WROC
Massachusetts Water Resource Outreach Center

Assessing Pollution Reduction Credits

Abstract

Pursuant to the MS4 permit, communities must reduce phosphorus from stormwater runoff by a prescribed amount. This process can be challenging. In collaboration with the Charles River Watershed Association, we conducted interviews, site visits and distributed a survey to understand the challenges communities face in assessing phosphorus reduction. Using this data, we developed recommendations to help communities in the Charles River Watershed streamline the process of receiving phosphorus reduction credit for existing structural BMPs. Our final recommendations took the form of a 6 page information sheet, which highlighted different approaches that can help communities be successful in phosphorus reduction.

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Background Information

Stormwater Runoff is a Problem!

Stormwater is any precipitation that comes from the sky, such as rain, snow, or sleet. The flow of stormwater is important as it refills our surface and ground water bodies. However, stormwater runoff can carry pollutants into these water bodies. **In 1996, stormwater pollution caused by urban runoff affected over 5,000 square miles of estuaries, 30,000 miles of rivers, and 1.4 million acres of lakes in the United States (EPA, n.d)**. Stormwater flows directly into surface water bodies, increasing the impact of point source pollutants. With the rise in industrialization and urban infrastructure, stormwater runoff has become one of the biggest sources of water pollution.

Figure 1: Cyanobacteria bloom in the Broad Canal of the Charles River observed July 27th, 2019

Stormwater runoff pollution happens when stormwater lands on impervious surfaces, like roads, and picks up pollutants as the water flows along, carrying these pollutants into bodies of water. Nitrogen and phosphorus, which mainly come from residential areas that contain agricultural fertilizer, manure, and other organic waste (see Figure 2), have the most drastic effect on watersheds. These nutrient pollutants feed toxic algal blooms (see Figure 1) and other invasive species which can produce dangerous toxins harmful to both the health of the river's ecosystem and to the public (DeGood, 2020). Aside from providing nutrients to water bodies, other materials, such as road salt, contain harmful chemicals like chlorine and sodium, which is toxic to wildlife and ecosystems (Remedios, 2021).

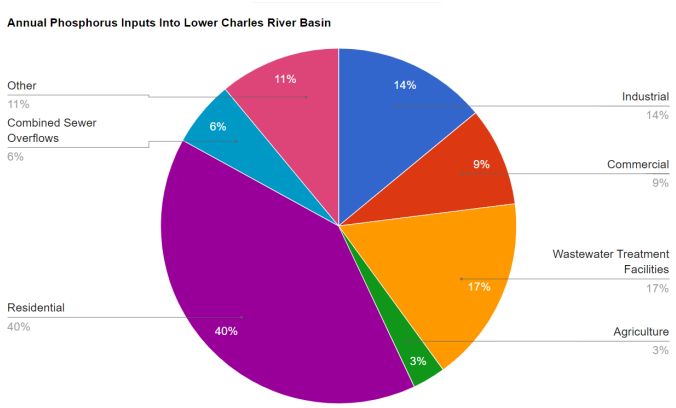

Figure 2: Percentages of annual phosphorus inputs into the Charles River taken from 2020

Development of the MS4 Permit

Congress passed the Federal Water Pollution Control Act (a.k.a. Clean Water Act or CWA) to regulate discharges of pollutants into United States waters (USEPA, 2013). Pursuant to the CWA, it is illegal to discharge any pollutants from a point source (such as a pipe) into US waters without first obtaining a permit (NACWA, 2018). Originally, this discharge permit only regulated point source pollution and had a limited view of what constituted point source pollution. That changed following a recognition that municipal separate storm sewer systems are point sources. Consequently, the US Environmental Protection Agency (USEPA) created the Municipal Separate Storm Sewer Systems Permit (MS4) to regulate stormwater

runoff pollution.

In further effort to protect surface water bodies, the CWA requires states to determine the Total Maximum Daily Load (TMDL) of any pollutant that an already impaired water body can receive (Borah, 2019). Total Maximum Daily Loads are written documents that calculate the maximum number of pollutants that are allowed to enter an impaired body of water and still meet water quality standards. To address the TMDL and ensure local bodies of water remain healthy enough to support aquatic life, the USEPA incorporated TMDL provisions into MS4 Permits to manage stormwater runoff pollution.

MS4 Permits require municipalities with impaired water to mitigate the impact of stormwater runoff (as seen in Figure 3). The permits are drafted by the USEPA and enforced by either the local environmental agency or USEPA. The MS4 permit details six minimum control measures that municipalities must comply with to mitigate stormwater pollution (Municipal Compliance Fact Sheet, n.d). The MS4 permit also includes ways communities can receive credit for their stormwater pollution reduction efforts. Pollution credit is granted to municipalities for the total volume of phosphorus, nitrogen and other pollution sources reduced in efforts to meet their TMDL goals for impaired waters (Appendix F of MS4 Permit, 2016) Communities utilize Best Management Practices (or BMPs) to mitigate stormwater runoff pollution, and receive MS4 pollution reduction credit.

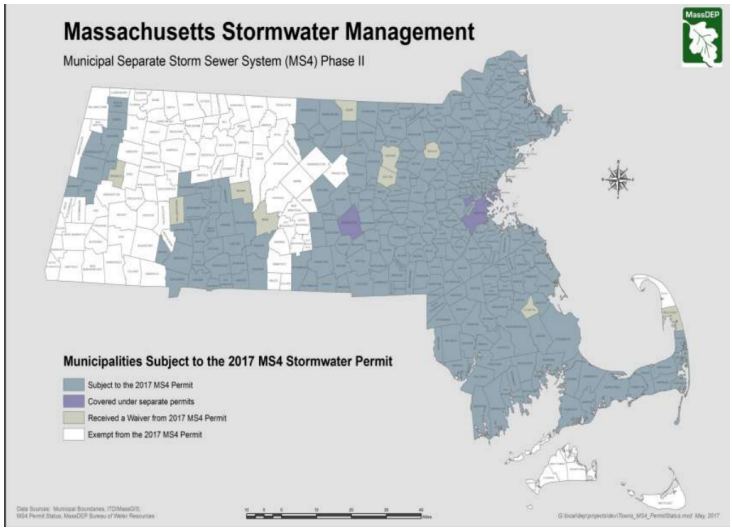

Figure 3: Map of Municipalities in Massachusetts which are subject to the MS4 permit

Best Management Practices

Stormwater runoff best management practices are methods to mitigate stormwater runoff and improve water quality. Municipalities implement BMPs to meet the requirements of the MS4 permit. Stormwater runoff BMPs fall into two categories: *Structural* and *non-structural*. Structural stormwater BMPs are systems that both collect and filter stormwater and stormwater runoff. Some examples of this include retention ponds, rain gardens (see figure 3), and green roofs.

