



Developing Stormwater Curricula for Central Massachusetts Fifth Graders

The Development of Educational Curricula on the Impacts of
Stormwater for Central Massachusetts Fifth Graders

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

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Abstract

Stormwater runoff can pick up and carry pollutants over impervious surfaces and get discharged directly into local bodies of water. The goal of this project was to spread awareness on the impacts of stormwater by supporting local fifth grade teachers at Shrewsbury, Holden, Charlton, and Hopkinton by interviewing stakeholders and building off of existing curriculum while complying with the Next Generation Science Standards. A *5th Grade Watershed Unit* was developed and will become a viable resource for the Massachusetts Department of Environmental Protection, Central Massachusetts Regional Stormwater Coalition, the Think Blue Campaign, and the fifth grade science teachers at the project schools.

Executive Summary

Introduction

Stormwater is a leading cause for water pollution all across the United States and it is the leading cause of impaired water quality in Massachusetts. Stormwater is often left out of curriculums due to the fact that students are not tested on it during standardized testing. Teachers play an important in educating youth and their families, providing a significant opportunity to increase knowledge on the impacts of stormwater. However, it can be challenging for teachers to find the right resources and know how to effectively use them when trying to teach their students on these environmental impacts. This issue created an opportunity for the Massachusetts Department of Education and the Central Massachusetts Regional Stormwater Coalition to come together and sponsor the 5th Grade Watershed Unit, which is a curriculum that incorporates stormwater in educational exercises and complies to the Next Generation Science Standards.

Mission, Objectives, and Methods

The goal of this project was to spread awareness on the impacts of stormwater by supporting local fifth grade teachers with effective lesson plans and curricular resources. For project objectives we:

- developed an understanding on current watershed curricula and teaching methods in project schools;
- maximized the existing curriculum to help build the 5th Grade Watershed Curriculum and
- shared our valuable resources with teachers.

We completed these objectives through conducting semi-formal interviews with the teachers at the project schools, curriculum coordinators of other stormwater curriculums, and resources at the K-12 STEM Center here at WPI.

Results and Findings

After analyzing the interview summaries of the semi-formal interviews conducted with the teachers at the project schools, curriculum coordinators of other stormwater curriculums, and resources at the K-12 STEM Center, we found the following:

Finding 1: Hands on activities are key for keeping fifth grade students excited and engaged.

Finding 2: While helpful, last year's IQP produced curriculum can be condensed and focused more on the Next Generation Science Standards to increase teacher appeal.

Finding 3: The Massachusetts Comprehensive Assessment System does not ask enough questions on the water cycle or stormwater to warrant teachers putting a large emphasis on it.

Finding 4: Teachers enjoy guest speakers, but there is a lack of communication between Town Engineers, who are familiar with local stormwater issues, and Teachers.

Finding 5: Teachers prefer to spread curriculum by word of mouth.

For finding one, some of the elementary schools we worked with do not have science class every day, so it is important to keep the students engaged when they do have science. For finding two, the teachers that worked with last year's project team were pleased with the outcome of the curriculum, however, they did not reuse the whole thing. They wanted a shorter curriculum that hit the same Science Standards. For finding three, over the last nine years of standardized testing in Massachusetts elementary schools, there have been a total of ten questions asked on the water cycle and zero questions asked in regards to stormwater. For finding four, every teacher that the team met with explained that they loved having guest speakers come in to speak to the class, but do not know how to get in communication with their town engineers. Lastly for finding five, we found that the most effective way to spread curriculum is through teacher to teacher connections.

Recommendations

Based on our findings, we recommend the following to improve fifth grade stormwater education:

Recommendation 1: Increase awareness on stormwater by spreading our curriculum to teachers and giving presentations in informal educational settings.

Recommendation 2: Send out requests to be a part of professional development days months in advance.

Recommendation 3: Identify school system "Champions" and town "Champions" -and develop a convenient method of communication between them.

Recommendation 4: The coalition should create an email group alias where people can easily be added or deleted to help contact between “Champions”.

Recommendation 5: Partner with the Massachusetts Department of Education in order to incorporate questions regarding stormwater in the MCAS.

For recommendation one, we built off of and improved the 2018 Water Education IQP Team’s work. In order for this curriculum to be taken to the next step, it needs to be shared in as many different ways possible. For next year, focus on spreading the curriculum. For recommendation two, start planning for a professional development day **now**. During ID2050, the prep term before the project, this was a main goal of our project. Through our teacher interviews, we quickly learned it takes a lot more time and planning than 7 weeks to coordinate a professional development day. For recommendation three, teachers enjoy having guest speakers, and town engineers are willing to come in and speak to students. Set up a convenient way for the most enthusiastic teachers and town engineers to communicate with each other. For recommendation four, an outlook email group alias is a group email where members can be easily added or removed. This is a possible solution to connect local champions, while making sure only the most involved members are receiving email updates. Lastly for recommendation five, partnering with the Department of Education would greatly help spread the 5th Grade Watershed Curriculum. The MCAS has not asked a single stormwater question over the last nine years, so getting the DOE to incorporate stormwater on the MCAS would be essential for getting teachers to spend their class time teaching stormwater.

Chapter 1: Introduction

Stormwater is a leading cause for water pollution all across the United States and it is the leading cause of impaired water quality in Massachusetts. Stormwater runoff is generated from rain or snowmelt that flows over land or impervious surfaces, such as paved streets, parking lots, and building rooftops, and does not soak into the ground (NPDES, 2018). Stormwater is an important but undervalued part of the water cycle that the public needs a better understanding of. While it is natural and helps support life, this natural system can easily be disrupted by human activity which can cause for serious problems. When teaching the water cycle in elementary school classrooms, teachers find it challenging to teach about the impacts that stormwater has on the environment. Stormwater is often left out of curriculums due to the fact that students are not tested on it during standardized testing. This is an issue because stormwater pollution is a serious concern that presents many dangers for humans, animals, aquatic organisms, and other forms of wildlife. Stormwater runoff picks up pollutants like trash, chemicals, oils, sediments that can harm our rivers, streams, lakes, and coastal waters (NPDES, 2018). Stormwater is a complex system that requires human ingenuity to develop organizations, campaigns, curriculums, and whatever else is necessary to help spread awareness on it, its impacts, and how to manage it effectively.

The National Pollutant Discharge Elimination System (NPDES) program of the Clean Water Act sets forth minimum control measures requiring communities to conduct public education and invite public participation in stormwater management efforts (USEPA, 2000). Although compliance with these measures has been reportedly high and slowly increasing over recent years (USEPA, 2000), there is little direct evidence to indicate increased knowledge or changed human behavior regarding stormwater issues.

The state has worked on creating Municipal Separate Storm Sewer Systems for towns to follow to effectively manage stormwater runoff. A Municipal Separate Storm Sewer System, or MS4, is a conveyance or system of conveyances that is owned by a city, state, town, or other public entity that discharges to waters of the United States (EPA, 2018). Over the next twenty years, municipalities foresee a significant increase in capital, operating, and staffing costs

statewide. In February 2012, the Water Infrastructure Finance Commission of the Commonwealth of Massachusetts produced a landmark report entitled *Massachusetts's Water Infrastructure: Toward Financial Sustainability*. In this report the legislature concluded that “\$18 billion in stormwater investment may be required over the next 20 years depending on federal regulatory requirements” (Bump 2017). While the cost might seem extreme it is a cheaper and safer alternative to letting the water become more polluted, which could present health and safety issues for drinking and leisure water bodies.

The general public still lacks understanding as to what stormwater is and how it gets into bodies of water. Due to the public's limited understanding, they are less prepared to take steps towards improving individual behaviors regarding recycling, pollution, and stormwater management. This is where the role that teachers play in educating the youth and their families is crucial towards gaining an increased knowledge on the impacts of stormwater. However, it can be challenging for teachers to find the right resources and know how to effectively use them when trying to teach their students on these environmental impacts. Teaching students now on these impacts can open up the opportunity to reduce the costs that Massachusetts has to pay for new stormwater management and infrastructure in the future.

Various resources and organizations for stormwater education exist at state, federal, and local levels. The Next Generation Science Standards are a new set of standards with the goal of improving science education for students of all levels. They have been internationally benchmarked with countries whose students have performed well in science and engineering fields (Next Generation Science Standards, n.d.b, 2019). These standards were released April of 2013 with the goal to be implemented across the nation. More states have slowly begun switching over to these new standards.

Massachusetts has many changes occurring simultaneously. First off, Massachusetts is currently in the process of switching over to Next Generation Science Standards. Also, the Think Blue Campaign, a campaign focused on spreading awareness on the issues of stormwater, is in their first year of launch (Think Blue Massachusetts, n.d.b, 2019). Future curricula, that need to be based off of Next Generation Science Standards, can benefit by including topics from Think Blue. Nearby cities have seen issues similar to what we have addressed in this project. In April

of 2018, a new Green Infrastructure curriculum was implemented into five public schools around Boston. Two new stormwater units were implemented, each based off of a different Next Generation Science Standard.

Stormwater education has been a topic of growing importance in recent years. In 2012, 13 towns in central Massachusetts wanted to implement stormwater programs, but lacked the resources required. These towns came together and pooled their resources to face their most challenging problems. After one year of successful collaboration, surrounding towns were eager to join the new group. During 2013, 17 towns joined what has become known as the Central Massachusetts Regional Stormwater Coalition (CMRSWC). With growth like this in one year, it became clear that towns were interested in implementing stormwater programs. The CMRSWC and the Massachusetts Department of Environmental Protection came together to sponsor this project. A 2018 WPI water education team's (Sakowich, C., Hull, M. E., Malafronte, S., & Nassar, V. A., 2018) project sponsors, with whom we are also working with, indicated that even though they made great lesson plans and kid-friendly educational videos, their work did not stick in the classroom. All of their research has given us a great stepping stone to build off of and improve, but in a slightly different direction.

