WROC
Massachusetts Water Resource Outreach Center

Facilitating Green Infrastructure and Low Impact Development in Central Massachusetts Communities

https://www1.nyc.gov/site/dep/water/rain-gardens.page

Abstract

In 2016 the USEPA issued the MS4 permit, requiring Massachusetts' towns to mitigate stormwater pollution. The MS4 encourages implementation of Green Infrastructure (GI) and Low-Impact Development (LID). We worked with the Massachusetts Department of Environmental Protection and the Central Massachusetts Regional Stormwater Coalition to identify barriers to and successes in implementation of GI/LID. We interviewed stormwater officials from five Massachusetts municipalities and toured GI/LID in each community. We identified difficulties with finding land, funding projects, maintaining installations and a lack of data on stormwater mitigation tools. Using our data, we developed actionable guidelines to help municipalities more easily implement GI/LID.

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Submitted to

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Background

What is Stormwater Runoff?

Every year, 26 thousand cubic miles of water falls onto the land as precipitation (Johnson Jeff, 2021), but before we had cities littered with impervious surfaces such as roofs, roads, and parking lots, all forms of precipitation would filter through the ground before entering larger bodies of water. Now, much of this precipitation becomes polluted before rejoining surface water bodies. The difference in the route stormwater takes is shown below in Figure 1 (PWD). This diverted precipitation is called **stormwater runoff.**

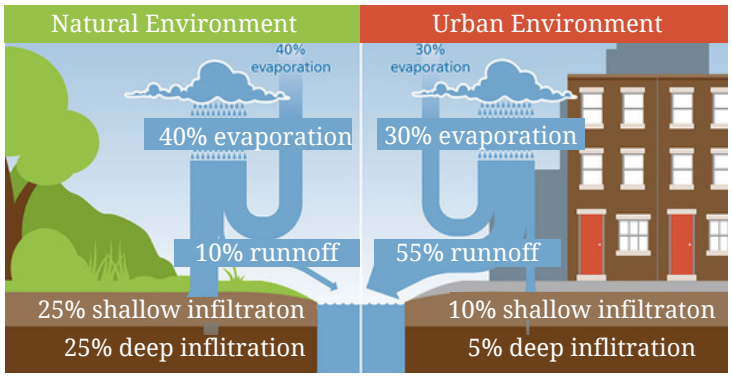

Figure 1. The above image from the Philadelphia Water Department's website shows how precipitation falls on the natural environment versus the urban environment.

This runoff flows into drainage systems, carrying pollutants from both impervious surfaces and the stormwater conveyance system (Hatt et al., 2004), into our surface water bodies (Bilotta and Brazier, 2008). These pollutants include heavy metals like zinc and lead (Bilotta and Brazier, 2008), and excess chemical nutrients such as nitrogen and phosphorus, which can lead to the overgrowth of invasive species such as algae and cyanobacteria (Chorus, 2000). Many municipalities have a storm drainage system separate from sanitary wastewater called an MS4, or the Municipal Separate Storm Sewer System.

1. MS4 and MS4 Permit

The MS4 is a network of drains and pipes designed to pick up stormwater runoff flowing on impervious surfaces and transport it into lakes and rivers as shown in Figure 2 (kentwa.gov). The MS4 system does not filter the water, meaning any pollution the stormwater picks up enters the surface water bodies. To reduce and eventually eliminate this threat, the US Environmental Protection Agency (USEPA) issued regulations interpreting the Federal Water Pollution Control Act (aka Clean Water Act) in the form of the MS4 Permit, a set of rules and regulations that work to reduce the amount of pollution that gets carried into the rivers through the MS4 (MS4 Permit Improvement Guide). Under the MS4 Permit, there are six minimum control measures along with a limit on total maximum daily loads that municipalities have to comply with (Six minimum control measures). **Each control measure is more detailed than they are described below, and municipalities struggle to fully understand and meet requirements due to the complexity of the regulations.**

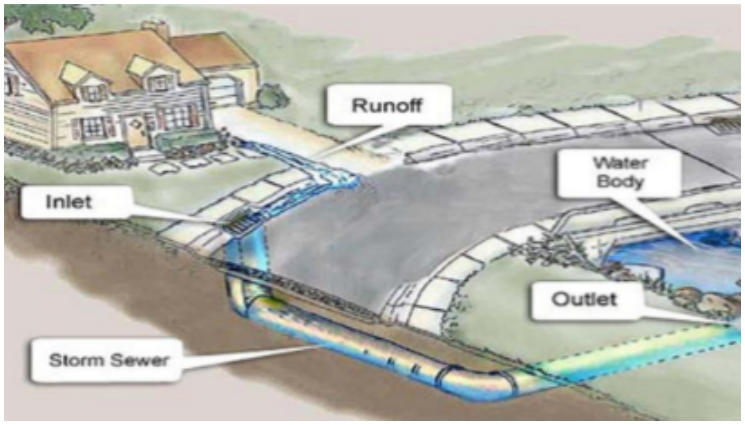

Figure 2. This is a simplified image of the MS4 system. Runoff enters an inlet grate at street level to then flow through a sewer system and out an outlet into a water body. From kentwa.gov.