Non-Structural stormwater BMPs seek to remove pollutants before they get picked up by stormwater. Some examples of this include street sweeping programs, catch basin cleaning programs, and structural BMP inspection programs (NACWA, 2018). However, in some projects, if a developer doesn't have space to implement a BMP the MS4 permit provides some flexibility. Off-site mitigation is another method to augment stormwater pollution reduction.

Figure 4: Example of a structural BMP called near the Broad Meadow Brook

Assessing Challenges with Stormwater BMPs

BMPs have proven to be effective in mitigating stormwater runoff pollution. However, their existence alone isn't enough to meet the requirements of the MS4 permit. Municipalities face challenges with data collection on BMP effectiveness, as well as locating, mapping, and maintaining BMPs.

Data collection is an important process to determine how much phosphorus a BMP is reducing, however in some municipalities there is little to no data on older BMPs (Whelton, 2016). Furthermore, some older BMPs have not had any recent maintenance or inspections. Municipalities are unable to receive credit for unidentified BMPs as well as BMPs that are not maintained. While these problems seem straightforward, communities often lack the resources necessary to fix this.

Figure 5: Annual Catch Basins Cleaning. Watertown Massachusetts, n.d. Photo Credit: Watertown DPW https://www.watertowndpw.org/161/Stormwater-Management

In order to map and maintain older bmps, municipalities need staff, money, and time. The cost to maintain and repair stormwater mitigation systems is an obstacle many communities face (Yencha, 2019). Without adequate mapping and maintenance, stormwater mitigation systems may lose their effectiveness over time.

Funding Stormwater Mitigation Measures

There are a multitude of ways communities can fund their stormwater programs. Municipalities must comply with the MS4 permit to meet stormwater regulations and the total maximum daily loads. Communities in the US are traditionally given generalized state funds that do not have to be allocated for a certain purpose and must be divided to fund other programs (Zhao, 2019). Communities can receive state funding through grants specifically allocated for stormwater management such as the Clean Water State Revolving Fund Loans provided by MassDEP (Massachusetts Government, 2021).

Communities could also employ taxes such as parcel taxes, which charge property owners an annual fee based on the total area of their land. For example, Culver City in Los Angeles County charges property owners a fee based on their type of property (Shimabuku, 2018). Stormwater utility fees are recurring fees that local municipalities and cities may implement to property owners to fund stormwater

management and projects. The money collected from these stormwater fees usually goes towards improving and maintaining stormwater infrastructure (Yencha, 2020). The town of Newton, Massachusetts charges residential homeowners a flat fee of $100 per year and other property owners based on the amount of impervious area on the property (see figure 6). Stormwater fees can vary among communities. As an incentive, towns can offer a reduction of the stormwater fee if a property owner implements and properly maintains on-site BMPs. Most stormwater programs can give a one-time credit for a new structural system as well. The town of Northampton, Massachusetts charges a construction fee for the construction of a structural BMP, such as a rain garden. Building a rain garden of the required size and design can reduce the construction fee to up to 25 percent (Northampton Department of Public Works, 2016).

	Impervious Area (ft^2)	Impervious Charge	Annual SW fee
Single family, Two-Three and Four-unit Residential	flat fee	$25/quarter	$100.00
Condos / Apts Residential (5 units or more)	Large residential	$0.047/ sqft ISA	varies by area, with minimum of $150 annually
Commercial	office, retail, etc.	$0.047/ sqft ISA	varies by area, with minimum of $150 annually
Industrial		$0.047/ sqft ISA	varies by area, with minimum of $150 annually
Tax Exempt	municipal, institutional	$0.047/ sqft ISA	varies by area, with minimum of $150 annually

Figure 6: US EPA. (2020, Nov 23). Massachusetts Stormwater Fee Summary [Excel Sheets]. https://www.mass.gov/doc/massachusetts-stormwater-fee-summary/download

Charles River Watershed Association

The Charles River, an 80 mile long river located in Massachusetts was once infamously known as “Dirty Water” by some, including the rock band Standells. Through efforts of the Charles River Watershed Association and others to restore the river, it is now considered a healthy river. One of the biggest sources of pollution in the Charles River is stormwater runoff, with studies in the early 2000’s showing nutrient pollution from stormwater runoff being twice as high compared to a healthy river system. Phosphorus is the main pollutant, with 74 percent of stormwater runoff pollution entering the Charles River being phosphorus.

The Charles River Watershed Association (CRWA) works with 35 Massachusetts municipalities. The CRWA’s mission is to protect and restore the Charles River and its watershed through science-based strategies to increase environmental quality and public health (citation). They have done work with communities to educate the public about climate change and help communities implement green infrastructure to mitigate stormwater runoff (Charles River Watershed Association, n.d).

Communities are doing great work to mitigate stormwater runoff. However, the CRWA is concerned that communities may not be receiving phosphorus reduction credits for existing BMPs to meet the MS4 Permit requirements (J. Moonan, D. Johanif, Personal Communication, March 21, 2022).

Mapping BMPs, old records, and keeping up with operation and maintenance are all

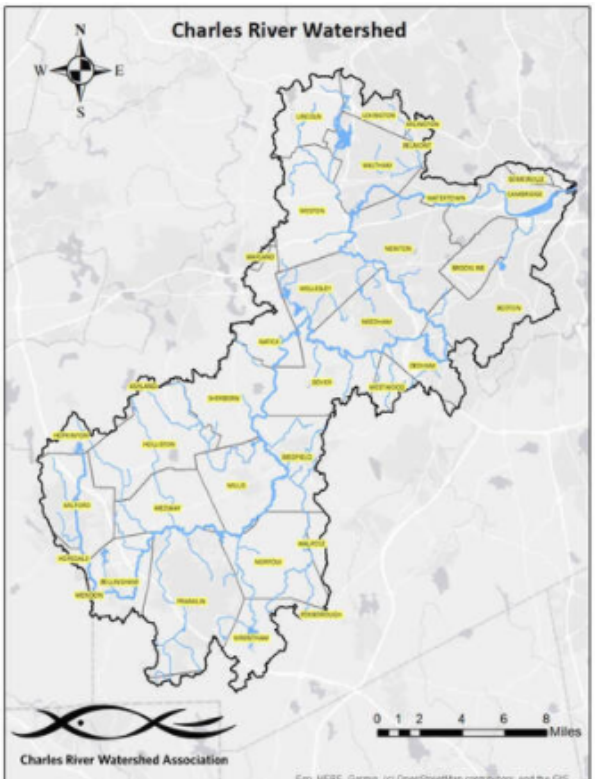

Figure 7: Map of the Charles River Watershed

challenges communities may face when attempting to receive credit for existing BMPs. The Charles River Watershed Association has found these issues as the inspiration for this project.

In collaboration with the CRWA , we worked with communities to help streamline data collection efforts and help municipalities receive appropriate credit for their existing stormwater runoff mitigation measures. We discuss our methodological approach to the project in the next section.

