, our plan for measuring our variables. In the final section we discuss our information sources and
units of analysis. Throughout this methodology section, we will refer to our project group as a whole by using the title project group.

4.2 Research Design

4.2.1 Concepts

The research question that drove our project was to identify gaps in stormwater system mapping, EPA NPDES annual reporting and MS4 compliance for Auburn, Charlton, Dudley, Holden, Leicester, Millbury, Oxford, Paxton, Shrewsbury, Spencer, Sturbridge, Webster and West Boylston. This entailed gathering information predominantly from Shrewsbury, Dudley, Charlton, Holden and Millbury and then, utilizing the information we obtained, to improve the functionality of the Zoho database, bring to light trends in municipal MS4 permit compliance issues and offer reviews of the effectiveness of both the Garmin and the Leica GPS units.

Our research question can be broken down into four major concepts: (1) Major gaps, (2) stormwater, (3) MS4 Permitting and (4) the Zoho Database. A major gap refers to the lack of information pertaining to the various aspects of the research question. For example, a major gap in MS4 permit compliance is the lack of required information being sent from municipalities to the EPA within the annual report. For the purposes of this research, our definition of stormwater incorporates the negative effects of excess stormwater runoff collecting pollutants over impervious surfaces and, in-turn, polluting large bodies of drinking/swimming waters. MS4 permitting refers to the requirements of the MS4 permits, as identified by EPA regulations. We paid particular attention to aspects of the permit that are not being followed, understood and implemented by the CMRSC. Lastly, the Zoho database specifically refers to a data collection program, useful for tracking MS4 compliance among municipalities through annual reporting. These concepts drove our methodology and provided tangible methods for analyzing our success.
<table>
<thead>
<tr>
<th>Objective</th>
<th>Variable</th>
<th>Indicator (How we measure the variable)</th>
<th>Source (Where we will look to find the answers)</th>
</tr>
</thead>
</table>
| Identify Major gaps | Information deficits | • Zoho database  
• Interviews  
• MS4 permits | • Municipalities |
| Stormwater | Non-mapped stormwater runoff  
The negative effects of excess stormwater runoff  
Level of contaminants in stormwater | • Interviews  
• Document analysis  
• MS4 permits | • Mass Watershed Coalition  
• DEP  
• Municipalities |
| MS4 Permitting | Municipality compliance  
Municipality understanding of the requirements | • Document analysis  
• Interviews  
• MS4 permits | • Regulation  
• Municipalities  
• DEP employees |
| Zoho database | Accuracy of Data collection program  
Amount of inputted data  
Potential to replace Annual Report | • Zoho database  
• Interviews  
• Surveys | • Zoho database  
• Municipalities |

Figure 4: Operationalization Rubric

4.2.2 Variables
We identified the variables pertaining to the four concepts which make up the research question. Figure 3 illustrates the operationalization of the major concepts behind our research project. In reference to the major gaps concept, our variable is information deficits. The variables including non-mapped stormwater runoff, negative effects of excess stormwater runoff, and the
level of contaminants in stormwater refers to the stormwater concept. In order to define the concept of MS4 permitting, we decided to title the variables; requirements of the MS4 permit, municipality compliance with the MS4 permit, and municipality understanding of the MS4 requirements. Our final concept, the Zoho database, is defined by the accuracy of the data collection program within each of the 13 municipalities as well as the potential of the database to be an alternative means of NPDES annual reporting.

4.2.3 Objectives
During the seven weeks of this IQP, our main concern was to identify missing information dealing with stormwater system mapping, EPA NPDES annual reporting, and MS4 permitting compliance within the 13 municipalities. In order to accomplish this task, we broke down our research question into the following:

1. Assessing and improving the functionality of the Zoho database.
2. Assessing the functionality Garmin and the Leica GPS mapping units.
3. Assessing municipal opinions of and ability to comply with the 2003 and 2010 MS4 permit

4.3 Measurements/Indicators
The project group addressed these variables and worked to complete objectives by conducting interviews and surveys with the 13 municipalities and MassDEP employees. More specifically, the project group interviewed the individuals from the towns Shrewsbury, Holden and Charlton whose responsibility it is to monitor and regulate stormwater runoff as well as MS4 permit compliance. For the interviewed parties the regulation of stormwater in the municipalities fell under the Engineering or Conservation Department. Our interviews with the municipality employees gave us insight on the progress and knowledge in the regulation of stormwater.
We gathered data on the current methods that the individual municipalities are using to manage and control stormwater runoff. We went through the annual reports of the 13 municipalities before GPS mapping started. The reports selected were specific to one municipality at a time to keep the collected data in a manageable format. Therefore, our unit of measurement for the project data collection was a single municipality. Using the information gathered on stormwater runoff per municipality, we assessed each of the interviewed municipality’s compliance with the MS4 permits. We did this using the most recent 2010 MS4 draft revision as well as the current 2003 MS4 permit, provided to us by Fred Civian, Stormwater Coordinator at the MassDEP. These MS4 reports were invaluable to define the steps it would take for a municipality to meet the stormwater runoff regulations. We utilized the stormwater prevention tactics currently used by the municipalities and referred to the MS4 permit to determine if the methodologies meet the MS4 permit requirements. We then, with the help of the municipality interviewee, utilized the obtained data to revise and improve upon the current Zoho applications. As explained in the following sections, conducting interviews and surveys provided us with and effective means of data collection per municipality.