Even with the amount of work that is being done to implement stormwater curriculums into schools, teachers still have a problem incorporating it into their lessons. The Department of Education needs convincing that the topic of stormwater runoff is important and should be incorporated into a section of the Massachusetts Comprehensive Assessment System, or MCAS. Teachers may have different standards and requirements that they have to meet, which causes them to refrain from teaching stormwater curriculums. Despite the implementation of new science standards across the nation, in order to incorporate stormwater curriculums in youth classrooms teachers must be educated on the impacts of stormwater themselves. Familiarizing teachers with lesson plans on stormwater and showing them how stormwater is a topic that can be intertwined with units that are covered on standardized tests is vital to making these curriculums sustainable. With the project now completed, we hope to deliver the message to teachers that this is something important that they will be able to use in their own lesson plans. If these developed lesson plans make it into the classroom, they would give students the general

knowledge they need going forward to make more informed, environmentally friendly decisions on water. We believe we have been able to help the CMRSWC along with the Think Blue Campaign in spreading stormwater awareness by getting local Massachusetts teachers to invest in our curriculum. Think Blue and the coalition need to be widely incorporated into society and this has been a great opportunity to do that.

This project improved on the 2018 Water Education project team's fifth grade stormwater curriculum and implemented the updated curriculum into four different fifth grade science classes in central Massachusetts. The team inspected the current watershed curricula, awareness, and teaching methods in the interested elementary school districts: Holden, Shrewsbury, Charlton, and Hopkinton. The evaluation and analysis of the 2018 team's project was used to improve the curriculum by incorporating the best teaching methods and the most engaging activities. Research on the Think Blue Campaign and the Next Generation Science Standards was done to integrate these standards into the curriculum as requested by our sponsors. We developed lesson plans to give to teachers to teach their students by making it so that they could easily understand the topic and feel comfortable teaching the lessons. Final recommendations and deliverables were presented and sent to interviewees and teachers at the project schools.

Chapter 2: Background

The background takes you through the thought process used while addressing the problems that this project dealt with. We start off by explaining the environmental dangers of stormwater in urban and rural areas. Next, we talk about MS4 permits and how local governments are dealing with stormwater management and the spreading of awareness for stormwater's impacts. The organizations that are spreading awareness and making sure that communities conduct public education and invite public participation in stormwater management efforts are then discussed. From 2000 to 2010 it was reported that compliances with public participation in stormwater management were relatively high, however, there is little to no direct evidence that prove the public's knowledge has increased on stormwater issues (Herringshaw, Thompson, Stewart, 2010). There is also little to no evidence that human behavior regarding stormwater management changed over this time. Due to the lack of supporting evidence, organizations like the CMRSWC and Think Blue Massachusetts were formed to help raise awareness on stormwater. We discuss why these organizations are important and how we will incorporate them into our curriculum as well as how we will incorporate the new Next Generation Science Standards. Research was conducted on currently successful stormwater curriculums and programs in place, as well as the 2018 Water Education team's project. Learning from and building off of these programs as well as incorporating the Think Blue Massachusetts campaign and the Next Generation Science Standards has helped create for a final product for teachers to use to educate their students on the impacts of stormwater.

2.1 Dangers of Stormwater

Stormwater is naturally occurring and should not be seen as a naturally dangerous process. The natural process of the water cycle is shown by Figure 1. The dangers involved with stormwater arise from human activity. Humans disrupt the process of stormwater runoff through their pollution in streets, rivers, lakes, and other water bodies. Stormwater disposal methods in both urban and rural areas are not taken seriously enough and have had a tremendous impact on the environment in more negative ways than positive ways.

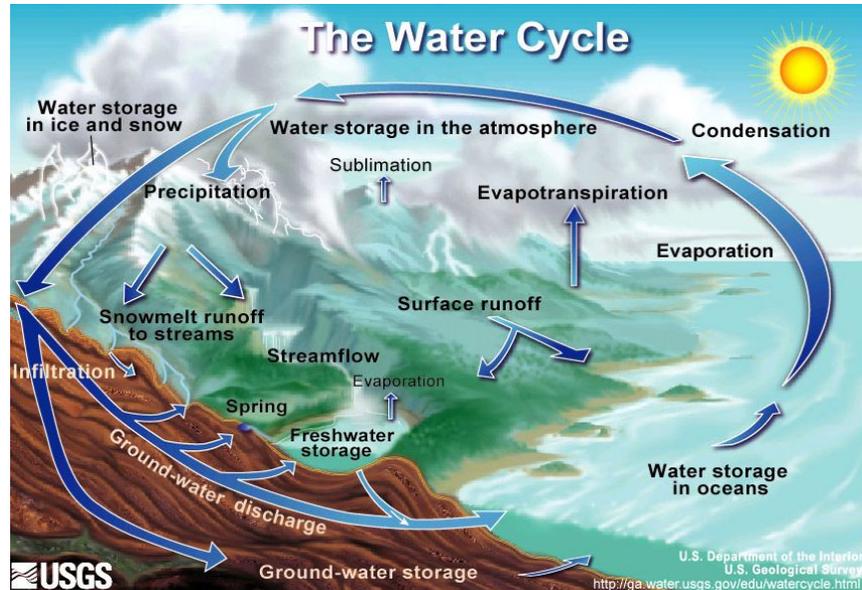


Figure 1: Water Cycle. Image of the Water Cycle in a more complex sense that shows its natural environmental process.

2.1.1 Stormwater Disposal in Urban Areas

The impacts of stormwater can have different effects depending on where it takes place in the world. Stormwater is managed different in urban areas than rural areas (Figure 2). Stormwater runoff is the number one cause of stream impairment in urban areas (Trees and Stormwater Runoff, 2019). These problems are where there are many impervious surfaces which include pavements, infrastructure, and industrial areas. These surfaces cause water quantity based issues. The problem with these surfaces are they prevent precipitation from naturally soaking into the ground and instead water runs rapidly into storm drains, sewer systems, and drainage ditches (EPA, 2015). When the water ends up interrupting these systems (overflowing), this can cause downstream flooding, stream bank erosion, increased turbidity, habitat destruction, storm and sanitary system overflows, and contaminated streams, rivers, and coastal waters (EPA, 2015).

While water quality issues are caused by impervious surfaces, the chemicals, pollution, and trash humans leave on roads causes water quality issues. Human interactions worsen stormwater runoff by adding nitrogen and phosphorus pollutants from fertilizers, pet and yard waste (EPA, 2017). Cars can leak harmful motor oil, leaving harmful metal chemicals barium

and cadmium on the roads. In preparation for storms, trucks leave salt and sand scattered across the roads. Impervious surfaces lead this contaminated water directly to storm drains, leaving no opportunity for soil and plants to filter out these said pollutants (EPA, 2017).

Urban areas usually have separate sewage and stormwater systems to help keep the two from mixing, as sewage water has to be treated before being discharged. However, cities that have combined stormwater and sewage systems, along with an abundance of rainfall or snow, cause significant problems. There are currently 772 cities in the United States with a combined sewer system (EPA, 2017). During these periods of heavy rainfall and snowmelt, some of these wastewater systems are designed to discharge excess sewage (untreated) into nearby streams, rivers, and other bodies of water (EPA, 2017). These overflows are called combined sewage overflows (CSO's) which hold untreated human and industrial waste, toxic materials, and debris (EPA, 2017).

2.1.2 Stormwater Issues in Rural Areas

Although polluted stormwater is more prevalent in urban areas, it also a great concern in rural areas. The United States has more than 330 million acres of agriculture land that produce food (EPA, 2005). In the 2000 National Water Quality Inventory, it was reported that agriculture nonpoint source pollution is the leading source of water quality impacts on surveyed rivers and lakes, the second largest sources of impairment to wetlands, and major contributor to impairment of ground water (EPA, 2005). These pollutants that are a result from farming include: sediments, nutrients, pathogens, pesticides, metals and salts.

Each of these individual sources of pollution results in different effects. The most prevalent source of pollution from farmers is soil that is washed off of fields. Rain water carries sediments and dumps them into nearby water bodies, making the water cloudy, ultimately preventing sunlight from being able to reach aquatic plants. Also, as sediments enter these bodies of water, they can clog the gills of fish. In addition, other pollutants like fertilizers, pesticides, and heavy metals are attached to these soil particles that are being washed into these bodies of water. Some other nutrients that farmers add to their land in the form of fertilizers are phosphorus, nitrogen, and potassium along with manure and sludge. The presence of these

nutrients in the water can cause algal blooms, deplete oxygen levels making the water deadly to aquatic life, or create a foul odor in drinking water (EPA, 2005). High concentrations of nitrate in drinking water can cause methemoglobinemia; a fatal disease in infants which can be caused from these fertilizers.

Another problem with farmers’ practices arise from the management of their animals. Farmers confine animals in small areas so they can be easily and efficiently fed. An estimated 238,000 working farms in the US generate about 500 million tons of manure each year. “Runoff from poorly managed facilities can carry pathogens such as bacteria and viruses, nutrients, and oxygen-demanding organics and solids that contaminate shellfishing areas and cause other water quality problems” (EPA, 2005). Along with the contamination of water bodies, ground water can also be contaminated by waste seepage. Farmers add many toxins to the soil which all eventually add into stormwater runoff when it rains. The effects that farming has on stormwater management is something that we believe should be incorporated into stormwater curriculums as there is an issue with the practices that farmers use.