Methodology

The goal of our project was to develop guidelines to help communities in the Charles River Watershed streamline the process of receiving phosphorus reduction credit for existing structural Best Management Practices (BMPs.) Phosphorus is the primary pollutant in stormwater runoff responsible for over-saturating surface water bodies and turning them into impaired waters. This is particularly true in the Charles River watershed. Thus, in collaboration with the Charles River Watershed Association (CRWA), we developed guidelines and recommendations to help communities receive credit for existing BMPs. To achieve our goal, we developed four objectives (illustrated in figure 1) that we explain in more detail below.

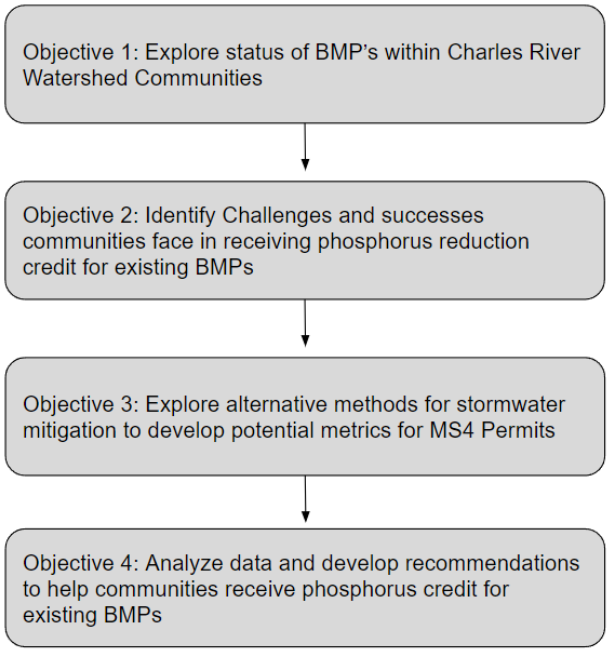

Figure 8: Flowchart of objectives

Objective 1: Explore status of BMPs within Charles River Watershed communities.

For our first objective, we explored the status of stormwater BMPs within eight communities in the Charles River Watershed. We chose these communities because the CRWA has a strong relationship with these communities and could help us connect with members of each town. In order to understand stormwater management processes, we conducted archival research, interviews as well as participant and direct observation.

To assess the quality of surface water bodies in the communities, we analyzed appendix F of the MS4 permit (US EPA, 2016**)**. This document is accessible online through the US EPA's website. Appendix F of the MS4 permit, lists TMDLs of phosphorus for each municipality. We took note of the TMDLs in each of the eight communities to understand the communities specific situation. Some communities have to remove a larger amount of phosphorus than others. The availability of such data is the prime reason we chose archival research, as the MS4 permit is publicly available and free use, making it a fantastic resource.

We conducted interviews with public works officials, sustainability directors, town engineers and stormwater managers within the given municipalities to gather additional information on the towns' stormwater BMPs. We wanted to interview people with firsthand experience working with

stormwater BMPs. These interviews helped us gain insight into the successes and challenges communities face. **See appendix B for our interview questions.**

The final method we used to complete Objective 1 is observation. We used both participant observation and direct observation, in the form of field research and BMP site visits. We traveled to 5 different communities to observe their stormwater BMPs and assessed their status while learning more about the community's stormwater management. By observing stormwater BMPs in person, we were able to get a better understanding of how accessible they are (for operations and maintenance) and how well they function. We also got a firsthand look at what structural BMPs look like, how they work, and any physical problem they incur, such as trash debris, leaf litter, or overgrown vegetation.

Figure 9: Well maintained BMP in one of the communities

Objective 2: Identify challenges and successes communities face in receiving phosphorus reduction credit for existing BMPs.

Our next objective was to identify challenges and successes communities face in receiving credit for their existing structural stormwater BMPs. This information was essential so we could identify methods communities had already used to receive credit, as well as develop new ideas to help them. Using the data we gathered from Objective 1, we took a closer look at where communities could benefit from additional resources and guidance. In addition, we conducted 10 interviews and distributed a survey to the CRWA email list and MassDEP statewide stormwater email list to get a better idea of the obstacle's communities are currently facing.

We then compiled this information into a data matrix to look for any similarities or differences in each municipality's stormwater management and level of success.

During the same interviews mentioned in Objective 1, we asked public works officials, town engineers, and green infrastructure planners from each town specific questions about challenges their communities faced, along with any successes they had. In addition to municipal employees, we conducted a semi-structured interview with Mark Voorhees, an environmental engineer that works for the United States Environmental Protection Agency (USEPA) Mr. Voorhees assists MS4 permittees in building technically sound and economically viable stormwater programs. His expertise allowed us to ask him questions about the technical aspects of the MS4 Permit and how pollution reduction credit works **(See appendix C for interview questions)**.

We also interviewed Laura Schifman, the stormwater coordinator from the MassDEP, and Kerry Reed, chairman of the Central Massachusetts Regional Stormwater Coalition. This semi-structured interview was a better method than a formal interview as it allowed us to ask our written questions as a team, and occasionally go off script for easier conversation (McIntosh, 2015). (See appendix C for interview questions)

Finally, we distributed a survey via email to multiple Massachusetts communities. The CRWA and MassDEP was able to assist us in this distribution by sending our survey via CRWA community alerts and through email lists. We used the research we gathered in objective one as a basis for the survey (see appendix F for survey questions and results). Once we collected all of the data, we organized it into a comparative data matrix of challenges and success so it would be easier to analyze. (See appendix G for matrix)

Figure 10: Poorly maintained BMP in one of the Communities

Objective 3: Analyze data and develop recommendations to help communities receive phosphorus reduction credit for existing BMPs.

To achieve the last objective and the project goal, we compiled all the information gathered from the previous three objectives. We then analyzed the data collected from data matrices and interview notes to develop our findings for the challenges and successes in the process of calculating phosphorus. We then developed recommendations in the form of a distributable infographic, which we hope will help communities receive phosphorus credit for existing BMPs (see appendix H for the final deliverable). To strengthen our recommendations within the infographic, we sought feedback from our sponsors share their names, members of the CRWA and other individuals who were willing to give feedback. The feedback helped us refine the infographic and make it a useful, digestible resources for everyone within the Charles River Watershed communities.

Findings and Recommendations

Introduction

After gathering data from our interviews, site visits, and survey, we were able to analyze the information, and use it to form our findings. The data fit into six main groups of challenges, each having multiple sub findings. We identified six main challenges: operation and maintenance, communication, privately owned BMPs, phosphorus calculations, old/unreliable plans, and public involvement. We learned that the challenges varied with communities and every community faced their own challenges, as well as successes. We hope these findings will shed some light on the issues with stormwater that communities are dealing with, and hopefully our recommendations can help communities with stormwater management. It is important to note that some of the questions had 15 total responses and some questions had a total of 13 responses. This was due to some survey response being incomplete (See appendix F in supplemental material).