4.3.1 Interviewing/ Surveying Municipalities

4.3.1.1 Why Interviews?

The project group collected the majority of the necessary information through interviewing. We interviewed the individuals within the towns of Shrewsbury, Holden and Charlton who deal with the issue of stormwater runoff as well as MS4 compliance. Larger towns, such as Shrewsbury had the resources to designate a specific individual within the Engineering Department who dealt with these issues. However, smaller towns such as Dudley and Millbury did not have the man power to have a formal interview. We conversed with Dudley Highway workers and Millbury DPW staff
while GPS mapping their MS4 system in order to obtain all of the necessary information needed to complete the desired data collection for each municipality.

During these interviews, we became familiar with each municipality’s current methods for controlling stormwater runoff. For this research project, interviewing was a practical and feasible means of collecting data. There were five specific municipalities that needed to be included in the interviewing and analysis in this project. Due to this relatively small number of municipal employees that needed to be interviewed, interviewing provided the most relevant information within the time constraints of the project.

Stella Tamul, an environmental analyst at the MassDEP and our primary contact, along with Aubrey Strause and Helen Pottle, project managers for Tata and Howard, assisted us in finding appropriate individuals to interview from each municipality. These interviews were conducted in a semi-structured manner. The project group went into each interview with a predetermined set of questions; however these questions did not restrict the potential direction of the conversation (See Appendix 2 for interview questions). The advantage to a semi-structured interview is that if the interviewee (i.e. the municipality employee) begins discussing something we had not anticipated, but is relevant to our research, we had the option of improvising to accommodate both the interviewer and the interviewee, while still gathering relevant information.

4.3.1.2 Why Surveys?

We obtained a portion of the information by surveying the 13 included municipalities. Surveys allowed us to obtain answers to questions that may pertain to multiple municipalities. Surveying allowed the collection of feedback on issues dealing with the research question driving this project. As an alternative means of data collection for what we needed feedback for, a survey served as a quick and sufficient replacement for obtaining answers to the desired question while
increasing the number of participants. The survey also acted as a precursor to the interview. It forced the municipalities to take a look at what we are asking of them and potentially research and prepare a well-developed answer to each of our questions. In addition, the survey gave us a means to distribute the Zoho user guide and the Zoho Creator application pertaining to the six minimum control measures. When a survey was necessary, we used email as the question distribution technique as conventional mail is a slower, more expensive process that often times does not yield a positive feedback rate.

Before we entered the field of our project, we went over and analyzed any data and information obtained from the NPDES annual reports as well as background sources pertaining to stormwater. This not only gave us a greater understanding of the larger societal issue of stormwater as a whole, but also shed some light upon any and all practices already put into place by these municipalities to combat the problem of stormwater runoff.

5.0 Findings, Discussion and Recommendations

5.1 Introduction
Upon the completion of the data collection and findings analysis phase of this project, we agreed upon several recommendations that will positively affect the CMRSC municipalities regarding their stormwater management capabilities. During the course of our project we had conversations and interviews with various members of the 13 municipalities involved with the CIC. These conversations gave our project group useful information concerning municipality MS4 understanding, knowledge of the stormwater system, compliance with the MS4 permit as well as the utility of the Zoho database for the inputting of MS4 annual reporting data. The data collected through municipal interviews and agency interviews was our primary source of information as only two of the 13 municipalities whom we sent our survey to, responded. Some of the trends that we
noticed during our interviews and discussions with municipality employees were a desire for a clearer worded MS4 permit, a more proactive role by the EPA/DEP to aid municipality efforts, more detailed application forms on the Zoho database, and a difficulty to fully comply because of a lack of manpower.

In the following findings/discussions and recommendations chapter, we will first discuss our findings from GPS mapping. Next we will present our analysis of the comparison between the Leica and Garmin GPS units and the necessity for Leica training. After that, we will discuss the municipality feedback pertaining to the MS4 permit, leading into a section discussing the need for an EPA statewide educational message concerning stormwater. Next we will present the need for an IDDE template issued by the EPA. In the subsequent section, we will explain the need for more detailed requirements pertaining to outfall discharge sampling and the difficulty in meeting these sampling requirements. Next we will discuss the difficulties municipalities face in implementing and maintaining their BMP’s. In the following section, we explain the feasibility of a potential stormwater tax to alleviate the financial burden that stormwater management presents to certain municipalities. In addition to analyzing current inefficient catch basin maintenance requirements we will discuss the Zoho database and our recommendations on the matter.

5.2 GPS Mapping
While certain municipalities agreed to meet with us to discuss MS4 topics pertaining to their town, our sponsors at the MassDEP felt that it would not only be beneficial for us to gain GPS mapping field experience, but it would benefit the municipalities in their compliance with the GPS mapping requirement of the MS4 permit. After we mapped for the municipalities they felt more comfortable speaking with us and sharing their experience with the MS4 permit. We completed outfall and catch basin GPS mapping for the towns of Shrewsbury, Dudley, Millbury and Charlton. In doing so, we were able to not only provide GPS mapping services for the towns, but were also
able to observe firsthand the current state of the MS4 systems. In general, the catch basins were not maintained regularly to promote the efficient catchment and distribution of stormwater runoff. Often times the grates were not only covered in leaves and other vegetation but sediment piled up as much as 5 inches, requiring a substantial amount of shoveling to reveal the catch basin grill.