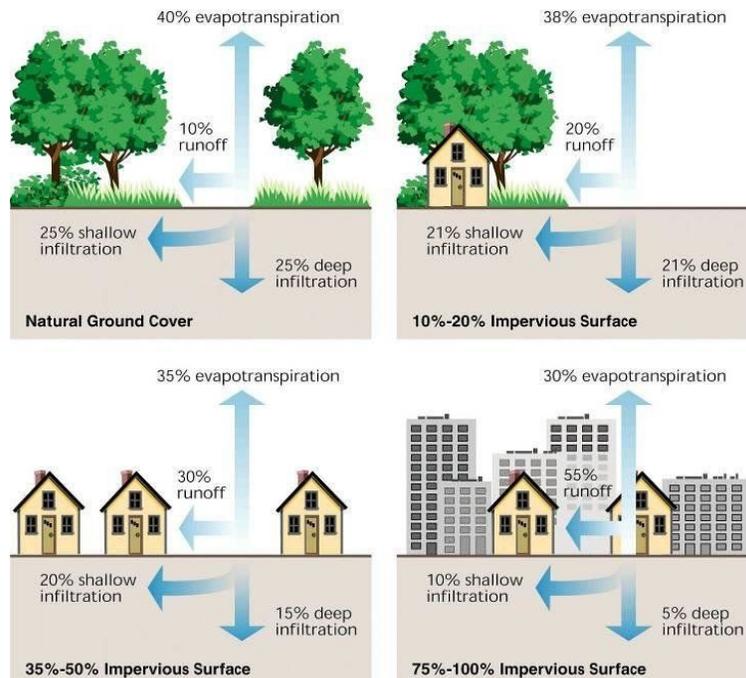


Figure 2: Environmental Effects; Urban vs Rural. Image comparing how the water cycle effects urban and rural areas.

2.1.3 Other Environmental Effects

Stormwater is generally feared for its long list of dangerous impacts to the environment but it should not only be looked at this way. In some areas stormwater is cleaned and processed so that it can be used as drinking water or for other household water uses. Other environmental effects caused by stormwater can be direct results of lack of stormwater management or a lack of maintenance which can cause for failures in infrastructure. Surface runoff has the ability to carry human and animal wastes that may have entered sewer systems due to aging or failing infrastructure or inappropriately maintained water systems (Stormwater - Issues and Impacts, 2019). The negatively impacting environmental effects caused by humans' pollution of stormwater is only going to grow and get worse if the general public is not better educated on its dangers.

2.2 Municipal Separate Storm Sewer System (MS4)

Municipalities are required to distribute educational materials on stormwater issues to comply with the National Pollutant Discharge Elimination System permit. Municipal Separate Storm Sewer Systems, or MS4s, are used to increase the public's knowledge on stormwater in hopes that they will change the behavior of the public to reduce the amount of pollutants in stormwater (EPA, 2018). It is of extreme importance for towns and cities to understand what an MS4 permit is so they can make their residents more aware of what they have to do pertaining to stormwater management. Another problem is that the municipal permit managers that write MS4's have technical backgrounds. They are not comfortable with education techniques and delivering their findings that they put into MS4 permits to elementary students. If the public are not educated on the impacts of stormwater, then they will not be able to understand what their town officials are asking for when trying to follow MS4 permit requirements. If they fail to complete these requirements, then there will only be more consequences in the future that deal with stormwater management, infrastructure, and funding. The Water Education team must look into and understand these MS4 permits, take its main points on the dangers of stormwater, and

put them into a curriculum that fifth grade students would be able to understand.

The first two points on the MS4 are important to educating the people on stormwater. Town officials, town engineers, and town water departments must comply and provide outreach to their communities. This can be helpful when trying to get town engineers or town water officials into schools to spread awareness. The first two points from the MS4 document follow:

1. Public Education and Outreach- Municipalities are required to provide educational material about stormwater to four audiences (residents, industry, commercial, and construction). The purpose of the educational material is to provide the targeted audience information about stormwater and how their actions may impact it. The permit requires 2 messages for each audience during the five year permit term.
2. Public Participation – Municipalities are required to at least annually provide an opportunity for the public to participate in the development/implementation of their Stormwater Management Program (SWMP). Notices must comply with state public notice requirements.

Source:

<https://www3.epa.gov/region1/npdes/stormwater/ma/six-minimum-control-measures.pdf>

2.3 Local Governments' Stances on Stormwater Management and Increasing Awareness

The government and its agencies have realized the significance of the stormwater issue, so they are attempting to enforce regulations to reduce the problem on a state and national level. However, abiding by these regulations and increasing awareness through education requires more money to be put into stormwater management by the local governments. Although these governments may want to participate in the effort to reduce stormwater dangers, many towns and cities do not have the extra money in their budget to put towards stormwater management. This tension has been especially exemplified after the recent MS4 permit was submitted by the EPA.

2.3.1 Local Governments Attitudes Toward EPA Regulations

While the state government and other organizations are making efforts to reduce the

effects of stormwater through regulations, local city and town governments are not always in favor of these regulations (US EPA, 2018). Whether the local governments are aware of the magnitude of the stormwater problem or not, these regulations can cause the local cities and towns to increase their costs or change their methods of stormwater management. For example, in 2016 the EPA issued a new MS4 permit which affected 200 towns throughout Massachusetts. This new permit forced communities to change their systems so that they must clean the stormwater before it is discharged into bodies of water. It also put a limit on how much stormwater could be released into streams (Thompson, 2016). “This permit is an essential step to make our waters cleaner and ensure that people can enjoy outdoor recreation without being exposed to potentially harmful water pollution,” said Dave Degan, an EPA spokesman (Thompson, 2016). Although this permit aims to decrease water pollution, it increased the local governments’ costs of stormwater management. The increase in costs include the construction of treatment facilities, enhanced monitoring, catch basin cleaning, and street sweeping (Thompson, 2016). Some local towns believed that the regulators had insufficient regard for the costs of this plan when they implemented it. Philip Guerin, president of the Massachusetts Coalition for Water Resources Stewardship, stated “All of it may be well-intentioned ... in a theoretical world, the right thing to do. But practically speaking, the cost is immense and the ability for cities and towns to even do it is almost incomprehensible” (Thompson, 2016). Mr. Guerin acknowledged that it was the right thing to do in a theoretical world and hopefully the local cities and towns also realize this. Governments are not enthusiastic about having to increase their costs for stormwater management which is a major problem that adjustments must be made to fix it. On the other hand, it is the regulators’ duty to be aware that many of these small towns do not have the budget to greatly increase their stormwater management processes. There is ongoing tension between the desirability of increased investment in stormwater infrastructure and education, and the costs for implementing and maintaining such efforts. Resolving this tension could be vital to ensure the success of our sponsors’ goals.

2.4 Organizations Spreading Stormwater Awareness

Organizations like MassDEP, the CMRSWC, and Think Blue Massachusetts are

organizations involved in spreading stormwater awareness. The CMRSWC and Think Blue Massachusetts were recently formed for this issue alone.

2.4.1 Central Massachusetts Regional Stormwater Coalition (CMRSWC)

The Central Massachusetts Regional Stormwater Coalition, also known as the CMRSWC or “Coalition”, was created in 2012 in order to reduce stormwater pollution and educate central Massachusetts communities on the dangers of stormwater. There are now 30 active communities in the CMRSWC, and all six towns who have expressed interest in being involved in this IQP project are members. By joining the Coalition, these communities seek to fulfill their needs of cost-effective regional initiatives, lessons learned from other communities, and increased potential for grant awards -(CMRSWC, 2019). They work together by sharing databases and standardizing certain stormwater procedures in order to become more efficient (CMRSWC, a). This collaboration has resulted in the development of a framework to manage stormwater systems and several tools to improve educational practices (CMRSWC, a). The regulations that the members of the Coalition have to follow are mostly EPA mandated through the MS4 permit. These rules and regulations enforced by the CMRSWC aim to assist its effort of benefiting the environment and the communities in regards to stormwater management.

In addition to improving the environment and assisting the communities, another goal of this organization is educating the towns’ governments and citizens on stormwater and how it can be dangerous. The Coalition is divided into three sub-committees. One of the three committees is the education branch, who is “responsible for developing and promoting outreach and educational materials required by the MS4 permit” (CMRSWC, 2017). This committee strives to increase awareness on this environmental issue through several different tactics. They created an educational website which provides information on stormwater, the Coalition itself, the MS4 permit requirements, and a toolbox on the best stormwater practices. They also have developed workshops, videos, and templates to educate community members on the MS4 regulations and the methods that should be used to adhere to this permit (CMRSWC, 2017). One way the CMRSWC has attempted to reach out to the youth is by planning activities at different events throughout central Massachusetts such as Earth Days and school fairs. The CMRSWC has been

contemplating different ways to educate their communities on stormwater, but they are continuing to research and discover the most effective approaches to spread awareness on this issue.

2.4.2 Think Blue Campaign

Another way Massachusetts is trying to raise public awareness on the dangers of stormwater is through a statewide stormwater and outreach campaign known as Think Blue Massachusetts that was launched in 2018. Think Blue Massachusetts is a statewide educational campaign made up of ten regional stormwater groups that joined forces in 2016 to help residents and businesses of Massachusetts do their part to reduce polluted runoff, and keep the state's water bodies safe, clean, and healthy (Think Blue Massachusetts, n.d.a / n.d.b, 2019). Think Blue's mission is driven by the belief that the public does not understand the impact that stormwater has on water quality and public health. Public awareness on the dangers of stormwater pollution must be raised in order to decrease the amount of pollution and pollutant loading (Think Blue Massachusetts n.d.a, Retrieved January 20, 2019).