Of the six control measures, this project focused on the following three:

- **Public Participation/Involvement:** requires municipalities to provide the public with the ability to participate in stormwater management. This spreads awareness of stormwater runoff pollution and gives the public the chance to help.
- **Illicit Discharge Detection and Elimination** control: municipalities must find and eliminate any source that is not made entirely of rainfall discharged into the MS4.
- **Pollution prevention/good housekeeping:** requires municipalities to implement housekeeping practices to reduce pollution.

Figure 3. This image may look like a normal garden, but it serves the purpose of a rain garden or a bioretention area. It slowly allows stormwater to infiltrate through a medium such as sand, soil, and/or gravel.

Stormwater Runoff Mitigation Methods

The USEPA describes Green infrastructure (GI) and low impact development (LID) as "cost-effective, resilient approach(es) to managing wet weather impacts that provides many community benefits..." (USEPA, 2015). Green stormwater infrastructure seeks to mimic the natural, or pre-developed hydrological conditions (Lu & Wang, 2021), by capturing and storing rainwater, promoting evaporation, and filtering stormwater runoff through soil within a decentralized system (Liu et al., 2015). Structural best management practices (BMPs) are the physical implementations of GI/LID. Figures 3 (University of Florida, 2014) and 4 (LeJava, 2015) offer examples of structural BMPs called rain gardens and bioswales. The MassDEP categorizes these BMPs into what stage in the filtration process the BMP functions.

Figure 4. The above image is an example of a bioswale. It is designed to receive sheet flow runoff from the adjacent parking lot, slow the velocity of the runoff, infiltrate a portion of the runoff through soil or some other media, and transport the rest of the stormwater to another location.

Table 1.
The table below describes the function of different stages of stormwater infrastructure and gives examples

STAGE	FUNCTION	EXAMPLES
Pretreatment	• Purpose: remove pollutants that are large in concentration of physical size to protect later stages of infrastructure • Location: near parking lots, highways, and gas stations	• Vegetated filter strips

Treatment	• Categories of Primary treatment:
	  ◦ Stormwater treatment basins
	  ◦ Constructed stormwater wetlands
	  ◦ Filtration BMPs
	• Purpose: to retain or remove as much pollutant as possible before further conveyance or infiltration
	• Location: near impermeable surfaces
		• Constructed wetlands
		• Bioretention areas
		• Rain gardens

Conveyance	• Moves runoff to another location for further treatment • Location: near curbs to help with flooding	• Grassed channels • Biofilter swales
Other (generally)	• Purpose: Stormwater Retention, Impervious Surface Reduction, Natural Stormwater Filtration and Infiltration	• Rain barrels • Green roofs • Permeable pavement

2. Successful Implementations of Green Infrastructure

Understanding stormwater mitigation methods is crucial to successful implementations of GI/LID. Karen Firehock, Executive Director of Green Infrastructure Center Inc., recommends creating a clear and concise plan for a successful GI project and recommends completing the following six steps:

1. Create a set of clear and compact goals with given time frames of GI implementation.

2. Identify key assets and resources that help with reaching the goals defined in step 1.

3. Evaluate the highest-valued natural assets contributing to the health of the community.

4. Find the most at-risk assets in the community, and what could be lost if no action is taken.

5. Understand which assets can be improved, especially assets identified in parts 3 and 4.

6. Combine all the previous steps to create a finalized plan that is ready to be implemented.

Given the environmental need of implementing GI, why is it not more widespread? The numerous barriers to the successful implementation of GI offer some insight.

3. Barriers and Challenges to Green Infrastructure

Understanding the following four main barriers is crucial to successful GI and LID implementation.

The first barrier is the financial cost of implementing GI and LID.
Currently, stormwater management infrastructure is paid for by public revenue and is planned to be spent on existing methods of infrastructure development and maintenance. Private investors are not interested in the long payback times for GI because of the belief that there is a lower financial benefit to implementing GI (Dhakal & Chevalier, 2017). Although some studies have found that GI is less expensive to build, it is unclear how to reliably estimate the costs and benefits that result from GI implementation. This makes it hard to fit into financial modeling and to secure capital funding or operational expenditures (Zuniga-Teran et al., 2020).