Operation and Maintenance

Finding 1: *Operation and Maintenance of BMP's has been a challenge for every community, however the challenges varied.*

7 out of the 7 communities we interviewed found the operation and maintenance of BMP's to be a challenge. The most common challenge throughout all communities is the need for more funds and staff in order to keep up with BMP maintenance. As shown in Figure 11, staff time and funding were the two biggest challenges. Without laborers and the budget to fund O&M of BMP's, they cannot be maintained and many BMP's are often neglected, not reducing the phosphorus as they were designed to.

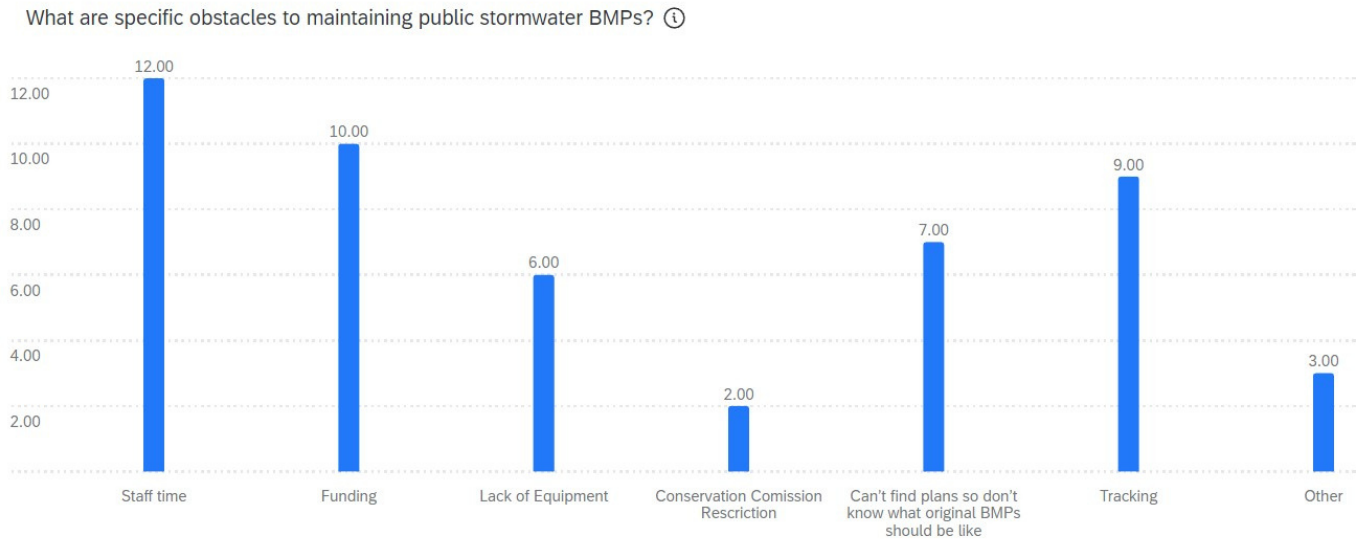

Figure 11: Survey Responses for BMP maintenance obstacles. This survey requires respondents to check all that applies. There were a total of 13 responses.

Some communities report lack of expertise among staff on stormwater management, which creates challenges in proper and timely O&M. Some of the survey respondents stated the need for more stormwater education internally. Educating staff on how and why the importance of maintenance and how to do it correctly is a challenge as communities find that there's a lack of expertise within the staff on green infrastructure and the importance of mitigating stormwater runoff.

BMPs with overgrowth of vegetation and trees is a challenge for communities to operate, maintain and even track. BMPs that are overgrown and full of vegetation are more difficult to maintain than newer BMPs. In order to maintain the overgrown BMP, this will take a lot of staff, time and funding inorder to clear tree debris, dead plants and trash. At the end of the maintenance, the cost to maintain may not be worth the amount of phosphorus that can be reduced. Educating the staff would prevent overgrowth from occurring in the future, however, BMPs that are overgrown and not maintained for over a decade would take a significant amount of time to maintain. Municipality E had a retention area that was not maintained for over 30 years and lacked the staff and time to clear the BMPs and make it effective once more. However, the Stormwater Superintendent from the municipality stated that smaller BMPs such as the catch basin, could clean out revelation quicker than this larger project (personal communication, March 18, 2022).

Recommendations

Given the aforementioned findings, **we recommend municipalities** that lack the necessary equipment or staff **outsource O&M work to consultants and contractors**. This way, towns don't have to go through the trouble of buying expensive equipment and training employees. Instead, their resources can be directed elsewhere, saving them time to work on other aspects of stormwater management.

If hiring a consultant or contractor for O&M is not an option, or if they need additional help, **we recommend towns facilitate staff training and education on stormwater runoff,** its challenges and the benefits of stormwater management. The CRWA hosts workshops, web seminars, and training, to provide education on stormwater maintenance, phosphorus calculations, and how to receive credit. Here is a link for one of the CRWA's workshops for getting credit for BMPs https://www.crwa.org/phosphorus-control-planning-support.html. Regular attendance at such workshops can help municipal employees better understand the requirements of stormwater BMPs.

We recommend that municipalities **conduct a cost-benefit analysis for maintaining older BMPs,** such as BMPs that are overgrown or built before 2008 (which is when the Massachusetts Stormwater Handbook was published) may not be effective anymore. Analyzing whether maintaining the BMPs is worth the amount of phosphorus credit can save time and money. Two communities we interviewed were able to estimate how much it would cost to reduce a percentage of phosphorus. From there, they were able to prioritize which BMPs should receive maintenance first.

Communication

Finding 2: *Communication can be an issue within a community and between communities.*

Many communities found that there was a lack of communication between the town engineers and owners of private BMPs. The lack of communication comes from ensuring that private property owners are meeting all the stormwater requirements, keeping up with maintenance of their BMPs and ensuring the BMPs are still effective. Communities that have ordinances and checklists in place to ensure operation and maintenance find that the level of in-person communication and BMP inspection on private property is limited mainly due to staff time. Some communities stated that homeowners did not know about BMPs on their property, which resulted in the BMP not being maintained. As the town engineer from Municipality D commented, sending out a notice to a homeowner requiring them to maintain the BMP would not make the residents pleased (personal communication, March 14, 2022).