2.5 Education Standards

The Water Education's team project of creating a curriculum for local fifth grade teachers to use to educate their students on the dangers of stormwater has been designed to meet certain science standards in the state of Massachusetts in order to connect what the students have to learn based off of their curriculum with the dangers of stormwater. These standards are set so teachers know what to teach their students to prepare them for standardized testing like the Massachusetts Comprehensive Assessment System, or MCAS test. The Next Generation Science Standards (NGSS) are a new set of science standards designed by the states for the states. The Water Education team followed the Next Generation Science Standards when designing the curriculum for students to learn.

2.5.1 Next Generation Science Standards

The Next Generation Science Standards were developed by a team of experts and

stakeholders in science and engineering, K-12 and higher education, and industry working together to improve science education for all students (NGSS,n.d.b). They were released for adaptation in April of 2013 (NGSS,n.d.b). Massachusetts’ current science curriculum was put in place in 2001, and was supposed to go under revision in 2009. Revisions were projected to be done by 2011, but they delayed the process to match the timeline of the Next Generation Science Standards. Although Massachusetts has been a lead state throughout the development and shown commitment to switching to the Next Generation Science standards (Figure 3), the process has taken longer than expected (NGSS, n.b.c). With the transition over coming soon, it is important we based our curriculum off of these new science standards. Rather than testing students on information directly from a textbook, the Next Generation Science Standards are designed to spark students’ curiosity for science by giving the teachers more freedom to create hands on, interactive curriculums that interest their students. A high quality science education means that students will develop an in-depth understanding of content while developing communication, collaborative, and problem solving skills that will serve them throughout their educational and professional lives (NGSS, n.b.d).

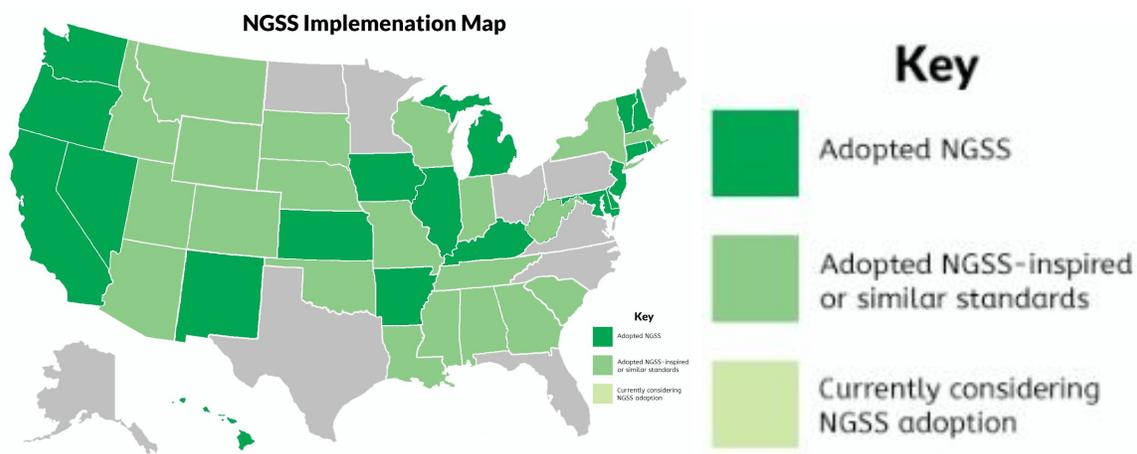


Figure 3: NGSS Implementation Map. Map showing which states have adopted the standards, and which states are in the process of switching.

The Next Generation Science Standards breakdown scientific learning into three separate dimensions: science and engineering practices, crosscutting concepts, and disciplinary core ideas (NGSS, n.d.e). The first dimension is science and engineering practices. Although scientific inquiry and engineering experimentation are similar, they have distinct differences. Scientific

inquiry begins with a question that gets answered through experimentation. Engineering identifies a problem that can be solved through design. By identifying the differences between these two practices, the Next Generation Science Standards hope to show students the importance that science, technology, engineering and mathematics (STEM) have on their everyday lives.

The second dimension of learning are the crosscutting concepts. There are seven crosscutting concepts: patterns; cause and effect; scale, proportion, and quantity; systems and system models; energy and matter; structure and function; and stability and change. These seven concepts are emphasized by the NGSS because they are necessary for students to get an in-depth scientific view of the world (NGSS, n.d.e). A stormwater curriculum would have cross cutting concepts from: energy and matter, and systems and system models. From energy and matter, it is important that students have retained information regarding cycles and flows. Stormwater and the water cycle are closely related topics, so it is important that students have an understanding on how matter flows in and out of a system. From systems and system models, students will be taught about the storm water systems currently in place, and how it is flawed. This way, they will understand there is a problem with the current system and it can be improved.

Lastly, the third dimension is disciplinary core ideas. The Next Generation Science Standards' core ideas have the power to focus K-12 science curriculums and include the most important aspects of science (NGSS, n.d.e). For something to be considered core, the idea must meet at least two out of these four categories. First, they have broad importance. This means the information studied can be useful when learning about another science or engineering field. Next, it should provide a key tool that helps students research more in-depth information. Third, the topic must be relatable to the students. This helps them stay engaged, and shows them the importance of science and technology. Lastly, the topic must be teachable over many grades, and become more involved as students progress through school (NGSS, n.d.e).

2.6 Current Successful Programs

Local communities and towns that have already developed successful stormwater education programs and implemented them into their schools' curriculums. The Water Education

team has researched these already developed programs to gain insight on how we can successfully incorporate our curriculum into schools.

2.6.1 MWRA - School Program (Massachusetts Water Research Authority)

The MWRA School Program is a successful program that has been updated by the Massachusetts Water Research Authority. This website has many different branches such as video links, project opportunities, and some hands on activities. This is something a teacher can use along with their students. On the MWRA School Program web-page, there are many different in-class activities, videos, and curriculum guidelines related to stormwater that teachers can use. They have demonstrations and hands on testing kits for students to experiment with. This is important to the project team, as the MWRA has already tried to incorporate stormwater activities into the classroom. This website is relevant to any future groups that want to teach more about the dangers of stormwater in the classroom.

Section Source: (Massachusetts Water Resources Authority, 2018)

2.6.2 Westford Public Schools

As stormwater education is important to push into the public, some schools in Massachusetts have already incorporated it into the science curriculum. Westford Public Schools has incorporated the “Living Lab” located in the Norman E. Day School. This lab is designed for grades K-5 and lets the students explore the world using scientific and engineering practices. So far they have two indoor activities along with one outdoor classroom that they are able to use in the warmer months. This outdoor classroom has a gazebo deck that looks out onto a brook habitat for students to have a more involved experience. They also have incorporated a rain garden which is a garden that has natural plants that absorbs stormwater runoff coming from roofs, streets, lawns and other surfaces. All of these lessons are arranged with the NGSS and arranged by the Social Studies Curriculum Coordinator for Westford Public Schools. These lessons are taught by two lab instructors. We reached out to Elaine Santelmann, Westford’s science curriculum coordinator, to get some advice on how to successfully implement our

stormwater curriculum into local fifth grade classrooms.

Section Source : (WPS, n.d.a)

2.6.3 Boston Water and Sewer Commision Fifth Grade Curriculum

Green infrastructure, or GI, is a new nature based technology that hopes to, “replace traditional grey infrastructure, including catch basins and storm drains, with natural elements such as plants, soil, and gravel,” (Metz, 2018) to deal with the stormwater created by cities. Boston Public Schools and The Boston Water and Sewer Commision teamed up to develop two new units for fifth grade curriculums, highlighting the effects that GI has on the city of Boston. Both of these units relate the engineering concepts from the Next Generation Science standards to stormwater and Green Infrastructure. These two units were developed from standards -5-ESS2-1 and 5-ESS3-1 and focus on Earth and Human activities. Each unit should take 3 to 5 class periods. They can be taught individually or in combination.

In the first unit, students must apply concepts from what they have previously learned about the water cycle. Students were asked to compare a map of Boston from the year 1630 to a map of Boston from today. After a short discussion, they concluded that where there used to be grass and marshlands is now completely covered by concrete. Having that much concrete where grass used to be “breaks” the water cycle in that area. To investigate the effects that different surfaces have on the water cycle, students were grouped up and went outside with 2 liter bottles of water. They tested how water reacted with impervious surfaces like concrete compared to porous surfaces such as soil and sponges. In conclusion, the teacher introduces to the students that by implementing GI and rain gardens that absorb water rather than funnel it into storm drains that they were helping to fix the water cycle in their area.

For the second unit, students must apply concepts they have learned on measuring temperature, planning, and experimentation. Students again compared a map of Boston from the year 1630 to a map of Boston from today. After a short discussion, they concluded where there use to be grass and marshlands is now completely covered by concrete. Asphalt is heat absorbing material, and causes the temperature in cities to rise. On top of that, cities have fewer trees to

block direct sunlight. This causes our cities to be consistently hotter than surrounding rural areas, causing cities to use more energy. To investigate, students were grouped up and tested temperatures at different locations around the schoolyard. Although the main function of GI is to help manage stormwater, their results should show lower temperatures from Green Infrastructure compared to asphalt. In conclusion, the teacher introduces to students that GI also helps cool down our cities.

2.7 2018 Stormwater Awareness Through Youth Watershed Education Project

An IQP team created a fifth grade curriculum on the environmental impacts of stormwater last year, so we have analyzed their work to discover how it can be improved. This team developed 10 lesson plans on stormwater and created a series of educational videos which were incorporated in the fifth grade science classes at Holden and Shrewsbury elementary schools. They stated in their report that children communicate school lessons with parents and teachers, who are active in the community (Cary, 2006). The 2018 team not only wanted to educate the students with this project, but were hopeful they could also spread awareness to adults in the community. As they were working to educate the students, teachers, and parents through their curriculum, they conducted large amounts of research and several interviews in order to develop findings which will be extremely helpful to our project.