The second barrier is the need for training, resources, and education on GI and LID topics for stormwater employees and the general public.
Stormwater officials have expressed the need for more information and knowledge, which would allow for better execution of GI tasks. On top of the scarcity of information, universities lack stormwater research opportunities in their engineering programs, resulting in a shortage of expert GI staff in the workplace (Dhakal & Chevalier, 2017).

The third barrier is political will and support.
Due to the lack of information available, it is hard for officials to support GI or LID (Roseen, 2011). Because GI requires community involvement, the implementation process is slowed down and governance is more challenging. When simultaneously trying to meet community demands and stormwater management, community demands trump stormwater (Finewood et al., 2019).

The last barrier is the long-term maintenance and performance of GI and LID.
Since GI and LID are relatively new concepts, local officials do not know what the long-term performance will look like in 15-30 years (Dhakal & Chevalier, 2017). GI and LID maintenance can be costly if done incorrectly or not maintained in an organized way. Improper maintenance is often a result of the lack of training within stormwater management. Without proper knowledge of maintenance practices, GI and LID implementation of the system as a whole will fracture (Roseen, 2011).

All four barriers must be addressed for successful GI and LID implementation. The Central Massachusetts Regional Stormwater Coalition (CMRSWC) aims to increase the ease with which GI and LID are implemented and managed.

4. Central Massachusetts Regional Stormwater Coalition

The Central Massachusetts Regional Stormwater Coalition (CMRSWC) is a group of 31 towns and cities in central Massachusetts working together to mitigate the impacts of stormwater runoff, protect water resources, and meet the requirements of the Massachusetts MS4 Permit in an efficient and cost-effective manner. The CMRSWC wanted us to assess GI and LID in the Massachusetts municipalities of Charlton, Framingham, and Natick. We will be working with the CMRSWC to develop streamlined guidelines to ease the maintenance and implementation process for GI and LID.

Developing Guidelines to facilitate GI/LID

Introduction

We worked with the Central Massachusetts Regional Stormwater Coalition (CMRSWC) and three central Massachusetts communities to develop a set of clear guidelines for implementing green infrastructure (GI) and low-impact development (LID) for central Massachusetts communities by comparatively analyzing successful past and current planning processes. We developed the following four objectives that directed us to a final set of guidelines.

Objective 1: Identify best practices for implementing Green Infreastructure and Low Impact Development

In order to develop the most useful guidelines for facilitating GI/LID, first, we identified and gathered an understanding of successful implementation practices for GI/LID. We began by interviewing Andrea Briggs, deputy regional director of the MassDEP Central Regional Office; Kerry Reed, CMRSWC co-chair and senior engineer of Framingham, Massachusetts; and Dr. Laura Schifman, stormwater program manager of the MassDEP Boston Office about GI/LID. Using their insights on GI/LID as a starting point, we began our research by conducting an online search for information on exemplary GI communities, interviewing staff involved in GI from the communities, and touring the GI and LID in the communities. We started by conducting research on the city of Philadelphia, Pennsylvania, and the regional enterprise zone of Devens, Massachusetts.

We researched past GI/LID field reports and studies from databases on both communities involving GI/LID implementation.

Figure 5. A rain garden installed on the Philadelphia I-95 extension managed by a collaboration between PennDot, Villanova and Temple.

In addition to online research, we conducted semi-structured interviews with people involved in or knowledgeable of GI/LID implementation in Philadelphia and Devens. We started with these two communities because they have high performing examples of GI/LID programs. An example of the GI/LID program is the I-95 corridor project shown above in Figure 5 (Kummer, 2017). We used semi-structured interviews because open-ended questions allowed us to gather more in-depth information from the interviewee (Galletta & CROSS, 2013). We learned more about the approach in Devens from an onsite tour of GI/LID given by Neil Angus, who is the environmental planner of the Devens Enterprise Commission.

The Devens Enterprise Commission functions as a board of conservation commission, health zoning of appeals, historic district commission, health, and planning. We learned more about the approach in Philadelphia through a combined, semi-structured interview with Dr. Robert Traver and Dwayne Myers. Dr. Traver is the director of the Villanova Center for Resilient Water Systems. He has written $5.5 million in grants, and he has received over 1800 citations in referred publications. Dwayne Myers worked with Philadelphia as a consultant with CDM Smith and has consulted for the Philadelphia Water Department since 1999. These interviews gave us insight into the planning practices behind GI/LID implementation as well as critical information relating to GI/LID implementation. We also used snowball sampling to see if the interviewees had suggestions for other communities to reach out to or other individuals who have experience with successful GI/LID (see Appendix C for interview questions).

We conducted field survey research on GI/LID in Devens, Massachusetts to see successful GI/LID implementation practices firsthand. While on-site, we gathered data on Devens GI/LID such as the type of GI/LID, the reason for implementation, and the benefits of implementation.