Some communities shared the lack of communication between the municipal departments (DPW, engineers, public health and conservation). For example, one town engineer found that the DPW could install BMPs without notifying them, which did not allow engineers to properly track and insert BMP into the geographic information system (GIS) (personal communication, April 19, 2022). According to three town engineers we interviewed, they have to remind the DPW/Highway Department to do the maintenance. We found there was no process on checking if maintenance was done and solely based on trust that it was done. However, some communities stated that they work well with other departments. We asked members from the stormwater division of Municipality E if there was any conflict with the conservation commission, and they stated that there wasn't any conflict and both had a mutual agreement that mitigation of stormwater is important (personal communication, March 20, 2022).

Communities that are not active participants in stormwater coalition, do not communicate their challenges and successes to each other. Many communities are struggling with problems that other communities have found a solution for. Communities are not always aware of these solutions and are not able to help each other due limited time to collaborate.

Communities in a stormwater coalition more effectively communicate their challenges and successes. Specifically, most communities within the Central Massachusetts Regional Stormwater Coalition do not have a TMDL for a large body of water such as a river, howevers few of the communities do. The communities without the TMDLs are looking forward to what the communities in the Charles River Watershed are planning to address the TMDL and their actions will help other communities in the future with stormwater management.

Recommendations

Communities should **join and actively participate in a regional stormwater coalition**. These types of organizations facilitate inter-community communication, allowing communities to help and learn from each other. Stormwater coalitions can also help give communities additional resources and information related to stormwater management.

Communities need to **persuade MassDEP to provide more communication to communities.** We suggest communities request the MassDEP to do a quarterly newsletter to help communities receive any additional information and updates. Resources for communication such as the stormwater emailing list are not easily available to every community. The MassDEP could provide communication resources to communities, such as registration for the email list, ways to join a stormwater coalition, and coalition meeting schedules. This would be a great way to allow regulators to work more closely together with communities to address the stormwater management issues.

Privately Owned BMPs

Finding 4: Most communities find mapping and maintaining privately owned BMP's to be a challenge because of the lack of easement/agreements to allow access for maintenance and inspection as well as regulatory authority for maintenance.

In the survey, our team asked municipalities to rank the credit calculation process from very easy to very challenging. The graph in figure 12 shows that 9 out of the 13 respondents ranked maintaining private BMP as “very challenging”. We inquired further, asking respondents to share what aspects they found to be challenging (see Figure 12).

Communities have trouble gaining access to private BMPs because there isn't any easement/agreement in place to allow for maintenance and inspection. This prevents communities from doing the necessary fieldwork to gather information for receiving phosphorus reduction credit and the mapping process. 9 out of the 13 survey responders lack easement for maintenance on private BMPs as seen in figure 13. Municipality E that does have easements for most private BMPs stated that newly developed roads with stormwater controls can’t be maintained until the town accepts the road, which can be a long and tedious

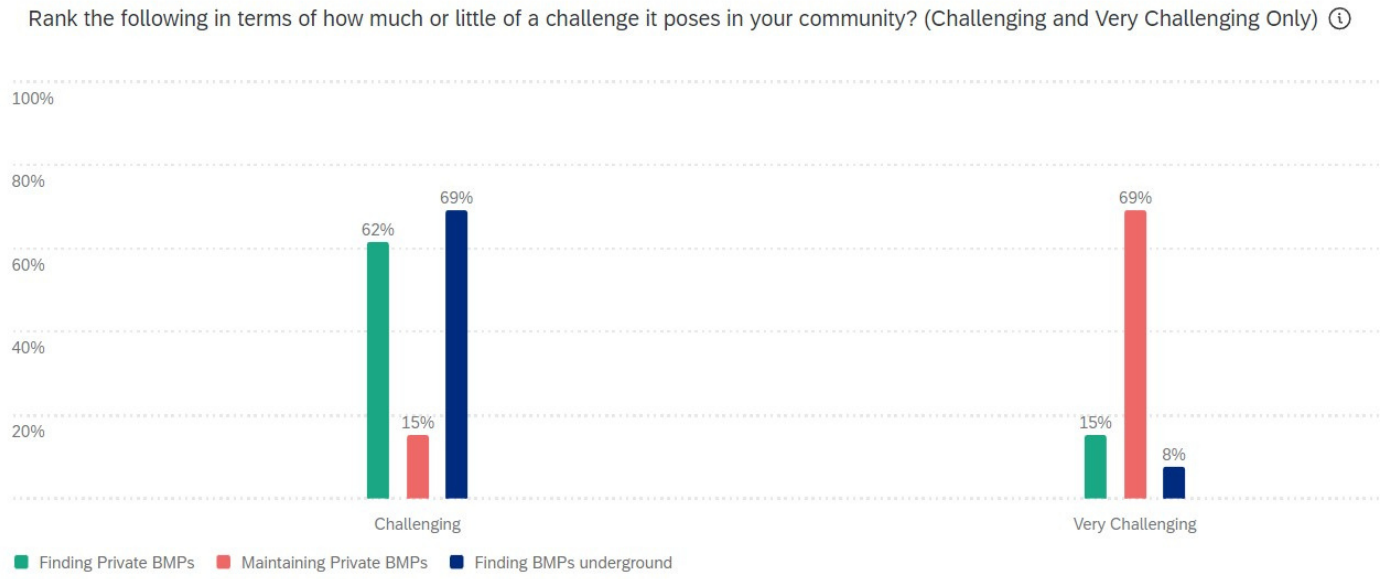

Figure 12: Survey responses for specific stormwater challenges communities. There were a total of 13 respondents. This graph only shows challenges regarding privately-owned BMPs. Refer to appendix F supplemental material for the complete data set.

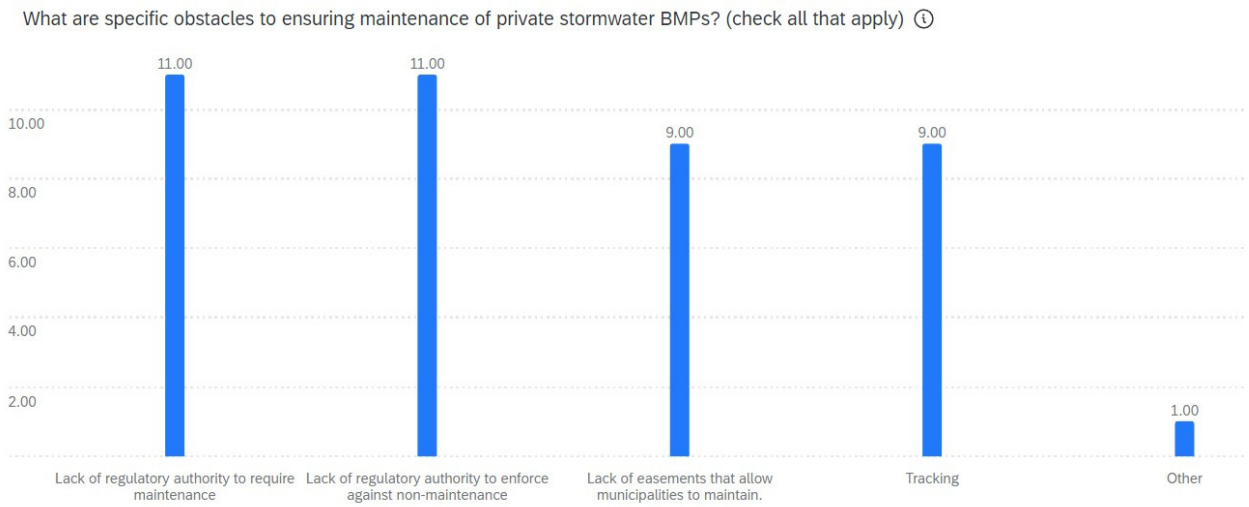

Figure 13: Survey responses of private BMP maintenance obstacles. There were a total of 13 responses.

process with obstacles such as legal process, meeting times and resistance from residents (personal communication, March 18, 2022). Going through the process of having an agreement can be difficult, especially if the property owner is unaware that they own the BMP.