Their first finding is teachers will not incorporate a curriculum into their classes if it is not easy to understand and use. Through their interviews, they discovered that many teachers have had difficulty finding applicable resources on how to teach stormwater runoff. Many of these teachers do not have the time, knowledge, or resources to use the curricula they are finding. They need a curriculum that does not involve expensive supplies and is easy to understand. They also found that teachers are more likely to use a lesson plan if it is user-friendly and has clear objectives. They want to know what questions students should be able to answer after the lesson is over, so incorporating one goal per day and establishing essential vocabulary can be valuable. Also, is it very helpful to have a tutorial or walk through lesson so they know how to use the curriculum. A teacher's confidence in their knowledge on the material impacts how they teach. This is why the tutorial could be crucial. A fifth grade teacher has some flexibility in the amount

of time they spend on each topic. If they feel confident in their ability to lead a discussion, answer questions, and conduct activities then they are more likely to spend time on the topic. In sum, successful curricula are those that teachers find easy to use and are confident in.

Another finding that they stated in their report is that the curriculum must adhere to local standards. In regards to this finding, they created their curriculum to comply with the MS4 permit and the Massachusetts Science Technology and Engineering Curriculum Frameworks. Since the MS4 strives to spread stormwater awareness, there must be a way to prove that this curriculum is increasing awareness on stormwater dangers. To measure their success, the project team used pre and post tests to show improvements. This tactic displayed the effectiveness of their curriculum in regards to the MS4 permit, but it did not show the impact it would have on the students' performance on standardized tests. However, they found that teachers and schools are heavily influenced by standardized tests. Unfortunately, there are very few questions about stormwater asked on the Massachusetts Comprehensive Assessment System (MCAS). This discourages teachers from focusing on the subject in their science classes because they do not want to waste time on topics that are not on standardized tests. Teachers will be more inclined to use a curriculum that covers several topics, especially if some of the topics are covered on the MCAS.

The last finding that the group published is that education will not be effective if the students are not engaged. If students are not engaged, they will lose interest and the curriculum will not be successful even if it is incorporated into the teacher's lesson plans. The curriculum must provoke some emotion within them. The team discovered that student engagement can be measured by the amount of questions that are being asked, students taking notes, and students making eye contact with the instructor. An engaging lesson plan is vital to keep the attention and interest of a fifth grade class. These findings are based on the information given by elementary school teachers, so the project team made sure to keep these in mind while developing their curriculum.

Section Source: (Sakowich, C., Hull, M. E., Malafronte, S., & Nassar, V. A., 2018)

Chapter 3: Methodology

Mission Statement

The goal of this project was to spread awareness on the impacts of stormwater by supporting local fifth grade teachers with effective lesson plans and curricular resources. The following lists the objectives taken to achieve this goal:

Objective 1. Developed an understanding of current watershed curricula, awareness, and teaching methods used in Holden, Shrewsbury, Charlton, and Hopkinton.

Objective 2. Maximized the benefits of the 2018 Water Education team's curriculum along with incorporating the Think Blue Massachusetts Campaign.

Objective 3. Created a fifth grade curriculum with the help of outside resources

Objective 4. Shared valuable resources with teachers.

This project focused on making improvements to the 2018 Water Education team's project based on feedback and information obtained from the project school teachers as well as other outside sources. Local schools and teachers were interviewed to gain insight in order to implement a curriculum into their science classes for several years to come. The following chapter will further explain the steps taken to complete the mission.

3.1 Developed an Understanding of Current Watershed Curricula, Awareness, and Teaching Methods Used in Holden, Shrewsbury, Charlton, and Hopkinton.

In order to support the teachers, we first needed to gain an understanding on what stormwater curricula was currently being used at the interested school systems. This insight was obtained through interviews with teachers from the project schools. The interview plan that was used follows:

Our Interview Plan

Overview: Since information on the dangers of stormwater is knowledge that can be learned through extensive research, the information found through interviewing teachers was the most valuable for this project. The following interview process was used to interview the teachers at the project school in a professional manner.

Interview Process

The goal of interviewing was to gather information from the people of interest. The following steps were taken to help the interview process and make the interviewers (us) better prepared.

Principle Elements:

1. Read about interviewing
2. Conduct background research about sponsor and project
3. Prepare an interview plan
4. Conduct the interview
5. Write up an interview summary
6. Send thanks and copy of interview summary

Step 1: Interviewed teachers in Holden and Shrewsbury

In order to improve the current stormwater curricula used in these elementary schools, we first wanted to interview the fifth grade teachers in Holden and Shrewsbury. These school systems worked with the 2018 Water Education team and were already familiar with what this project was trying to do, so the feedback received from them was helpful in reshaping last year's curriculum. The two teachers that worked with last year's IQP Water Education team were from Dawson Elementary School in Holden, MA and Sherwood Middle School in Shrewsbury, MA.

Step 2: Revised the interview questions based off of our answers from the Holden and Shrewsbury schools, then interviewed Charlton and Hopkinton

Next, we revised the interview questions in order to interview teachers from Charlton and Hopkinton on what they wanted out of the curriculum. When interviewing these supporting school systems, our team asked specific questions in order to understand why stormwater was

not being incorporated into their lesson plans. These interviews were useful to receive answers on what needed to be done so that the curricula would be used in the classroom. These teachers did not have prior knowledge regarding last year's curriculum. This made their input helpful, but also made the interviews slightly harder to conduct. These new sets of interview questions were designed to find out the current understanding that these teachers had on stormwater and how we could incorporate it into lesson plans that they would use. Also, we sought to discover which lesson types, activities, and assessments these professionals felt were the most effective in fifth grade classrooms. The teachers that were interviewed were from Hopkins Elementary School in Hopkinton, MA and Charlton Middle School in Charlton, MA. After these interviews were conducted, interview summaries were composed to gather the most important information from each teacher.

Fifth grade teachers of Holden, Shrewsbury, Charlton, and Hopkinton

Teachers from different school districts may have different standards and requirements that they have to meet, which causes them to refrain from teaching stormwater curriculums. The interviewed teachers gave critical insight on their best teaching methods and the materials they had available in the classroom. This allowed for us to design the final curriculum to meet the criteria of the table below.

Table 1: Design Criteria for Curriculum. Categories and Content to Consider for Interviewing Teachers When Designing Curriculum.

Category	Questions
Accessibility	<ul style="list-style-type: none"> ● Do teachers know where and how to easily find it? ● Do many teachers in several different schools know about it? ● Is there something like a website or presentation that the teachers have access to that explains the curriculum?
Usability	<ul style="list-style-type: none"> ● Do the teachers feel confident enough in the subject matter to lead a discussion? ● Do the teachers have a strong understanding of how to conduct the lessons/activities? ● Do the teachers feel that the topics and lessons covered in the curriculum are important enough to be used in their classes?
Engagement	<ul style="list-style-type: none"> ● Are the students asking questions throughout the lessons/activities? ● Are the students making eye contact with the instructor? ● Are the students taking notes as they are learning new information? ● Do the students seem to be excited about and enjoying the activities?
Feasibility	<ul style="list-style-type: none"> ● Is the curriculum concise enough so that the teachers have enough time throughout their year/class period to use it? ● Do the teachers have the resources to conduct the lessons/activities? ● Are the resources that are necessary for certain activities inexpensive?
Applicable	<ul style="list-style-type: none"> ● Does the curriculum relate to other topics the students are learning about in class? ● Does the curriculum relate to some topics more heavily covered in the MCAS? ● Are the lessons and assessments challenging, yet realistic for a fifth grade classroom?
Success	<ul style="list-style-type: none"> ● Do the students understand and enjoy the curriculum? ● Do the students perform well on the assessments? ● Does the curriculum spread awareness on stormwater dangers to teachers, students, and parents?

Step 3: Re-Group with Sponsors: Fine Tune Final Product Aspirations

After gaining a better understanding of what was needed to produce the curriculum, we also needed to know if this is what the sponsors were looking for. This was important in contemplating our approach to developing the curriculum and how the sponsors wanted it to be presented. This step was the start of our final production. We met with our sponsors, as well as teachers, to know exactly what they wanted us to do to incorporate the curriculum into schools in the central Massachusetts area.

Step 5: Reach Out to WPI K-12 STEM Representatives to Make Curriculum

Lastly, our team was in contact with the on-campus K-12 STEM representatives to figure out how to create the curriculum while also complying with the Next Generation Science Standards. Our team was in contact with one member of the K-12 STEM program who helped us decide on what NGSS would be best to use for the curriculum.

3.2 Maximized the Benefits of the 2018 Water Education Team's Curriculum Along With Incorporating the Think Blue Massachusetts Campaign

A major aspect of the project was working to build off of the 2018 Water Education team's curriculum. Our sponsors were pleased with last year's curriculum and wanted us to build off of it without having to make a whole new curriculum.

Step 1: Built off of the 2018 Water Education team's curriculum

The 2019 Water Education team's was tasked with assessing the 2018 Water Education team's curriculum and discovering ways to improve on it, along with spreading the Think Blue Campaign. Feedback was received throughout the interviews conducted in Objective 1 to discover what aspects of the curriculum were successful, engaging, and applicable to the Holden and Shrewsbury fifth grade classes. These lessons and/or activities were then incorporated into this year's curriculum. We worked to improve the elements of the curriculum that did not seem to attract positive feedback from the teachers. We were able to reuse a significant amount of last year's curriculum into this year's project. Then, we were able to focus more time on

implementing it into local schools rather than having to develop the curriculum for all seven weeks.