This data helped us understand where successful GI/LID has been implemented and the benefits from those implementations. After we understood the best practices of GI/LID, we assessed the current planning and implementation methods within Charlton, Framingham, and Natick.

Objective 2: Assess GI/LID Planning and Implementation within Charlton, Framingham, and Natick

To assess current practices, we conducted in-depth research with three communities: Charlton, Framingham, and Natick by conducting interviews, facilitating focus groups, reviewing past projects, and collecting data for analysis. Comparing and contrasting the situations of these three municipalities with varying levels of historic development and community support yielded a more well-rounded perspective.

First, we interviewed the relevant personnel from each municipality: John Digiacomo, William McDowell, Claire Rundelli, and Jilllian Wilson-Martin from Natick; Kerry Reed, Alison Elliot, Amanda Smith, and Robert McArthur from Framingham; and Angela Panaccione from Charlton.

Project Objectives

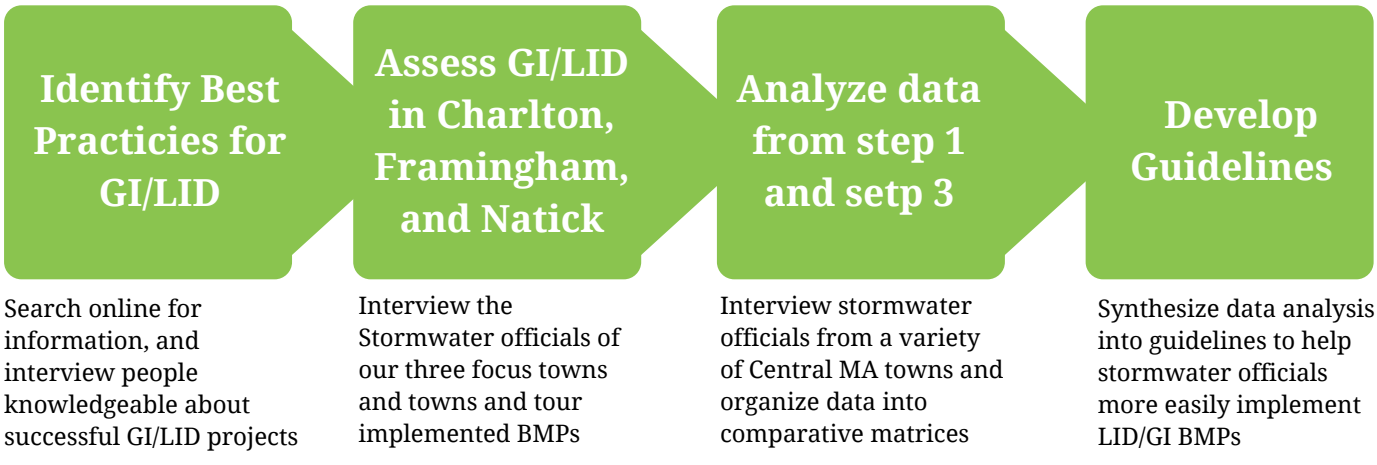

Figure 6 Summary of our Project objectives

The purpose of these interviews was exploratory to provide us with some baseline knowledge of the GI/LID situation in each town, and they give us the opportunity to ask questions directly to remove gaps in our understanding. We conducted semi-structured interviews for this detail-oriented phase of the research. In every interview and focus group, we asked participants about challenges, successes, and suggestions for improvements (see interview questions, Appendix E).

Objective 3: Comparatively analyze the findings from Objectives 1 and 2, and identify processes that worked best

The goal of data analysis is to organize and inspect data in order to discover useful information to draw conclusions and make informed decisions (Masters in Data Science).

Figure 7. A rain garden adjacent to one of Natick High School's parking lots. the areas of lowered curb allow the runoff to flow into the grass

We organized our data into comparative matrices that allowed us to identify the prevalence of a variety of roadblocks and solutions for implementing GI/LID in different towns. Using this information, we were able to identify and analyze the results of different key practices and decisions. Next we decided which processes could realistically be used based on productivity and practicality. Then we worked to develop guidelines that utilize the selected practices.

Objective 4: Use findings from Objectives 1-3 to develop guidelines for how municipalities can best facilitate Green Infrastructure and Low Impact Development

With the knowledge gained from steps 1-3, we drafted a set of guidelines for Massachusetts communities to increase the ease with which they can implement and maintain GI/LID. The suggestions in the draft were informed by interviews with the municipal workers at all levels, Laura Schifman and Andrea Briggs from the MassDEP, and the content analysis of planning suggestions within the current literature.