![Covered Catch Basin](http://www.pavementresources.com/catch-basins-and-storm-drains/)

Once we were able to view the interior of the catch basin, we often times noticed a buildup of sediment and other solids, completely blocking any stormwater from flowing to the outfall pipe. In many cases, the outfall pipe was completely hidden by the surrounding environment, making it quite difficult to locate and map. Typically, the concrete and metal outfall pipes had noticeable degradation of their structure while any pipe composed of corrugated ADS (Advanced Drainage System) plastic or PVC (Polyvinyl Chloride) did not have substantially noticeable decomposition. (See Figure 6)
Figure 6: Outfall Examples

An MS4 system with clogged catch basins negatively impacts the surrounding roadways and natural environment. If stormwater runoff cannot infiltrate into the catch basin due to a blockage or an overflow it will continue along its path, gaining speed and picking up any containments it travels over and eventually flowing into the nearest unclogged catch basin or low point in the landscape, discharging its pollutants to said location. Alternatively, according to Joe Kosiba of Millbury DPW, the stormwater could, depending on the landscape, congregate around the low point that is the catch basin, cause hazardous driving conditions, pick up more pollutants due to the wider area of coverage, and eventually drain into the nearest low point of the surrounding landscape. This mass
drainage would add pollutants to the surrounding environment as well as erode the landscape, leaving a path for future stormwater to follow.

While out in Shrewsbury, we noticed an unknown substance discharging from an outfall (See Figure 7). Shrewsbury Town Engineer, Bradford Stone, expressed concern for this particular outfall due to its location. This outfall connects to storm drains in Shrewsbury center, in the vicinity of a Dunkin Donuts and a Seven Eleven convenience store. Brad deduced that this unknown substance, if it was not a naturally occurring bacterium, could potentially be years of coffee being spilled into the catch basin or grease traps from the convenience store being directly discharged into the catch basin. Shrewsbury is a fairly proactive municipality in its stormwater management. They not only have an almost completed GPS map of their MS4 system but an employee (Dan McCullen) dedicated to the town’s GIS program. Therefore Brad noted that he would have to return to this specific outfall for inspection on the unknown substance.

![Figure 7: Potential Illicit Discharge](image)

When mapping the MS4 systems of each municipality, there was a noticeable difference in the outfall location techniques. In towns with a previously mapped MS4 system, finding the outfalls that were not GPS mapped posed less of a challenge due to the previously created Computer Aided Design (CAD) drawings of the MS4 system. In towns with no engineered drawings of the MS4
system, finding the outfalls consisted of peering into the catch basins and following the direction of the outflow pipe until we discovered the outfall. Not only was this method less efficient but it showed the true nature of the knowledge that the municipality lacked pertaining to its MS4 system, emulating the need for a better educated municipality workforce.

5.2.1 Finding 1: Leica CS25 Tablet vs. Garmin Oregon 450
While performing GPS mapping, we had the opportunity to use two very different GPS units. The first unit we used was the hand held Garmin Oregon 450 and was provided to us by the EPA (See Figure 8). The other unit was the Leica CS25 provided to us by the Central Massachusetts Regional Stormwater Coalition. Both GPS units excelled in certain areas and had drawbacks in others.

The Garmin unit had an estimated accuracy range of 2-5 meters. While this is not a very precise range, it provides enough accuracy to give municipalities the ability to locate the outfall as necessary. Overall, the Garmin unit was very simple to use. We simply had to turn it on, create a waypoint and name that waypoint to correlate with the outfall. On average this process took about 1 minute. The unit never had any trouble gathering a GPS connection even when mapping in heavily wooded areas. The unit was rugged enough so that if we mishandled it, there was minimal to no damage maintaining full functionality. This GPS unit is much more affordable than the Leica, generally priced at $300, making it very practical for a municipality with a limited budget. One major drawback to this unit is the lack of post processing capabilities. Post processing, in terms of this project, is the actions that the municipality must perform to take a GPS point of an outfall/catch basin, perform an inspection of the structure and then superimpose the GPS point on an orthographic map. In order for us to view our mapped points, we had to download Garmin’s Basecamp software. This software is free on Garmin’s website and simply required the user to upload the GPS points from the unit onto a computer and select which ones were to be
superimposed on the orthographic map. This program then allowed us to export the GPS points as a usable .gpx file, a usable format for an individual wishing to develop an MS4 map.

Figure 8: Garmin Oregon 450

Being a vastly more precise unit, the Leica tablet equipped with a GG02 antenna is generally accurate between 2-4 centimeters. The Leica was much more complex than the Garmin unit. Prior to obtaining an initial fix, we had to power up the tablet roughly 20 minutes in advance. This allowed for Windows 7 to load all necessary programs and configure any updates. Once the tablet was fully powered and connected to AT&T wireless service, we had to establish a Bluetooth connection between the tablet and the antenna using a program called Zeno Connect. This took an additional 5 minutes. After we established a Bluetooth connection, the unit had to obtain a minimum number of satellites and obtain a fixed position. With that being said, for every desired point after the initial one, the unit obtained a fix at a faster rate. The Leica unit offered access to pre designed forms pertaining to outfalls, catch basins and storm drains. These forms contain dialogue boxes which make in the field mapping, inspection and documentation of physical properties of the structure possible. Completing these forms in the field completely bypasses all post processing as it is all completed on the tablet when the form is populated and submitted to PeopleGIS. Once standing above the desired catch basin/outfall and after obtaining a fix, we simply had to push the
“map it” button on the corresponding PeopleGIS form and the Leica unit populated the X, Y and Z coordinates. The form also offered inspection fields which we could populate, describing in detail the structure, its physical condition and location. Inspection forms allow for the user to record and photograph the physical status and the functionality of each MS4 structure they map. This promotes efficiency due to the fact that the municipal employees will not have to go back and inspect the MS4 structure as the information is stored in the PeopleGIS database. Not only are inspection forms more efficient, but they prevent problem areas (such as a clogged catch basin) from being looked over or forgotten during MS4 maintenance. Once submitted, all post processing is completed and the populated form is sent directly to the PeopleGIS database.