3.3 Created a Fifth Grade Curriculum With the Help of Outside Resources

The next objective was to discover and research already existing and successful stormwater curricula outside of the school districts that we were working with. Creating a curriculum is a difficult process which is why finding pre-existing lessons and activities was helpful when trying to improve on last year's project. Our project utilizes valuable pieces from existing curricula while also meeting the sponsors' requests of what to incorporate. This was done by researching current stormwater curricula, talking to the sponsors, and talking to outside sources who have had experience with designing lesson plans for youth classrooms.

Step 1: Researched and built off of other curricula in place

Once there was a good understanding of what the 2018 Water Education team did in their lesson plans, other curricula and organizations that were aimed toward stormwater education were researched and used for reference. The Think Blue Massachusetts Campaign was one of the main stormwater educational resources that was utilized. This campaign provided ideas and tactics on how to educate people on the dangers of stormwater. Their rubber ducks were used to spread awareness at local events like the Sherwood sixth grade community meeting and Charlton's Earth day. After incorporating Think Blue, it was made sure that the curriculum followed the Next Generation Science Standards.

Next, available stormwater curricula which was used in other parts of the state were analyzed for valuable information. The curricula that were previously designed and researched by the team were from the MWRA, the Westford Living Lab, and The Boston Water and Sewer Commission. The Boston Water and Sewer Commission Fifth Grade Curriculum was an actual curriculum that was implemented into five different schools in the Boston area. Curricula such as this was extremely helpful to the development of our final product. We conducted interviews with a member of each one of these groups to get ideas for how they designed their lessons, why they designed them, and how they spread them after they were designed.

Step 2: Began developing the curriculum

Once information was gained on the current curricula used in the surrounding school districts, last year's curriculum, and stormwater curricula outside of the surrounding schools, the curriculum for this year's project was developed. The curriculum was designed based off of the feedback received on last year's project and the information gained from interviews and observations. Improvements were made in the areas of last year's final product that did not seem to be successful or feasible, while adding whatever we thought was necessary to make it successful and sustainable. This led to creating a curriculum based on be three main sections:

- Educational videos
- Educational hands-on activities
- Assessments to evaluate its success

3.4 Shared Valuable Resources with the Teachers.

After completing the first three objectives and finalizing the curriculum, the final objective of the project was to share the lesson plans and valuable resources with the teachers. One of the most important aspects of the project is to ensure that teachers and schools will reuse these lessons in future years. It will be vital to develop products and methods that make the lessons and activities readily available and easy to use for the teachers for years to come. In order to do this, we presented our resources and curriculum to the teachers at the supporting school districts. We went to a POD day at Sherwood Middle School in Shrewsbury, MA, as well as a community day at the school. We also presented some activities at Charlton's Earth day. The curriculum was sent to all of the teachers that worked with this year's project team, along with a few others.

Step 1: Make the curriculum easy and accessible

The first step of this objective was to develop resources that will make the curriculum accessible and easy to use for the teachers. Some of the resources that were used for making the curriculum more convenient for teachers to use long-term include:

- Videos (to teach the teachers and the students) that explain the dangers of stormwater and how these dangers can be reduced
- Videos on how to conduct different educational activities on stormwater and the water cycle
- Vocabulary
- The use of Five Science Standards under the Next Generation Science Standards
- Clear Instructions and steps

Possible Step 3: Expand the product

Finally, the ultimate goal is to not only get this curriculum incorporated into fifth grade classrooms in the interested school districts, but for it to expand further than that. If the curriculum successfully satisfies the six dimensions given in Table 1 (Located in Section 3.1), the fifth grade teachers may spread the word of certain activities and lessons to teachers of other grades and other school districts. Elementary school teachers are constantly sharing resources and lesson plans, so if this project continues to be successful, it could hopefully be spread to different school districts throughout the state. We are hopeful that our final product, with the help of our sponsors, can assist the Think Blue campaign by spreading stormwater awareness to elementary school students throughout the state for many years to come.

Chapter 4: Findings

The findings in this section are based off of teacher interviews, extensive research, and conducting field studies with students as well as teachers. Through interviews, we received feedback about the curriculum that the 2018 Water Education IQP team put together and about each teacher's understanding of stormwater in general. Last year's IQP team did great work, however, their curriculum did not stick in the two classrooms that they implemented it into. Creating a curriculum that would likely be used over and over again by teachers became the driving factor for our work. Based on the interviews and data collected, there are five major findings that were developed. These findings will be helpful towards the curriculum spread amongst teachers and sticking in the classrooms it has already been implemented into for years to come. Summary write-ups for the interviews about what the teachers liked and disliked about last year's curriculum as well as other findings based off of these interviews can be found in Appendix C.

Finding 1: Hands on activities are key for keeping fifth grade students excited and engaged.

The most common finding that was discovered from speaking with the teachers at the project schools is that hands-on activities are a must. While some of the elementary schools that were worked with do not have science class every day, it is important that the students stay engaged with the lessons when they do have science. In elementary schools, science takes a back seat to other subjects like math and language arts which makes it harder for teachers to always find ways to keep their students engaged during science. The best way to keep the students engaged and excited about learning is through hands-on activities and making the lessons relative to local locations that the students recognize and can relate to. This is their last time to enjoy school in an elementary school setting.

Finding 2: Condense last year's curriculum and hit more Next Generation Science Standards to make it more appealing for teachers to use.

Finding two relates to improving on last year's Water Education curriculum by shortening the amount of lesson plans while using the same amount of Next Generation Science Standards.

The teachers that worked with last year's project team were pleased with the outcome of the curriculum, however, they did not reuse the whole thing. Both teachers said that they reused the first six lessons, but the last four were dry and could have been condensed into fewer lessons. We combined some last year's lessons along with developing a few new lessons to ultimately create a five-lesson unit, with a sixth lesson being a "lab day" made up of three activities that can be used within other lessons. This newly created watershed curriculum hits on five Next Generation Science Standards; the same amount of standards that the group last year had, but in fewer lessons.

Finding 3: The Massachusetts Comprehensive Assessment System does not ask enough questions on the water cycle or stormwater for teachers to put a large emphasis on it.

Over the span of 2009-2017, standardized testing in Massachusetts elementary schools has seen a total of ten questions asked on the water cycle and zero questions asked in regards to stormwater (Sakowich, C., Hull, M. E., Malafronte, S., & Nassar, V. A., 2018). Due to the lack of testing on these subjects, teachers refrain from teaching about them. During all of the interviews the teachers told us the same thing; stormwater is not taught on the MCAS. Teachers want to teach to their students the topics that they know will be covered on the MCAS at the end of the year. It was of extreme importance to make sure that each lesson that was created hit on at least one Next Generation Science Standards. Even if the lessons hit on Next Generation Science Standards we cannot be sure that the teachers will reuse the lessons until the Department of Education stresses the importance of the water cycle and stormwater on its standardized testing.

Finding 4: Teachers enjoy guest speakers, but there is a lack of communication between Town Engineers and Teachers.

Every teacher that the team met with explained how they enjoy having guest speakers come in to talk to and teach their class. The teachers said that regardless who the guest speaker is that comes in to visit, the students show they are more engaged than when just learning from their regular teacher. We thought it would be a great idea to get town engineers into classrooms to teach some of the lesson plans for when after IQP is over. The problem is that these town

engineers and teachers do not know how to contact each other and there is a lack of communication between them. The town engineer would gain outreach points to fulfil the first requirement under the MS4 permit and the teacher would get a guest speaker that would help her students learn without having to teach them! It is critical to find ways to get these “Champions” in better contact with one another.

Finding 5: Teachers prefer spreading the curriculum by word of mouth.

After completing the curriculum all that can be done now is to spread it. The best way to do this, we have found, is through teacher to teacher connections by spreading the curriculum by word of mouth. We have learned that trying to contact the Department of Education for help in spreading it will either take years to do or will end in no help at all. We also learned from interviews that trying to approach the superintendent of a school district and working down into the school to implement the curriculum also does not work. The most efficient way to spread curriculum is by spreading it from teacher to teacher and hoping that it is good enough for teachers to want to reuse and spread to other teachers.

Chapter 5: Recommendations

Recommendation 1: Increase awareness on stormwater by spreading our curriculum to teachers and giving presentations in informal educational settings.

Share this curriculum with teachers at the project schools and encourage them to spread it to their colleagues. Sell them on the fact that it hits on five Next Generation Science Standards and covers many topics that are covered in fifth grade science topics. It also covers other subjects like reading, writing, math, and critical thinking. There are also many hands-on activities that will keep the students engaged.

The curriculum was developed to be used in fifth grade science classrooms, but many activities and lessons can be used with kids of all ages in different environments. These activities can be piloted at informal educational settings. For example, our group presented and conducted one of the activities from our curriculum at the Ecotarium during Earth week in front of several kids of all ages. We also hosted a table at the Charlton Earth Day where kids performed hands-on activities from our curriculum. Events such as Earth Days, summer camps, curriculum conventions, and Ecotarium days are opportunities to spread the curriculum and awareness to students of all ages and to teachers. This curriculum was developed to be spread throughout classrooms and school districts, but it should also be shared in other settings to spread awareness about stormwater.

Recommendation 2: Send out requests to be a part of professional development days months in advance.

From our interviews, the process to get into a professional development day starts earlier in the year by asking for availability. In order for it to be valuable to teachers, the session must be long enough to count towards the required education credits that teachers must complete (For example, ten hours is one point). If this is not possible, then we recommend partnering with the WPI K-12 STEM club as they hold informal professional development days once a month. From what we have learned from our POD day at Sherwood Middle School, their professional development days happen every other month and they happen within their school district. A professional development day presentation should be able to hold 3-6 hours of content.