Other communities that have easements that allow municipal employees to enter the property for maintenance purposes, which makes identifying and maintaining BMPs easier. For example, Municipality H has an easement in a HOA, allowing for the DPW to perform maintenance in a retention area that is technically the HOA responsibility to maintain (Personal connection, April 20, 2022). There were challenges with maintenance in the neighborhood with the HOA because of the lack of expertise to figure out when the BMP needed to be maintained. Having an easement allowed for the correct maintenance and inspection to be done, which prevented future flooding from occurring.

Many communities lack the authority to require maintenance and enforce against non-maintenance. 11 out of the 13 survey responders found that their communities lack authority for maintenance of private BMPs, such as stormwater ordinance/bylaw and regulations, as seen in figure 13. Municipality D has ordinance and checklists in place to ensure operation and maintenance and find that the lack of staff time limits in-person communication and inspection with private owners and contractors (personal communication, March 18, 2022). Some communities that have, or are in the process of updating, a stormwater ordinance, require private property owners that have undergone the permit process to submit their O&M annually or more often. This is helpful in locating final BMPs, confirming maintenance, and completing the phosphorus calculations.

Recommendations

Include Specific Requirements in Local Stormwater Ordinance/Bylaw and/or Regulations. Require projects that undergo

local permitting to submit their O&M plan and complete yearly inspections to ensure proper and timely maintenance. For example, Municipality B is still in the process of developing a system for maintaining privately owned BMPs . Their plan is to develop a stormwater ordinance that will require private property with a certain amount of impervious surface. Municipality D have checklists in place to ensure maintenance is being done and have yearly inspections to ensure the maintenance matches the checklist (personal communication, March 18, 2022)

To maintain and get credit for privately owned BMPs, the DPW should **establish easements with private owners**. Although there are a lot of obstacles to establishing easements such as legal restrictions and resistance, this can be crucial for communities that need to depend on private property to meet their TMDLs. Two of the communities we interviewed that have easements for private property found that the easements were accepted when a problem were to occur. Municipality E had better luck getting easements after getting the street accepted by the town. The legal process to allow the DPW to maintain is less time consuming (personal communication, March 30, 2022). Municipality H were able to get an easement when the swale overflowed with water (April, 19 2022). A selling point for some private owners was having the town maintain BMPs on their property, which overall could improve the aesthetic of the property without the owner having to do any work.

Watch MS4 Permit sessions regarding private BMPs. The Charles River Watershed Association held a workshop that describes calculations of privately-owned stormwaters BMPs and how communities can ensure maintenance of private BMPs. This workshop had lots of tips and tricks with the challenge with private BMPs as well as real world examples of communities dealing with the MS4 permit. https://www.crwa.org/phosphorus-control-planning-support.html

Phosphorus Calculations

Finding 5: *Most communities interviewed are in various stages of calculating their phosphorus reduction.*

It seems like there is some sort of disconnect between regulators and communities. During our interviews, we found that the phosphorus calculations are only done through calculating the amount and type of BMP, not actual field measurements of phosphorus reduction. Communities find assessing the effectiveness of BMPs to be challenging because there is no real way to figure out if the BMPs is actually reducing the amount of phosphorus it is supposed to. Most of the communities we interviewed questioned if their phosphorus reduction calculations are actually representative of what their communities BMPs are actually reducing.

Many communities are still working on their phosphorus reduction plan. Some communities are still in the process of identifying and maintaining existing structural BMPs, preventing them from credit calculations for those locations. 2 out of the 7 communities we interviewed hired, or plan to hire a consultant to work on the calculations, so they lack some knowledge on the process. One tool that assists phosphorus calculations is the BMP Accounting and Tracking Tool, known as the BATT tool. This tool helps track

and calculate phosphorus reduction from BMP's based on the type and other data regarding BMPs. 3 out of 7 communities were able to do some calculations with the BATT tool, but are still working towards completing it.

Most Challenging ←——————————→ Least Challenging			
Plans/Drawings	Field Measurements	Assumptions	Software

Figure 14: We asked 13 respondents "How challenging was it to use the following information to calculate phosphorus reduction for existing stormwater BMPs?" The respondent ranked challenges from a range of very easy to very challenging. See supplemental material to see the full data set.

Field measurements are difficult for communities for a variety of reasons. Challenges include lack of staff to perform fieldwork, unsure what to measurement to collect in the field and access to private BMPs for maintenance and inspection as one survey respondent commented that some BMPs are surrounded by a fence and padlock. 7 out of 13 survey responses stated that field measurements for calculations of phosphorus to be a "challenging" or "very challenging" in reference to figure 14. 3 out of the 13 survey responses found that it is unclear what measurements needed to be collected in figure 16.

Most Used ←——————————→ Least Used				
Assumptions	Plans/Drawing	Software	Other	Field Measurements

Figure 15: What information do you use to calculate the phosphorus reduction achieved by stormwater BMP? There are a total of 13 respondents and were asked to check all that apply. Those that answered other mention land use data, spreadsheet provided by developer, have not started calculations and consultant handles the calculations. Refer to supplemental materials for the full data se

Communities that did start the process of calculating phosphorus found some challenges in the process. Some municipalities had trouble with the BATT tool as some found the tool to be confusing and assumptions had to be made if fieldwork could not be done. As seen in figure 15, *assumptions* were one of the most used pieces of information to calculate phosphorus. Municipality C had to make lots of assumptions because the town does not have the necessary personnel to acquire all of the field measurements necessary for the calculations (personal communication, March 17, 2022). Communities are unclear on what assumptions have to be made as seen in figure 16, with 6 out of the 13 respondents choosing unclear assumptions. Some assumptions that have to be made include: underlying soil conditions and accuracy of plans. Plans should include information such as drainage area and volume of BMP, which are all necessities for the BATT tool. This information is likely to be missing in older plans (see finding 16 for more details) and utilizing fieldwork is often challenging for communities as seen in figure 4.