One factor that may make the Leica unit unappealing to certain municipalities is the price of this unit and antenna. The cost of the Lieca tablet and all associated equipment including the mounting pole and the GG02 antenna is about $14,000. In addition, a MTS (Maine Technical Source) RTK (Real Time Kinematic) yearly subscription must be purchased at a cost of roughly $1,200. Total, the full use of the Lieca will cost about $15,000 a high price that may be too high for low budget municipalities. Additionally, the cost of all PeopleGIS services, paid through the CIC Grant is $27,500 for the first year and $12,000 for each additional year (Flanders, 2012). While this may be too much to spend on a per municipality bases, the CMRSC has been able to absorb the costs through the CIC Grant and obtain everything necessary to effectively utilize the Leica unit.

Over the course of our GPS mapping experience with the Leica tablet, we observed some additional issues which may cause troubleshooting problems for a user who is not properly educated and trained. For example, when first using the tablet after powering on, system updates and error messages may appear which require a basic knowledge of Windows 7 and the tablet. The tablet may not be able to establish a Bluetooth connection with the antenna, or the unit may have difficulty
obtaining an initial fixed location. Incidentally, one solution is to restart the GG02 antenna.

Without training or prior knowledge on the unit, this could effectively end outfall mapping for the day. This is more problematic given the current status of the limited number of Leica units available to the 13 municipalities. As of December 2012 there are two fully functional Leica units available for the municipalities of the CMRSC to use.

5.2.2  Recommendation 1: Leica Implementation and Training
After analyzing the effectiveness of the both the Garmin and the Leica GPS units (See Figure 9), we recommend that the EPA require the use of the Leica (or a comparable GPS unit) for municipal MS4 system mapping. The Leica provides the ability to post process in the field, bypassing any unnecessary processing off the field, as well as a more accurate, detailed and inspected MS4 system map. However in order for the Leica to be as efficient as possible we came to the conclusion that training prior to use of the Leica unit is necessary to obtain a prior knowledge in order to troubleshoot any problems that may arise while in the field. Not only that, but some potential operators of the tablet may not be familiar with all of the necessary programs to run the unit such as “Zeno Connect”, the program required to establish a Bluetooth connection between the antenna and the tablet. We recommend that the MassDEP conduct a short but efficient training session providing knowledge sufficient enough to troubleshoot the unit and maximize efficiency when using the tablet out in the field. Not only would the training sessions teach municipal employees how to operate and troubleshoot the Leica, but it would also provide opportunity for the attending municipalities to establish a relationship with the MassDEP.
### Table 1: Comparison of Leica and Garmin

<table>
<thead>
<tr>
<th>Category</th>
<th>Leica</th>
<th>Garmin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start Up Time</td>
<td>Roughly 25 Minutes to Start Tablet and Establish Bluetooth Connection to antenna</td>
<td>1 Minute</td>
</tr>
<tr>
<td>Time to Map a Location</td>
<td>First Fix: 10 Minutes, subsequent fixes: 30 seconds - 1 minute</td>
<td>30 Seconds</td>
</tr>
<tr>
<td>Battery Life</td>
<td>6 Hours</td>
<td>Greater than 8 hours</td>
</tr>
<tr>
<td>Cost</td>
<td>Roughly $15000 for Tablet, Pole and GG02 Antenna</td>
<td>Roughly $300</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>Would Require Training</td>
<td>Minimal (2 minute) training</td>
</tr>
<tr>
<td>Post Processing</td>
<td>PeopleGIS Forms for onsite mapping, inspection and orthographic view</td>
<td>Must use Garmin’s Basecamp software on a computer. No onsite post processing</td>
</tr>
<tr>
<td>Accuracy of Lat/Long/Elevation Coordinates</td>
<td>2-4 centimeters</td>
<td>2-5 meters</td>
</tr>
<tr>
<td>Maneuverability</td>
<td>Alone the tablet is easy to carry, however when attached to the 8 foot pole with the GG02 antenna, it is quite difficult to take through wooded areas</td>
<td>Fits in the palm of hand/any pocket. Very easy to take in wooded areas.</td>
</tr>
<tr>
<td>Durability</td>
<td>Ruggedized Tablet</td>
<td>Ruggedized handheld device</td>
</tr>
<tr>
<td>Reliability of Obtaining a Fixed Location</td>
<td>Struggles in wooded areas</td>
<td>No observed issues</td>
</tr>
</tbody>
</table>

#### Figure 9: Comparison of Leica and Garmin

5.3 Finding 2: Municipality Feedback on MS4 Permit

For our municipality interviews, we had the opportunity to sit down and speak with Bradford Stone (Shrewsbury Town Engineer), John Woodsmall (Holden Director of Public Works), Isabel McCauley (Holden Town Engineer) and Todd Girard (Charlton Conservation Agent). We discussed matters pertaining to the MS4 permit through the six minimum control measures, their municipality’s compliance (See Figure 10) and the feasibility and usefulness of the Zoho database in its current state (directly obtained from the previous IQP). The obtained feedback provided us with the ability to identify trends within the three municipalities to relay to the MassDEP so that they may better assist with MS4 compliance. These trends focused in on developing a Public Education
and Outreach message, creating an IDDE program, detail and requirements of the Good Housekeeping control measure and EPA follow up regarding the Post Construction control measure.