Contacting the Massachusetts Association of Science Teachers (MAST) is also recommended, as they have a national conference on science education in Boston on April 2-5, 2020. This would be a great place to disseminate this curriculum that was developed.

Recommendation 3: Identify school system “Champions” and town “Champions” -and develop a convenient method of communication between them.

A common theme that was discussed throughout the teacher interviews was that teachers love having guest speakers during their classes. Guest speakers increase the students’ level of attention because a new voice and face naturally causes the students to be more intrigued. Also, teachers enjoy bringing in experts on certain subject matters because the experts probably have more information and a different point of view on the topic. On the other hand, our sponsors informed us that town engineers and members of the MassDEP want to go into schools and educate the youth about environmental science topics, such as stormwater. A major reason why this does not occur often is teachers do not realize that they have this resource, and town engineers do not know whom to contact within the school systems. Often times, town engineers will reach out to a superintendent or principal, but do not have success with getting into classrooms because these people are too busy with other tasks. Identifying a teacher or curriculum coordinator within the schools who can make decisions on what occurs in science classrooms or are very passionate about environmental issues will be essential to getting town engineers into classrooms. We decided to call these teachers and the town engineers who are willing to go into classrooms the “Champions”. Identifying these “Champions” and giving them a convenient method of communication is vital to spreading awareness on the impacts of stormwater. Our team created a database that contained the information of the town engineer “Champions” and the school teacher “Champions” in the towns we worked with. This database was shared with the CMRSWC and the teachers to be expanded on so that the “Champions” have each other’s contact information. Teachers want guest speakers, and town engineers want to educate the youth on environmental issues, so creating convenient communication methods between the identified “Champions” is essential to spreading awareness.

Recommendation 4: The coalition should create an email group alias where people can easily be added or deleted to help contact between “Champions”

As it is understood that there is turnover in the professional industry, it is recommended in making a group alias (group email) with all of the town engineer champions included in it. This could be done through the CMRSWC and all of the town champions can address the situation if a teacher is looking for someone to talk in their classroom. This is recommended because, as mentioned above, teachers would love to have a guest speaker come in and talk to their class, but do not know whom to contact from their town. With making a group email, the teachers would be able to email a singular email address where it is sent to all of the town engineers in the CMRSWC area. This will allow Town Engineers to receive the email and decide amongst themselves as to who will be going in and presenting to the teachers. The curriculum could be used as an activity for town engineers to take into the classroom.

Recommendation 5: Partner with the Massachusetts Department of Education in order to incorporate questions regarding to stormwater in the MCAS.

It is clear that there is a stormwater issue in the United States and that public education is needed. In order for the 5th Grade Watershed Unit to have the biggest impact, the state of Massachusetts needs to incorporate more questions about stormwater in the Massachusetts Comprehensive Assessment Systems (MCAS). The science MCAS is tested in the fifth grade and covers material from grades three through five. On the MCAS from 2009 through 2017, only 6% of the total questions were related to the water cycle with zero of those relating to stormwater. If only 6% of the questions relate to the water cycle, there is clearly no push for stormwater making a presence on the MCAS. We recommend the MassDEP and the CMRSWC to partner with the Massachusetts DOE to critique the standardized tests and put a larger emphasis on the water cycle and stormwater.

Chapter 6: Outcomes

The outcome for this project is the 5th Grade Watershed Unit curriculum. This curriculum includes a series of lessons and hands-on activities that aim to engage the students while informing them on the water cycle, pollution's effects on stormwater, and methods to reduce these effects. The curriculum begins with a hands on activity that teaches the students on the lack of available freshwater in the world. Then, there is a lesson and poster activity on the water cycle and how stormwater runoff is incorporated into this process. Next, there is a fun lesson that illustrates how certain human activities can cause pollution which can harm the quality of water. This activity leads into a lesson which teaches the students on the difference between impervious and porous surfaces. The last lesson introduces several stormwater management practices which help reduce pollution's effects on water quality. The sixth section contains three hands-on activities which can be used as a final "lab" day or can be incorporated into earlier lessons as they are taught. We recommend starting with the first two lesson, while the rest can be taught individually or out of order.

This curriculum includes hands-on activities to ensure that the students are engaged and enjoying their learning experience. However, some reading, writing, and math skills were also incorporated. The lessons were made to hit on five of the Massachusetts and Next Generation Science Standards so that they comply with state regulations. The goal of this curriculum is to inform the students on water education and pollution's effects on stormwater.

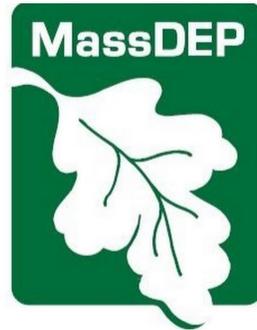
Appendix A:

5th Grade

Watershed Unit



CENTRAL
MASSACHUSETTS
REGIONAL
STORMWATER
COALITION



5th Grade Watershed Unit

Welcome to WPI's fifth grade Watershed Science Curriculum! This curriculum includes a series of lessons and hands-on activities that aim to engage the students while informing them on the water cycle, pollution's effects on stormwater, and methods to reduce these effects. The curriculum begins with a hands on activity that teaches the students on the lack of available freshwater in the world. Then, there is a lesson and poster activity on the water cycle and how stormwater runoff is incorporated into this process. Next, there is a fun lesson that illustrates how certain human activities can cause pollution which can harm the quality of water. This activity leads into a lesson which teaches the students on the difference between impervious and porous surfaces. The last lesson introduces several stormwater management practices which help reduce pollution's effects on water quality. The sixth section contains three hands-on activities which can be used as a final "lab" day or can be incorporated into earlier lessons as they are taught. We recommend starting with the first two lesson, while the rest can be taught individually or out of order.

This curriculum includes hands-on activities to ensure that the students are engaged and enjoying their learning experience. However, some reading, writing, and math skills were also incorporated. The lessons were made to hit on five of the Massachusetts and Next Generation Science Standards so that they comply with state regulations. The goal of this curriculum is to inform the students on water education and pollution's effects on stormwater. We hope that you enjoy this learning experience as much as the students!

	Chapter	Topic	Standards Met	Key Phrases	Goal of the Lesson
Lesson 1	The Water Cycle	The Importance of Freshwater	5-ESS2-2	Saltwater, Freshwater, Frozen Freshwater, Groundwater, Underground Wells, Desalination, Pollution	Show students the limited amount freshwater available for Earth's animals, plants, and 7.7 billion people. **Describe the importance of keeping limited freshwater pollutant free**
Lesson 2	The Water Cycle	Evaporation, Condensation, Precipitation, and Stormwater Runoff	5-ESS2-1	Water Cycle, Hydrosphere, Precipitation, Condensation, Evaporation, Stormwater Runoff, Geosphere, Atmosphere, Biosphere	Students will be able to know the differences between precipitation, condensation, and evaporation while also learning about the importance of runoff in the Water Cycle.
Lesson 3	Watershed	Pollution's Effect on Water	5-ESS2-1	Groundwater, Runoff, Watershed, Pollutant, Non-Point Source Pollution, Point Source Pollution	Students will identify different pollutants and understand how they negatively affect human life and water quality.
Lesson 4	Stormwater Runoff	Impervious Vs. Pervious Surfaces Through the Use of GIS / Google Maps	5-ESS3-1	Stormwater Runoff, Best Management Practice, Urban Environment, Rural Environment, Impervious Surfaces, Pervious Surfaces, Rain Barrel, Rain Garden, Green Roof	Students will understand and model the difference between pervious and impervious surfaces in an urban and rural environment.
Lesson 5	Stormwater Runoff	Best Management Practices (BMPs)	5-ESS3-1 5.3-5-ETS3-2	Stormwater Runoff, Best Management Practice, Urban Environment, Rural Environment, Impervious Surfaces, Pervious Surfaces, Rain Barrel, Rain Garden, Green Roof	Students will understand what best management practices are and how they can naturally filter water. Then, they will engineer a BMP model to incorporate into a scenario and use scientific writing to back their reasoning for their design.
Lesson 6	Watershed/ Stormwater Runoff	Lab Day: Enviroscope, Impervious Vs. Pervious Surfaces, Water Filtration	5-ESS3-2	Hydrosphere, Precipitation, Condensation, Evaporation, Groundwater, Runoff, Geosphere, Atmosphere, Biosphere	Show students the limited amount freshwater available for Earth's 6.8 billion people, animals, and plants so they understand the importance of keeping our water bodies pollutant free.

Massachusetts 2016 Standards Addressed:

5-ESS2-1: Use a model to describe the cycling of water throughout a watershed through evaporation, precipitation, absorption, surface runoff, and condensation.

5-ESS2-2: Describe and graph the relative amounts of salt water in the ocean; freshwater in lakes, rivers, and groundwater; and fresh water frozen in glaciers and polar ice caps to provide evidence about the availability of fresh water in Earth's biosphere.

5-ESS3-1: Obtain and combine information about ways communities reduce human impact on the Earth's resources and environment by changing an agricultural, industrial, or community practice or process.

5-ESS3-2 (MA): Test a simple system designed to filter particulates out of water and propose one change to the design to improve it.

5.3-5-ETS3-2 (MA): Use sketches or drawings to show how each part of a product or device relates to other parts in the product or device.

Grade 5 Unit Goals:

1. Students will be able to explain the process of the water cycle.
2. Students will be able to model the process in which pollutants reach bodies of water and how it impacts the water cycle / environment.
3. Students will be able to use maps and sketches to identify local watersheds and the bodies of water they flow to.
4. Students will be able to identify different materials and their effect on stormwater runoff.
5. Students will be able to identify different designs that help protect Earth's resources and the environment.