We used an iterative design process for developing these guidelines. Our iterative design process involves 3 steps. 1) We drafted the guidelines using the data collected in objectives 1-3 and the subsequent analysis. 2) We showed the draft guidelines to our project sponsors. 3) We edited the guidelines after receiving feedback. (see Appendix B draft survey). Once we received the feedback, we resumed step 1 of the iterative process. We believe the final set of guidelines is something meaningful and helpful to central Massachusetts communities. We hope to make it easier for communities to live more sustainably within the greater environment by helping them to protect the surrounding water.

Findings

We formatted this section to follow a general planning process for a structural best management practice (BMP). We begin the section by discussing the first step in any new BMP project, identifying land for a project. Next, we discuss findings related to budgeting, public education and outreach, considerations for incentives, communication between departments, and we end with the long-term operations and maintenance of a BMP. Each finding is accompanied by a recommendation.

Locating Space to Install Stormwater BMPs

To install a stormwater BMP, you must first find a place for it to go.

Finding 1: Many communities often do not have the space to put in large public BMPs. The most successful public BMPs are incorporated into a preexisting plan for a public facility.

Finding municipal land available for green infrastructure and low impact development (GI and LID) is proving difficult for many central Massachusetts municipalities. The most successful municipal projects we found while touring Framingham and Natick, MA have been on public land. For example, at Farm Pond Park in Framingham, MA we observed a rain garden that was installed to manage stormwater from the adjoining skatepark (see figure 8 right). More examples of green BMPs being incorporated into preexisting municipal projects are the GI BMPs we toured at the Natick High School and John F. Kennedy in Natick, MA (see Figures 4, 5, and 6 in Appendix M).

Angela Panaccione, the conservation agent from Charlton, MA, agrees we found that even rural communities struggle to find enough land for publicly installed BMPs.

Figure 8. The above image is the rain garden next to the skatepark in Farm Pond Park in Framingham, MA. This rain garden was implemented on public land. Confusion around how to properly maintain the rain garden has caused the rain garden to be overgrown.

Some communities have a large amount of undeveloped private land that could be used for surface BMPs like rain gardens or detention basins, but often this is not publicly owned land, so it would not be possible to use that land for municipal projects. Given the limited space many municipalities are dealing with.

We recommend (R1): that communities consider smaller BMPs like sidewalk bump-out infiltration and tree box filters that can be integrated into existing projects like sidewalk replacements.

In a survey distributed to the members of the Central Massachusetts Regional Stormwater Coalition (see Appendix L for complete survey results), only 1 of the 6 communities reported that they had sidewalk bump-out infiltration BMPs. Smaller infiltration BMPs such as sidewalk bump-outs and tree box filters could be a LID/GI implementation route for communities that have little space on municipal and public right-of-way land. Figure 9 for an example of a sidewalk bump-out infiltration BMP.

Figure 9. This is an example of a sidewalk bump-out for infiltration. Notice the gap in the curb that allows water to enter. This image is from the Philadelphia Water Department.

These projects could be integrated into existing municipal upkeep projects, like sidewalk replacements or sewer line refurbishments. Designing GI/LID as a macro-scale system instead of individual installations is a better way of implementing GI/LID. This system could comprise larger BMPs like rain gardens or constructed wetlands, or it could comprise the aforementioned smaller BMPs that would be easier to construct in tight spaces.

Finding Ways to Gather Funding for GI/LID Projects

While finding space to install a BMP, the municipality must secure funding for the installation as well as operation and maintenance. In this section, we describe three ways to obtain funding for GI/LID projects: incentives, fees, and enterprise funds. Incentives are something that motivates someone or a group of people to undertake or achieve something. A fee is money paid for a specific piece of work or service. An enterprise fund, stated by the Massachusetts Government, "is a separate accounting and financial reporting mechanism for which revenues and expenditures are segregated into a fund with financial statements separate from all other governmental activities" (mass.gov, 2017).

Finding 2: Incentive programs can increase the amount of GI/LID implementation.

The GI/LID implementation in Philadelphia, Pennsylvania and Devens, Massachusetts have been propelled by successful incentive programs. For property owners in Philadelphia, reducing their stormwater fees is an incentive. One of the benefits of using a stormwater fee instead of a tax is that taxes have more legal requirements that must be met, while a fee must only be able to be reduced by the actions of the resident. The stormwater fee takes into account the area of impervious surfaces on your property. See Figure 10 for further explanation. For example, if your business has a large amount of impervious surface, the water utility bill from the PWD would be higher than a business with less impervious surfaces, if they used the same amount of water.

Figure 10. The above image from the Philadelphia Water Department shows how it calculates its stormwater fee. The areas in blue and orange are the impervious surface and the total lot area respectively.

If you live in a condominium with many units, your stormwater fee would not be as high as a business with large impervious surfaces. Residents see this stormwater fee as an incentive to implement GI/LID on their property as it reduces their water utility bill. Devens has also implemented a building incentive program, although it does not relate to stormwater and GI/LID. Buildings that achieve LEED certification are eligible for a 15% discount on permit development costs up to $10,000 per project by using the green building incentive program.