<table>
<thead>
<tr>
<th>Control Measure</th>
<th>Feature</th>
<th>Resource</th>
<th>Policy</th>
<th>History</th>
<th>Training</th>
<th>Audit</th>
<th>Compliance</th>
<th>Record Keeping</th>
<th>Outreach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Program</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Annual Reports</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Figure 10: MS4 Compliance Based on Annual Reports**
The first minimum control measure, Public Education and Outreach, generated much more discussion than we originally anticipated. Going in to this project we assumed that this would be a very simple control measure to comply with, however we soon realized that municipalities find it difficult to generate educational messages specific to their municipality. A common trend we noticed between the interviewed municipalities was that they would find it extremely useful if the EPA or the MassDEP provide them with specific options to use as their educational messages. Many municipalities do not have the budget or manpower to put in sufficient time to create a legitimate educational message. To address this issue, it is necessary for the EPA and Congress to designate funds for NPDES Education and Outreach messages so that they can create statewide messages for municipalities to implement. Using these funds would be an effective way to create a widespread message educating the general public on stormwater runoff and how to manage it.

An example of a message could potentially be a specific pamphlet which is distributed statewide to each Phase II municipality or a link that the EPA/DEP provides with information on how to prevent stormwater runoff at a local level. We believe that if the EPA or the DEP created the educational messages, the municipalities would only have to distribute the message to the general public and could focus more of their resources on more complex aspects the MS4 permit such as developing an illicit discharge detection and elimination program (IDDE).

5.3.1 Recommendation 2: EPA to Create Statewide Educational Message
In order to get the residents of Massachusetts to actually see an educational message on controlling stormwater runoff, it would be extremely beneficial if the EPA took the lead role in developing an advertisement campaign, bringing to light the issues of stormwater. To reach the general population, the EPA could create television commercials and radio advertisements to ensure that they are actually viewed. This campaign would vastly increase the number of residence exposed to the educational message. John Woodsmall noted that currently the residents of Massachusetts
generally do not pay much attention to the provided educational messages, whereas, according to Todd Girard, Conservation Agent for Charlton, if the message was broadcasted on the television, the potential for awareness of stormwater would increase. While something as simple as a poster at the town library does fulfill the requirement for an educational message, its impact does not have the potential to be nearly as widespread as that of a television commercial.

While most towns believe there is difficulty in creating an effective educational message, some towns such as Charlton have had great success in utilizing creative educational techniques. Todd Girard states that in his town of Charlton MA, they have a program called “Casting for Conservation”. This program involves Todd going out, over the course of the year, with various groups of residents, ranging in age from Boy Scouts to full grown adults, and taking them fishing in different bodies of water in Charlton containing MS4 outfalls. While fishing he explains to them the importance of the MS4 system, how it helps control stormwater runoff and how it is a major contributor to river and lake pollution. He believes that if he just took people out on an outfall inspection day and showed them what an MS4 system is, he would get a very small turnout and the people who attended would lose interest. By implementing fishing into the equation, he gives the public incentive to learn about their MS4 system and the effects of stormwater runoff. Even though Todd and Charlton created an extremely effective form of public education, he still stated that a statewide educational program from the EPA or DEP would vastly increase public awareness and knowledge of stormwater runoff.

5.3.2 Recommendation 3: IDDE Template

Another common problem area for municipalities lies within the requirement to implement and enforce an IDDE program. During our interviews, the municipalities voiced their concerns with the lack of funds dedicated to IDDE program as well as the guidelines within the permit. According to John Woodsmall, the EPA should create a statewide IDDE template for the
municipalities to populate and implement at the local level. This would cut back on the amount of time and manpower necessary to adequately complete a sufficient IDDE program on a per municipality basis. Additionally, a template would detail exactly what needs to be included in the IDDE program, clearing up any municipal confusion.

5.3.3 Recommendation 4: More Detail in Outfall Sampling Requirements
On a more specific level, John Woodsmall expressed concerns with the wet weather sampling requirements and how there are not guidelines dictating when samples should be taken. For example, a wet weather sample could be taken at the first flush of the storm, after three hours into the storm or twenty four hours into the storm. It is discrepancies in the permit such as this that create difficulties for municipalities in discerning the permit requirements.

5.3.4 Finding 3: Difficulty in Meeting Sampling Requirements
Additionally, according to the 2010 draft MS4 permit, each municipality must take inventory of 25% of all outfalls (EPA, 2010). Inventory includes sampling the water discharging from the outfalls both during periods of precipitation (wet weather sampling) as well periods of no precipitation (dry weather sampling)(Delaware River Basin Commission, 2012). As a whole, we found that municipalities have difficulty to keep up with this permit requirement as it requires a substantial time commitment and municipal resources. However, John Woodsmall agrees with the permit requirement to rank and highlight priority areas of the MS4 system. Municipalities benefit from this requirement as it lists the most important areas to sample during periods of wet weather, allowing limited municipal resources to be used in the most effective manner possible.