Communities are Overwhelmed by the Amount of Phosphorus Required to Reduce. Municipality D used the BATT tool to calculate phosphorus and found that the amount of phosphorus removed for the installment of 25 BMPs was very small, which made the phosphorus reduction requirement seem impossible for the community (personal communication, March 17, 2022). Municipality B has very limited land space as well as a large TMDL and will need to depend on private BMPs to reduce the phosphorus, which is a challenge in itself (personal communication, March 21, 2022).

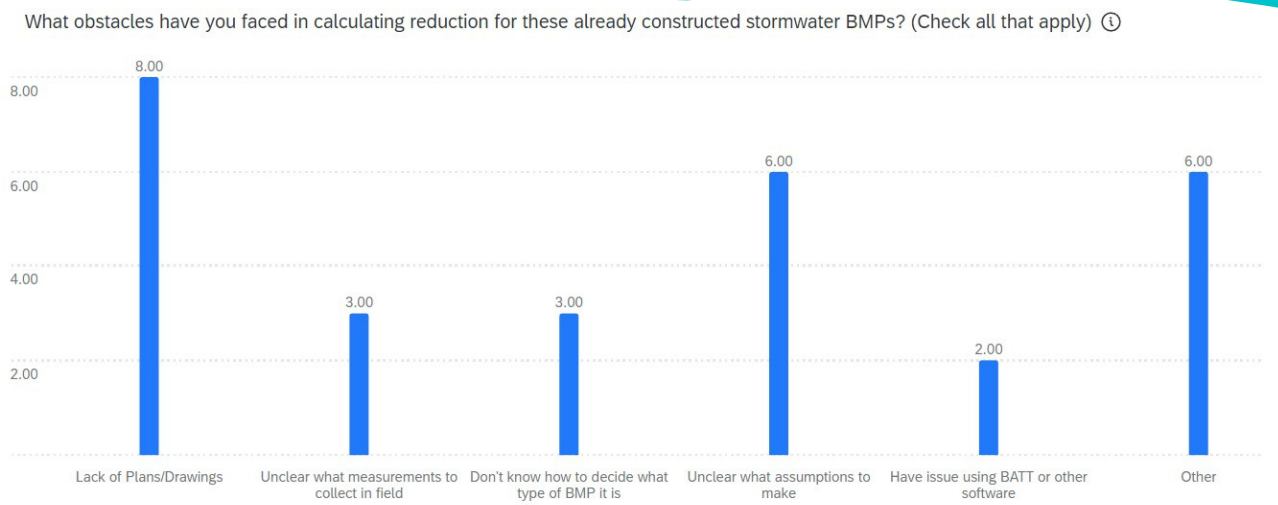

Figure 16: Survey response of phosphorus reduction calculation obstacles. There were a total of 13 respondents and were required to check all that apply. Those that answered others mentioned lack of access to private BMPs, hired a consultant and are still in the process of phosphorus calculations.

Recommendations

Keep Record and Track of Maintenance. Develop schedules to stay organized and keep track of all O&M completed and how frequently it is done. One of the requirements to receive credit is to show annual O&M. Communities who kept track of maintenance allowed them to start the credit calculations. Some communities kept track of their maintenance utilizing spreadsheets that detail when maintenance was done and can be utilized by multiple departments. If the GIS system has the capability to keep track of maintenance, this can help keep everything organized. One community utilized PeopleGIS, which allows for forms to be filled out with inspection and maintenance details.

Data to Collect in Field Measurements. If a community is unsure of what could be collected in the field, measurements such as drainage area, impervious vs pervious, infiltration rates, volume of BMP and verifying type of BMPs are some of the data that could be collected with fieldwork. Inorder to prevent future field measurements, requiring projects that undergo local permitting to submit phosphorus reduction calculations, pre and post new and redevelopment can help reduce some of the workload. One community suggested that the data needed to be inserted into the batt tool be collected in a simple and concise way in future plans.

Utilize the BATT Tool Although communities have some challenges, the BATT tool is approved by EPA to calculate phosphorus credit. CRWA provides training with BATT tools that may help the community with the program and the US EPA has training as well as useful documents that guides the user through the program. Many communities stated that the BATT tool is one of the better ways to not only calculate phosphorus, but other sediments such as nitrogen.

Hire a Consultant: Having a consultant in charge of phosphorus credit can help jumpstart the community with calculations and save valuable time. One community found that hiring a consultant was actually the less costly option. Some communities lack

the expertise on how to calculate phosphorus and some communities still need to perform maintenance before calculations. Having a consultant will allow communities to save time and resources, and focus on other aspects of stormwater management.

Old/Unreliable Plans

Finding 6: *Communities noticed that records and plans were often inaccurate, or missing, which made mapping and calculating phosphorus difficult.*

Our team found that almost every community utilizes plans in order to locate public BMPs, as 15 out of the 15 survey respondents stated plans to be one of the ways communities locate public BMPs, as seen in Figure 17. Communities do run into issues with missing plans and or unreliable plans.

Communities noticed that records and plans were often inaccurate, especially if the plan was permitting-only ,which may not reflect what was actually built. Some plans were more than thirty years old, and the BMPs had not been checked on or maintained since they were built. According to one town engineer, they went out to analyze stormwater controls but noticed BMPs were in a different spot or not built as planned. A few times, town engineers or members from the DPW would have trouble finding old underground BMPs because the plans were not built as seen in plans and no one knew where they were. Looking through older plans may not be an effective way to determine locations of BMPs.

Communities found that older plans were missing the necessary information. Communities utilizing plans to calculate