This program has encouraged developers to make green projects in Devens. It is an example of an effective building incentive program that could be adapted to include stormwater management and GI/LID.

We recommend (R2): implementing a discount on permit development costs for implementing GI/LID to incentivize developers.

Finding 3: Private companies do not incorporate stormwater-friendly developments unless incentives make them more profitable or they are forced to by regulations.

There was a program in Framingham that incentivized the LID practice of cluster development, but developers avoided doing this because there was another development type, over 55, that was more profitable. This resulted in developers choosing the more profitable one, the over 55 development, instead of the LID cluster development. This demonstrates the cluster development incentive program is not utilized as intended.

We recommend (R3): that engineers and planners working on municipal code should ensure that the intended incentive programs are attractive enough to developers for them to choose the more sustainable option.

We recommend (R4): that engineers and planners working on municipal code should look into regulating private developments to require stormwater infrastructure.

Finding 4: Securing funding for GI/LID projects is challenging without the implementation of a stormwater fee, stormwater utility, or incentive program. Grant programs have been successful, but the ability of a town to receive grants is limited.

Sufficient money is often not earmarked in existing municipal budgets for new GI/LID project installations, and unforeseen complications can quickly cause these projects to become more expensive than anticipated (Ashland, interview). However, some programs have helped communities fund GI/LID. The Philadelphia Water Department (PWD) has an integrated water/sewer/stormwater utility bill, such that every property owner pays a monthly bill that the PWD can use to fund stormwater infrastructure. This *stormwater fee* also acts as an incentive for property owners (Philadelphia, interview). The town of Ashland, Massachusetts has an enterprise fund, which they claimed to be “a godsend” in funding the ongoing maintenance of their many rain gardens (Ashland, interview). Devens, Massachusetts also utilizes an enterprise fund. In Devens, this fund allows the Devens Enterprise Commission to create more public BMPs such as rain gardens or infiltration basins and incentives for permit application refunds.

Conversely, Charlton, Framingham, Holden, and Natick do not have incentives, fees, or funds, and they receive little public funding for GI/LID. Kerry Reed from Framingham stated that most of the money for implementing GI/LID in Framingham comes from grants. See Table 2 below for a community funding comparison.

Table 2: The table below shows a comparison of communities and whether they utilize fees, an enterprise fund, or incentives to assist with GI/LID implementation.

MUNICIPALITY	FEES	FUNDS	INCENTIVES
Ashland		x	
Charlton/Framingham/Holden/Natick			
Devens		x	x
Philadelphia	x		x

Various grants exist for GI/LID, but some require fund matching, such as the 319 grant. Grant 319 allows municipalities to receive the grant money needed to implement GI/LID (US EPA, 2015). However, this grant can not be used to meet MS4 requirements because it is intended for use in nonpoint source pollution under the Clean Water Act. Moreover, to obtain the funding, municipalities are required to match 40% of the federal grant. This fund matching requirement can make it difficult for municipalities with already limited funds to receive the grant. Ashland has found success with the Municipal Vulnerability Preparedness (MVP) grant and the Hazard Mitigation Assistance (HMA) grants to act as a funding source for stormwater BMPs (Ashland, interview).

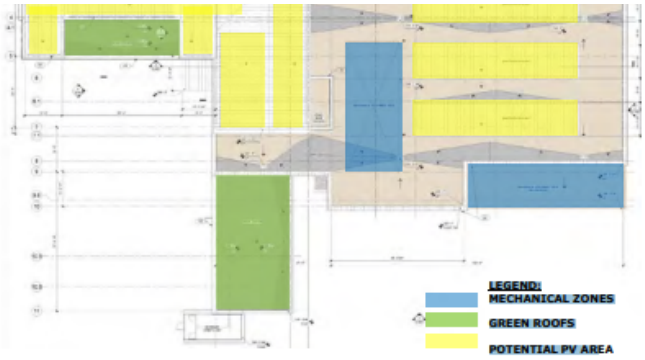

Figure 11. The plan for Ashland's new community Administration building includes a green roof and was paid for by its enterprise fund.

The MVP grant is for municipalities to advance priority climate adaptation measures to increase climate change resilience from events such as flooding or extreme weather. The MVP grant requires a 25% match to receive the grant. This less stringent fund matching requirement makes the MVP grant easier to receive than the 319 grant (Municipal Vulnerability Preparedness (MVP) Program | Mass.Gov, n.d.).

We recommend (R5): conducting additional research to identify potential funding sources for stormwater BMP installations.

We recommend (R6): implementing a stormwater fee or enterprise fund to increase the funding for GI/LID projects.