When discussing the Stormwater Management in new Development and Redevelopment (Post Construction) control measures with the municipality employees, it was surprising to find that all of the interviewed municipalities had a bylaw regulating pre, current and post construction sites (Interviews with Stone, Girard and Woodsmall). These bylaws detail the implementation of BMP’s
such as a construction site runoff inspection checklist, developing an erosion control regulation, construction site runoff control education to comply with the Construction runoff control measure. More specifically, Todd holds meetings in Charlton twice a year to educate construction workers on how to deal with runoff from/at a construction site. Charlton adopted their bylaw on May 16, 2011 as detailed in their 2012 annual report, fulfilling the requirement for post construction regulation (Town of Charlton NPDES Phase II MS4 Annual Report, 2012).

Similar to municipalities, the EPA is feeling the effects of the tough economic times. This can be seen in the lack of funding and resources for the delegation of responsibilities pertaining to stormwater runoff and the MS4 permit. Todd Girard notes that EPA follow up is so difficult due to the fact that Thelma Murphy is the only EPA Regional Office NPDES Stormwater go to contact for Region 1. EPA Region 1 includes Maine, New Hampshire, Vermont, Massachusetts, Connecticut and Rhode Island. This makes it quite understandable why towns struggle with EPA inclusion in their stormwater management plans. One contact for six New England states is an insurmountable about of area to cover for one employee. We noticed that the interviewed municipalities expressed frustration with this issue. They agree that it is quite difficult to get the EPA to follow up with questions as well as other post construction regulations, making it difficult to effectively implement and regulate their stormwater bylaw required by the MS4 permit.

5.3.5 Finding 4: BMP Implementation and Maintenance Cost
Another, more obvious finding is that implementing and maintaining the municipal BMP’s puts quite a burden on the town budget, the minimal municipality manpower and may be impractical at times. John Woodsmall explains this in his comments to the EPA on the 2010 draft MS4 stormwater permit. Woodsmall notes that in order to comply with section 2.3.3 (g) of the draft MS4 permit which states;
“An existing discharge to Outstanding Resource Water is not authorized by this permit unless it is receiving the highest and best practical method of treatment as determined by the MassDEP” (EPA Administered Permit Programs: The National Pollutant Discharge Elimination System, 2011).

Therefore the town Southborough (John worked for Southborough before becoming employed for Holden) would have to spend a total of upwards of $1,000,000-$2,000,000 in order to retrofit all 100 outfalls at a cost of $10,000-$20,000 each (Woodsmall, 2010). This amount of money not only burdens the town budget, but takes away from other development areas that the money may be earmarked or needed for.

In order to mediate the cost of implementation of these BMP’s John Woodsmall noted that some municipalities such as Newton, Chicopee and Ayer have already implemented a stormwater service fee while others are proposing to do the same. This tax would be based primarily on land area and on average would potentially cost two to forty dollars quarterly depending on the municipality’s requirement.

5.3.6 Recommendation 5: Potential for Stormwater Tax
John Woodsmall believes that all Phase II municipalities should have a stormwater tax and if they don’t have one already, should look into implementing one. We understand that no one enjoys additional taxes, but we are in concurrence with John on this matter. A tax pertaining to stormwater would not only raise awareness on the matter but it would help offset the staggering costs to keep this detrimental environmental pollutant to a minimum. Therefore we recommend that the DEP and future IQP groups/independent researchers compare the pros and cons of implementation of a municipal based stormwater tax against the pros and cons of a state imposed stormwater tax. This
would ensure extensive planning and unity regarding the different tax structure as well as water
department funding mechanisms that could potentially be used in order to pass this law and help
ensure maximum statewide effort to strengthen stormwater management.

5.3.7 Finding 5: Inefficient Catch Basin Maintenance
A standard concern that all of the municipalities that we interviewed shared was the
proposed requirement in the 2010 draft permit to make it mandatory to clean every catch basin that
is 50% full. According to John Woodsmall, this is an extremely inefficient use of the limited
municipality resources and manpower as this would require monthly inspections of all catch basins.
In addition, the older catch basins are much shallower than the more recently installed ones,
therefore they would fill up much faster than the newer catch basins. John proposes that instead of
cleaning the catch basins on the basis of each individual basin’s level of sediment volume require a
percentage of the catch basins be cleaned each year. Again, we agree with this statement.

5.3.8 Recommendation 6: Catch Basin Maintenance Requirement
While it would be environmentally safe to clean the catch basins when they are 50% full, it is
just too impractical to consider implementing this requirement as many municipality DPW’s have
very few employees. Therefore after analyzing the information obtained from John Woodsmall, we
recommend that the requirement to clean catch basins be changed from when any catch basin is
50% full to cleaning a set percentage of the municipal catch basins on a yearly basis. In addition to
cleaning a set percentage of high priority catch basins per year, a percentage of the lower priority
catch basins need to be cleaned yearly to ensure that the same catch basins aren’t being cleaned from
year to year while the lower priority catch basins are left alone. Bradford Stone from Shrewsbury
duly notes that within his town, the DPW cleaned almost 100% of the catch basins yearly up until
about 14 years ago. As development and roadways increase yearly (between 1998-2008 Shrewsbury
added 26 miles of roadway), it became increasingly difficult to keep up with the catch basin cleaning.
Last year Shrewsbury was only capable of cleaning 16% of its catch basins. So implementing an even more stringent catch basin cleaning requirement is impractical and just not feasible for Shrewsbury, as it is for many other Phase II municipalities.