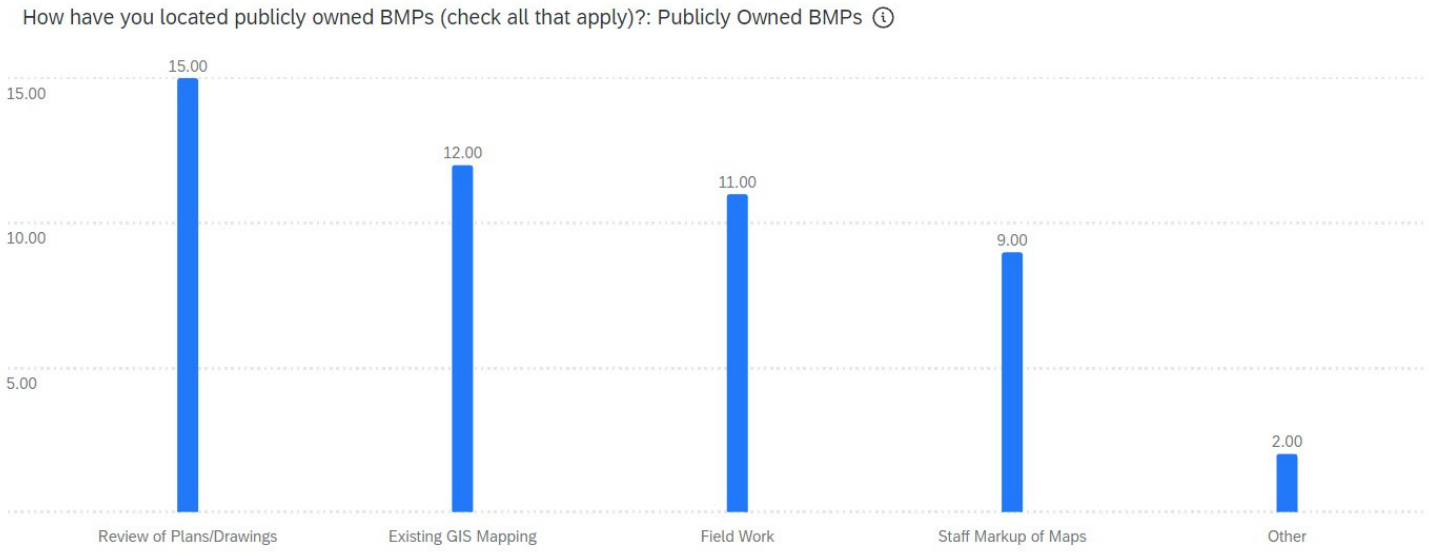

Figure 17: Survey Results for locating public BMPs. There were a total of 15 responses for this question.

phosphorus find some plans were unreliable and missing necessary information to calculate the phosphorus (drainage area, impervious vs pervious, infiltration rates, volume of BMP). This is especially true for older plans pre-MS4. Communities often require for implementation or redevelopment of BMPs to be processed as as-built so communities can have the information that older plans are often missing.

All communities have some missing plans (especially older plans that were not digitized) or paper plans lost in files. As seen in Figure 16, 8 out of 13 respondents choose lack of plans/drawings as an obstacle. This only slowed the process of the calculations, as now there is a need to go out and survey the BMPs. This is a challenge for communities that depend mostly on plans as they dont have the necessary personnel to do fieldwork, or may not know what to collect in the fields.

Communities that did identify all the private BMPs found that **surveying the area with the BMPs** is a lot more effective than just depending on the as-built plans, as they can assess the status of the BMP and ensure that the BMP was built as it was laid out in the plans as well as find any missing information. Regulators of the MS4 permit as well recommended communities go out and do fieldwork.

Recommendations:

Digitize Plans. If older plans are accurate and have necessary information for calculating phosphorus, digitizing these plans into a GIS system will help keep everything organized and easy to access. One community had successes with digitizing plans by utilizing interns to do bulk scans and filling out information via excel.

For unreliable locations based on plans, complete physical field work to find BMPs. Develop a strategy for data collection in advance. Communities recommended during early spring or late fall when vegetation is at a minimum.

For BMPs identified to have missing plans, but location is known, we would recommend that the department first assess if BMP needs maintenance, as many communities we interviewed stated that surveying the land is not possible if the vegetation and overgrowth is at its maximum. Once you've assessed if maintenance is needed, take field measurements by utilizing a survey crew or consultant that can help receive the necessary data.

For BMPs missing necessary information, but location is known and plans are representative, utilizes land-use data and state soil maps for information not available in plans. Field measurement can help find drainage area, impervious vs pervious, infiltration rates, volume of BMP and type of BMPs. One community found that some plans had a BMP listed as a detention basin, maybe a retention basin.

Gap Analysis for any missing information that the BATT tool requires. For plans that have any missing information, hiring a consultant to do gap analysis to find that information will make entering information into the BATT tool easier and older plans more accurate. For example, someone may not know infiltration rates and may not know how to find it. Hiring a consultant to find that information may

make utilizing the BATT tool easier. One community outsourced a consultant to survey the BMPs to figure out how communities can receive credit and this will allow for the community to utilize the data collected from the consultant in the future.

Require Electronic As-Builts Drawings for Future BMPs To avoid missing information with future plans and the possibility of losing drawings, communities should require as-built electronic drawings for future implication of BMPs, Many communities have already started this practice and found that plans are a lot more organized than in previous years. Some communities required information that is required in the BATT tool, such as infiltration rate and storage area, are in the plans and collected in a simple and concise way.

Public involvement

Finding 7: *There is a lack of public education in all of the communities, which is preventing support for stormwater projects and creating obstacles towards stormwater funding (stormwater fees and general town funds competing).*

Communities that get their stormwater funding through the town general fund or stormwater fees did not have the support of the community or town officials. Community members would rather have more funding for other departments, leading to a smaller fraction of the money being allocated for stormwater. This was mostly because community members were not educated or involved in stormwater management. Each community that currently has a stormwater fee or is in the process of implementing one, saw resistance from the public due to the disapproval of the added expense and lack of understanding the importance of stormwater management. Town members felt that the tax/fee was unfair or too high because they saw stormwater management as an unnecessary expense rather than an important utility.

Many communities had BMPs built in public areas, but do not take advantage of the educational potential. These BMPs were built in areas like parks or schools, providing the perfect setting for public education. Without signs that tell the purpose of these BMPs, the opportunity for public education and involvement was missed. Municipality B found that members of the community were more enthusiastic about stormwater when they were properly educated and allowed to get involved in the process**s**. This community allowed members of a neighborhood to choose the plants going in the rain garden on their street. These community members were excited about the progress of the project and were willing to keep up with future maintenance. Community plantings were another great way to get the community involved in stormwater projects such as rain gardens.

Recommendations

BMPs in public areas are a good way to educate community members about stormwater management, so we recommend towns put signs up to explain what the BMPs do and how to help maintain them. We recommend communities consider putting up signage for BMPs in areas like parks and schools. This will help people understand that BMPs are for stormwater rather than just aesthetics. A better understanding of stormwater management may encourage

people to keep them clean and to vote in favor of future stormwater projects and funding.

Another recommendation is to **inform the community of current and future stormwater projects, and give them an opportunity to get involved.** An example of this is letting residents have some creative freedom over rain gardens in their neighborhood. Giving the choice of the plants going into the rain garden, or the design can help inspire passion for the project. Additionally, towns can schedule community plantings for rain gardens and establish garden clubs. Towns could post community plantings on the town or school website so that it can be a community service opportunity for students. This can also help the town become more aware of stormwater to increase engagement and support.

Conclusions

This project was an intense introduction into the real issues communities in the Charles River Watershed are facing in their stormwater management. Stormwater runoff is a huge issue and many communities are still in the early stages of stormwater management. Communities must establish strong phosphorus reduction plans, and continuously update them based on new findings and the successes of other communities. Stormwater runoff pollution isn't going away, but there are a multitude of ways to tackle it collaboratively with other communities and regulators.

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