Education and Outreach

Once municipalities have secured sufficient funding and an appropriate location for the GI, a lack of support from residents can stop a project from progressing.

Finding 5: A lack of public support can hinder the implementation of GI/LID.

The general public is often opposed to GI/LID installations. The main concerns we found the public to have are the lack of aesthetic appeal of common GI/LID BMPs, the ability of rain gardens to attract pests such as mosquitoes, and the risk of children drowning in larger retention basins. Many planned BMPs have been rejected because of concerns such as these. In communities like Ashland, Devens, and Holden, MA, residents have shown more public approval and education of GI/LID, and more BMPs have been implemented. We were told by Neil Angus, the Environmental Planner of the Devens Enterprise Commission, that the environmentally friendly design of the community is a feature that attracts potential residents. Therefore, it is in the best interest to foster public approval of GI/LID concepts to ease the future implementation of GI/LID.

We recommend (R7): town Conservation Commissions collaborate with outside groups, such as environmental activist groups and schools, to arrange GI/LID educational activities.

Figure 12. Natick middle school offers an educational opportunity using its rain garden.

Finding 6: Town meetings can be an obstacle to the implementation of GI/LID municipal code improvements.

An effective way to increase the ease of implementation of GI/LID features is by improving the town zoning laws. These improvements would include changing outdated codes that make implementing BMPs impossible, and adding codes that require municipal reconstruction projects to add GI/LID when public infrastructure and public right-of-way features are rebuilt. In order to change these codes, those improvements must pass through the town legislative body, such as a town meeting or board of selectmen. These meetings in the municipalities we interviewed are often infrequent, and many only convene twice a year. Voters at these meetings in towns with fewer BMPs often do not consider the implementation of GI/LID as a priority, as they seem to not understand the importance of GI/LID installations. As a result, municipal code revisions are sometimes rejected at this stage of implementation. GI/LID BMPs can reduce flooding and prevent algal blooms, which are events that people care greatly about eliminating.

Figure 13. This algal bloom on the Charles River is from the EPA's webpage about challenges facing the river.

If local officials knew more about the advantages of GI/LID as it relates to these events, those projects might more easily pass through the town council.
We recommend (R8): using volunteer groups, school groups, or a standard pamphlet from conservation groups to educate residents about the importance of BMPs in keeping waterways clean and roads clear.

Finding 7: Uncertainty around the details of these novel projects deters their use by town planner and engineers.

Town planners and engineers lack much of the information they would like to know when planning BMPs.
Several of the BMPs we toured were not as effective or efficient as they could have been. Some examples of these include: i) making retention basins that were larger than needed and are now taking up valuable space, ii) using plants that are not suitable for rain gardens because the plants cannot handle both wet and dry conditions, and iii) leaves clogging the BMP.

Figure 14. This is a series of three oversized detention basins in South Natick Hills. It was designed with software that made a far too large estimate.

Given more time, staff, or both to plan the projects and research, these problems could have been avoided. However, some of these pitfalls were a result of using novel technology.
Engineers in Natick oversized older detention basins in private developments based on drainage estimation software, and these detention basins occupy large areas of valuable land that could have been developed differently. The novel technology also makes the anticipated cost, drainage projections, and project timeline more difficult to judge.

This limits the ability of these plans to reliably comply with EPA grant specifications or political promises. This deters towns from applying for grants that may help them fund these projects, and politicians from supporting these projects.

Figure 15. This detention basin doubles as green space in dry times for a new private development on Wayside Rd in Natick.

We recommend (R9): Public Works Departments and Conservation Commissions show project sites that demonstrate the effectiveness of GI/LID to any other DPW employees and elected officials who are uncertain about implementing it in their communities. Several of our interviewees expressed that demonstration sites were a big factor in the decision to implement GI/LID in their community.

We recommend (R10): town engineers, town planners, and conservation commission members communicate and collaborate with coalition groups such as the Blackstone Watershed Collaborative and the Central Massachusetts Regional Stormwater Coalition, as well as other nearby municipalities to share knowledge and resources. These relationships have aided municipal members by sharing educational materials and monetary resources.

Communication Between Departments

Finding 8: GI/LID projects are often interdepartmental projects that require efficient collaboration. More frequent communication between departments correlates with more diverse types of GI/LID installations. Four out of six communities we surveyed reported that they communicated daily, and they felt that they communicated effectively.

The communities we worked closely with, Framingham, Natick, and Charlton, all reported that they felt they communicate well between departments. At the outset of our project, we anticipated that siloed departments would be an issue, as the lack of communication between departments came up in one of our interviews as well as in our research. However, this was not a common issue. From our survey distributed to the Central Massachusetts Regional Stormwater Coalition, 4/6 respondents communicated daily or more frequently with other departments about stormwater management.