5.4 Finding 6: Varying Expertise and Capabilities of Municipal Departments

After communicating and obtaining information from employees in varying municipal departments we realized that there is a difference in the level of understanding pertaining to the MS4 system and permit. We observed that in general, town engineers had a strong understanding of the MS4 permit as well as the layout of the MS4 system. Even if certain points were not mapped within the GIS software, CAD drawings provided a general location of outfalls and catch basins. They also understood the details of the MS4 permit as town engineers often deal with designing and overseeing the implementation of stormwater mitigation measures in order to comply with the permit. However, town engineers had a theoretical understanding of how the MS4 system actually functioned, while DPW workers generally were the exact opposite. DPW workers knew where almost all of the catch basins were located but did not know where many of the outfalls were located due to the fact that they performed the annual catch basin and general MS4 maintenance. They were able to look into the catch basins and know where the water flowed in order to connect multiple catch basins and find the desired outfall. However, when asked about the MS4 permit, the DPW workers just knew that it existed but had very little knowledge of the specific requirements that the permit entails.

There was also a noticeable difference in the technological understanding between engineers and DPW workers. When the Garmin and Leica unit were discussed with the town engineer, he often knew just as much about it as we did as he understood the general thought process behind the GPS mapping process. While the DPW workers knew that we were helping to create a map of their
MS4 system, they did not have much previous knowledge of using GPS units for this purpose. Instead they understood by memory where most of the catch basins were located but fully understood the need for a map to make MS4 maintenance more efficient.

5.5 **Finding 7: Zoho Database Feedback**

Before we took actions concerning the Zoho database pilot program, we had to analyze the current applications implemented by the previous IQP sponsored by the MassDEP, to ensure that they would yield results that would reflect that the Zoho database is a viable option to clarify the MS4 permit regulations and the compliance to said regulations. There was general agreement that while the Zoho database could potentially make annual reporting much easier and increase communication with the MassDEP, some minor changes have to be made in order to make it an efficient and usable program. We found that municipalities would be willing to populate the Zoho database over the course of a year as long as it doesn’t require more time, man power and financial resources. Therefore, the expectation that a municipality will not only populate the Zoho database and then populate a separate annual report with the same information needs to be discarded. The ability to export the information from the Zoho database directly into an annual report would promote its use and ensure more detailed annual reporting. More specifically, Brad Stone requested that within the Construction and Post Construction section that there be a more detailed form with site specific information such as the ability to upload site plans, site inspection plans and the site’s stormwater pollution prevention plan (SWPPP). With the greater level of detail implemented into these control measures, the overall appeal of the database will drastically increase. Through the implementation of the Zoho database, our group along with the MassDEP hopes that this form of regulated annual reporting will allow the MassDEP to observe exactly where each municipality is lacking in compliance and therefore giving them the opportunity to provide assistance as needed.
5.5.1 Recommendation 7: User Guide and Ability to Export
As a whole, there needs to be a user guide distributed to the participated municipalities. Our project group created a user guide that will suffice in educating municipality workers on how to populate and submit information on the Zoho database (See Appendix 3). In addition, within the database there needs to be a feature that allows each municipality to export their own inputted data either directly into an annual report or into a format which can then be inserted directly into an annual report.

5.6 Summation of Recommendations
As a whole, our recommendations at the culmination of this project are stated thusly:

- The EPA to make mandatory the use of the Leica GPS system for MS4 mapping.
- The MassDEP to hold training sessions on the use of the Leica GPS system.
- The EPA to create specific educational messages for municipal use concerning stormwater runoff, fulfilling the first control measure of the MS4 permit.
- The EPA to create an IDDE program template for municipalities to populate and model their own IDDE programs improving municipal understanding of permit requirements.
- The EPA to clearly specify their requirements pertaining to wet and dry weather sampling.
- The EPA/MassDEP and subsequent IQP groups to compare the pros and cons of a potential statewide versus per-municipal stormwater tax.
- The EPA to look into altering their requirements on catch basin maintenance to allow for a percentage of catch basins cleaned each year as opposed to cleaning each basin when it reaches 50% capacity.
- For the created Zoho database user guide (See Appendix 3) to be distributed to the municipalities of the CMRSC and any other potential users of the Zoho database.
• The municipalities to have the ability to export their inputted data from the Zoho database directly into an annual report.

We have come to draft these recommendations after careful data collection through review of municipality NPDES annual reports, conversations with municipal employees during field work mapping MS4 systems, as well as more formal interviews with town engineers and conservation agents of these towns. These recommendations were put together to aid the 13 municipalities within the CMRSC in their MS4 compliance, annual reporting, and GPS MS4 system mapping.

6.0 Conclusion
Stormwater runoff continues to wreak havoc upon Central Massachusetts as the EPA continues to revise and refine the 2010 draft of the MS4 permit. Going out to municipalities such as Shrewsbury, Dudley, Millbury, and Charlton gave us firsthand experience with the varying levels of MS4 understanding and stormwater management techniques across Central Massachusetts. It is, in part, the issue of understanding and non-compliance that we have attempted to alleviate.

During the course of this project we have also dealt with two different types of GPS devices used to create waypoints to mark the locations of catch basins and outfalls; the Garmin Oregon 450 and the Leica CS25GPS tablet. We found the Garmin’s user interface much simpler than the Leica. The Garmin is also fairly low cost, smaller in size and more simplistic to use making it a feasible option for many municipalities. With that being said, the Garmin’s waypoints were only accurate in a range from two to five meters. The Leica, on the other hand, was accurate from a range of two to four centimeters when it mapped a fixed point. The Leica unit does require base level knowledge of Windows 7 as well as the ability to troubleshoot through potential problems. The accuracy of the Leica tablet will become very useful if a municipality must locate an outfall that has a documented illicit discharge. The Leica unit also eliminates the need to post-process the recorded points, as
PeopleGIS provides online forms, which a surveyor can fill out in the field describing and inspecting the catch basin or outfall.

After using the Garmin and Leica units to assist some of the towns with their outfall and catch basin mapping, we had the opportunity to sit down and talk with their town engineers or conservation agents to discuss their opinions of the MS4 permit, their level of permit compliance, and the potential usefulness of the Zoho database. We observed similar trends in the conversations that pertain to the municipalities’ opinion of the 2010 draft permit and how it could be improved upon. Brad Stone (Shrewsbury), John Woodsmall (Holden), Isabel McCauley (Holden), and Todd Girard (Charlton) all expressed the importance of Public Education and Outreach. Todd Girard especially emphasized how the education of the average person is incredibly important, because if a stormwater tax is indeed levied, it is the average person who will want to understand why they are being asked to pay the state or town more money.

All three of the municipalities that we spoke with agreed that they would rather have the EPA provide a set of messages to distribute to their citizens rather than using valuable municipality time and money to create their own Public Education and Outreach program. If the EPA did this, the municipalities would be able to simply implement those parameters immediately and then move on to other requirements of the permit. John Woodsmall of Holden also made mention of his desire to see the option of an “off the shelf” form for an IDDE program; especially for towns who are struggling in this area. One of the issues he had with this section of the permit was that there was no specification of when a municipality should take wet weather samples. The permit is quite vague on this subject, where he would rather it be more specific for the benefit of the towns taking samples.
The towns we interviewed all expressed concern with the MS4 permit, in terms of its regulations and requirements. These concerns address some sections of the permit being too stringent, while others are too flexible and open ended. Interviewed municipalities expressed the desire for a more active role on the part of the EPA. It is much easier for a federal agency with access to a greater abundance of resources and reputation to do things such as start a national advertisement campaign to inform the public of a stormwater issue.

During our discussions with these municipalities, we demonstrated the online Zoho database, and its potential functionality. While the town engineers and conservation agent we talked to were receptive to the idea of an alternative to the method of filling out their annual report currently, they did have some concerns about the logistics of the database. Brad Stone wanted a more detailed form for Construction Site Stormwater Runoff Control to include an option for site-specific information input. Isabel McCauley pointed out that once a municipality submitted their information, it was difficult or impossible to edit, and this will have to change before the Zoho database is fully implemented for municipal use.

By going out to municipalities and assisting them in their catch basin and outfall mapping, our project group was able to gain firsthand knowledge of the status of the towns’ MS4 system, while sitting down with town engineers and conservation agents allowed us to take a step back and view their systems from a permitting standpoint. All three towns that we talked to expressed a desire for the EPA to take a more active role in the guidelines for control measures such as Public Education and Outreach, and IDDE systems. With the addition of the Leica GPS unit, a proactive role of the MassDEP in training towns on the system, and a more widespread knowledge of the issue of stormwater, the municipalities of Central Massachusetts will have greater success complying to the draft 2010 MS4 permit when it is finally enacted.
Bibliography


Andreen, W. L. (2004). Water quality today--has the clean water act been a success? Alabama Law Review, 537(55)


Flanders, K. (2012). In Gaudette A. (Ed.), Authorization to proceed MapsOnline/PeopleForms storm water project PeopleGIS.

Flinker, P. (2010). In Millar S. (Ed.), The need to reduce impervious cover to prevent and protect water quality Rhode Island Department of Environmental Management.


Appendices

Appendix 1: General Interview Questions

Opening Questions

- How long have you been with your town’s engineering/conservation department?
- How often do your municipality leaders hold open meetings?

Municipality Logistics

- What is your opinion on the six minimum control measures of the 2003/2010 MS4 Permit?
- What is the level of completion of your stormwater mapping systems?

Permitting

- How does your municipality abide by the 2003 permit and the newer 2010 draft of the MS4 permits?

Zoho Database

- Would your municipality be willing to directly input stormwater and permitting data into the Zoho database?
- Is there a specific point-person in your department who could be designated to deal with the Zoho database?
  - If so, would this be willing to receive specified training in the Zoho database?
- Would you like to receive a final copy of our report?
Appendix 2: EPA Boston Green Roof
Appendix 3: Zoho User Guide

Getting Started

- You will receive an email containing a link to the requested Zoho form.

The Zoho Database
Municipality User Guide

Create An Account

- Once you have clicked the link, you will be brought to a login/new account page.
- If you have an account sign in.
- If you do not already have a Zoho account, you will be asked to create one.
- It’s free to create an account!

Populate and Submit

- Once you have populated the form, simply click on the submit button at the bottom of the page.

The Form

- You will be brought to the page containing the form of which you are required to populate.
- This is an example form.
View Your Municipality and Other Municipalities Submitted Data

- If you wish to view the data you just submitted as well as the data submitted by other municipalities, simply click the link consisting of the title of the form plus the word "view".
- For example, for this form you could click “Public Education/Outreach View” in the upper left portion of the page.