Figure 16. This rain garden at Framingham's Bowditch Field Athletic and Cultural Complex required a high level of communication between departments to implement and maintain properly.

In our survey, we also asked about the rate of correspondence between departments, which also correlated to more diverse installations of BMP types in each community.
We recommend (R11): structuring more frequent meetings between departments that work on stormwater. Daily communication is best, but a formal weekly meeting between departments such as public works and the conservation commission may ease the implementation of GI/LID.
We recommend (R12): a restructuring of municipal departments, or the formation of a partnership between key departments to facilitate the implementation of GI/LID.

Operations & Maintenance

Finding 9: Operations and Maintenance (O&M) is an issue in both public and private BMP installations due to the lack of funding and education for O&M workers.
Maintenance has been a problem for every municipality we spoke with or surveyed. GI and LID measures require specific and periodic Operations and Maintenance which cannot be readily assumed by the existing Town Facilities Staff. In addition, staff need to be able to identify and maintain specific plants for some surface BMPs. Natick's grounds and facilities operators currently do not have the training to identify and maintain these plantings for proper long-term operations. We interviewed a conservation director from Charlton who said they do not have any designated O&M workers, as a result, they have catch basins that are not maintained. Framingham reported that there was confusion on how to complete necessary maintenance on their municipal properties. The Conservation Commissions in Charlton and Framingham also reported that they are understaffed and are too busy to perform regular checks on BMP sites after construction is finished. The town of Ayer reported they have trouble with O&M due to lack of education and understaffing for public BMPs, and for private BMPs, there are issues with owners either being uneducated on proper maintenance or choosing not to spend money on maintenance.
We recommend (R13): that the Public Works Departments, Conservation Commissions, and/or Planning Boards should recommend to the municipal legislative body to require a funding plan for operations and maintenance of public infrastructure before implementing BMPs.

Figure 17. An example of an educational placard to explain the purpose and importance of the rain garden

We recommend (R14): that the CMRSWC should offer joint training for O&M workers, and Public Works Departments, Conservation Commission, or Town Planning should put educational signage on BMPs to further educate maintenance workers.
Consider standardized signage from the CMRSWC, Think Blue Massachusetts, the Mass Audubon, or another environmental organization. Plant identification is one area that is difficult for O&M workers; tags next to plants or educational signage with pictures of the species could serve a dual purpose to educate the public and make it easier for workers to differentiate between weeds and intentional plants.
We recommend (R15): developers work closely with maintenance workers to ensure they design something maintainable for them.
We recommend (R16): the developer provides a detailed O&M plan to be followed by maintenance workers. This should be implemented as a municipal regulation.

Finding 10: Operations and Maintenance (O&M) is an issue in both public and private BMP installations due to a lack of responsibility or confusion about who is responsible for O&M.

Through interviews and surveys, communities have reported multiple times that there is an issue with holding people accountable for maintenance. Framingham DPW has trouble understanding who is responsible for maintaining the BMPs for private installations. Once the developer finishes implementing the BMP, they move on to other projects and pass the O&M of the BMP to the owner of the deed. In most cases, this leads to the O&M not being done. According to an Ashland representative, maintenance is often brought up as an issue with cemeteries, parks, and school facilities not wanting to perform maintenance of BMPs.

We Recommend (R17): the Department of Public Works, Conservation Commission, and/or Town Planning should require maintenance of private BMPs to be performed by establishing fines and regulations or an incentive in municipal code for maintenance over time.

We Recommend (R18): regulations should be put in place by municipalities that clearly state which parties are responsible for maintaining public and private BMPs.

Deliverable

The complementary document to this report is our deliverable, *Guidelines for the Implementation of Green Infrastructure and Low-Impact Development in Central Massachusetts Communities* (see Appendix A). That guidelines document is a simplified adaptation of the Findings and Recommendations chapter. It is intended to be read by town engineers, town planners, and conservation agents. The sections discussed in the guidelines document are community education, space/land, funding, incentives, and maintenance. Each section has a shortened version of our findings and recommendations along with links to our recommended resources for further reading.

See our Supplemental Materials to read Guidelines for the Implementation of Green Infrastructure and Low-Impact Development in Central Massachusetts Communities in full.

Figure 18. This photo was taken on 3/29/22 at the John F. Kennedy middle school in Natick while touring their BMPs.

Conclusion

In our research, we found that a lack of broad public knowledge of the impacts of stormwater runoff has led to limited public support for stormwater mitigation efforts. This lack of support has made it difficult for communities to fulfill the requirements of the MS4 permit. Without support from the community, the local lawmakers are less inclined to prioritize GI/LID.

Operations and maintenance are necessary for structural BMPs to remain operational and effective over the long term, and making sure that there is a responsible party for O&M will help BMPs to protect the environment for years to come.

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