Lesson	Chapter	Topic	Unit Goal	MA Standard
1	The Water Cycle	The Importance of Freshwater	1	5-ESS2-2
2	The Water Cycle: with Strong Importance on Stormwater Runoff	Evaporation, Condensation, Precipitation, and Stormwater Runoff	1 and 2	5-ESS2-1
3	Watershed	Pollution's Effect on Water	2 and 4	5-ESS2-1
4	Stormwater Runoff	Impervious Vs. Porous Surfaces Through the Use of GIS / Google Maps	3	5-ESS3-1 5.3-5-ETS3-2
5	Stormwater Runoff	Best Management Practices (BMPs)	5	5-ESS3-1 5.3-5-ETS3-2
6	Watershed / Stormwater Runoff	Lab Day: Enviroscape, Impervious Vs. Porous Surfaces	2 and 4	5-ESS3-2

Lesson 1: Amount of Freshwater in the World

Introduction

Chapter	The Water Cycle	Day 1	Grade Level: 5
Title of Topic	The Importance of Freshwater	Time: 40-50 minutes	
Desired Outcome from Lesson: Students will realize how limited clean, freshwater is and will understand why it is important to protect our bodies of water.			
Topic of Lesson: Earth's water is 97.5% salt water and only 2.5% freshwater. Of Earth's freshwater, only 1% is easily accessible from rivers, lakes, etc. This lesson will give students a visual representation of the lack of available freshwater.			
Goals of the Day: Show students the limited amount freshwater available for Earth's animals, plants, and 7.7 billion people. **Describe the importance of keeping limited freshwater pollutant free**			
Essential Vocabulary:			
<ul style="list-style-type: none"> ● <i>Saltwater</i>- Water (as of the ocean) that naturally contains a significant amount of salt. ● <i>Freshwater</i>- Bogs, ponds, lakes, rivers, streams, and any other bodies of water bodies that consist of water not containing salt. ● <i>Frozen Freshwater</i>- Freshwater that is not easily accessible due to being frozen in glaciers and ice caps. (Water locked up in ice and snow) ● <i>Groundwater</i>- Water that moves down into the ground (due to gravity) passing between particles of soil, sand, gravel, or rock until it reaches a depth where the ground is filled, or saturated, with water. 			
Extended Vocabulary:			
<ul style="list-style-type: none"> ● <i>Underground wells</i>- A structure created in the ground by digging, driving, or drilling to access liquid, like water. ● <i>Desalination</i>- A process that takes away salt and mineral components from saltwater. ● <i>Pollution</i>- The presence of a substance or thing that has harmful or poisonous effects in the environment. 			

Teacher Guideline

Overview:

- 97.5% of Earth's water is saltwater.
- 2.5% of Earth's water is freshwater.
 - Of that freshwater, about 69% is frozen
 - About 30% is groundwater
 - About 1% is other freshwater

Note to Educator:

This lesson is a hands-on activity and gives a visual representation to students on the lack of easily accessible freshwater.

Materials:

- 2 liter bottle
- Four other containers that can hold water
 - One of them should be able to hold 2 liters of liquid
 - The other three can be less than 2 liters
- At least one graduated cylinder (in milliliters)
 - Or any liquid measuring tool that has milliliter increments
- Large board/paper (for bar graph)
- Water
- Salt (optional)
- A cover for one of the containers (optional)
- A freezer (optional)



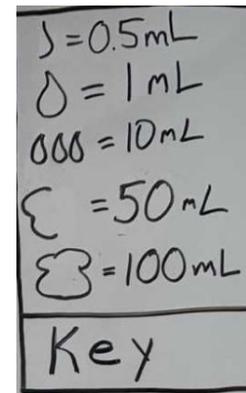
Instructions:

1. Split up the class into 4 groups.
2. Fill the 2 liter bottle with water.
3. Explain to the class that this bottle represents all the water in the world.
4. Assign each group one category of water: Saltwater, Frozen Freshwater, Groundwater, and Other Freshwater (you can wait to tell the groups which category they are until after the exercise if wanted).
5. Give each group one container that can hold water.

- a. The salt water group needs the biggest container.
6. Give each group the 2 liter bottle and the graduated cylinder. Then, have them measure their respective amount of water out of the 2 liter bottle to put in their container. (have the salt water group go last)
 - a. Frozen freshwater (glaciers and ice caps) = 34.5 mL
 - b. Groundwater = 15 mL
 - c. Other freshwater (bogs, ponds, lakes, rivers, streams, swamps, etc.) = 0.5 mL
 - d. Salt water = the rest of the water (or 1950 mL)
7. Explain that the container with 0.5 mL of water is proportional to the amount of easily available freshwater in the world.
8. Then, create a graph on a large piece of paper or on the board.
9. Have the students label the x-axis for the four different categories of water.
10. Then create a key next to the graph which depicts:



- a. Half of a droplet = 0.5 mL
- b. One water droplet = 1 mL
- c. Three connected water droplets = 10 mL
- d. Half of a body of water = 50 mL
- e. A body of water = 100 mL



(See pictures of what the key [right] and final bar graph [below] should look like)

11. Call students from each group up to the board to complete the graph.

Extra Steps Part 1:

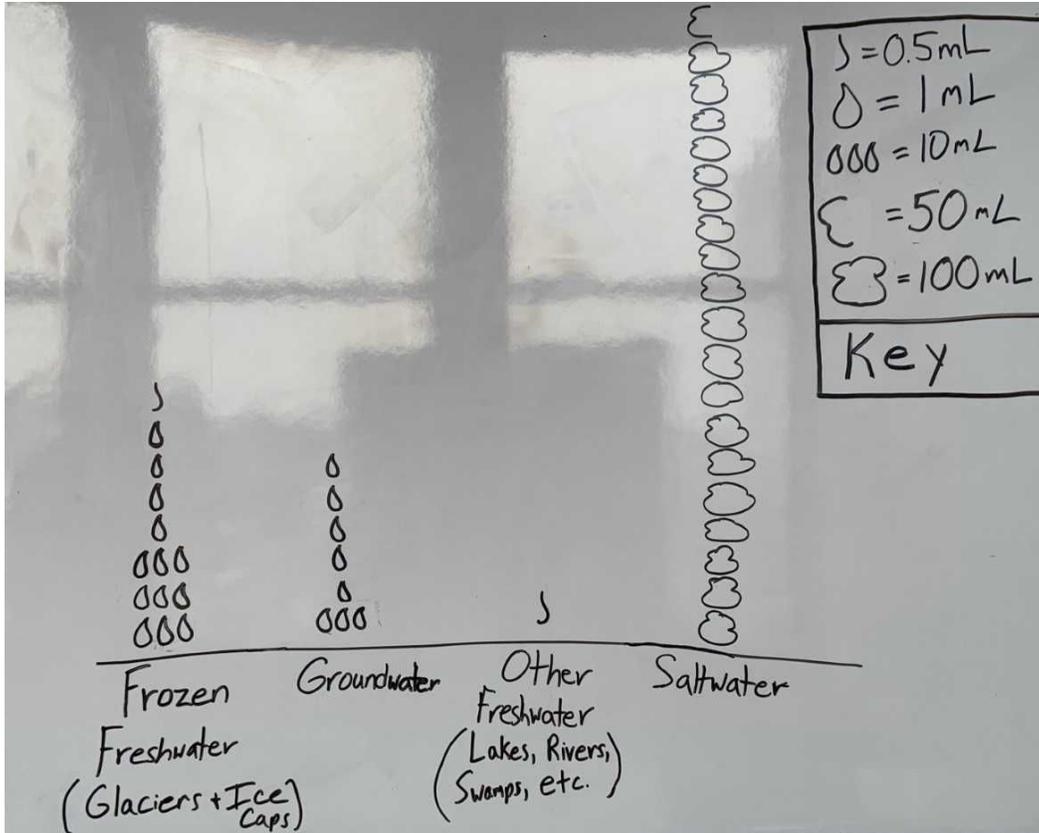
12. If wanted, add salt to the salt water container, put the cover over the groundwater container, and put the frozen freshwater in the freezer. Tell the students that the remaining open container is proportional to the amount of easily available freshwater in the world. They will see that it is impossible to share this water throughout the class.
13. Have the students then take time to discuss with their groups as to how they would ration the amount of freshwater between humans, animals, and plants. Each group should write down responses on a piece of paper.
14. After 5 minutes / end of student discussion, ask each group how they would ration freshwater and see what they think about the lack of fresh water in the world.
15. Possible option- give background about how much water they use in a day.

Extra Step Part 2

1. Add food coloring to the water to show pollution effects. Put an emphasis on the lack of freshwater and what fewer drops of food coloring to the “other freshwater” container does to the water. The scarcity of water should make for fewer droplets of food coloring to make the water darker than in the other containers.

Exit Ticket

1. Why is it important to keep pollutants out of our freshwater?
 - a. There is very limited available freshwater so we must keep it clean.
2. What are some ways that you and your family can conserve freshwater?
 - a. Possible answers: Fix leaking faucets, take quicker showers, turn off the faucet when brushing your teeth, do not waste half full water bottles, etc.
3. Can you think of some ways that humans can make saltwater, groundwater, and frozen freshwater available for human use?
 - a. Possible answers: underground wells, desalination methods, etc.



Example of the Graph Explained in Part 1

Information from: <https://water.usgs.gov/edu/earthwherewater.html>

Lesson 2: The Water Cycle Poster Contest

Introduction

Chapter	The Water Cycle	Day 2	Grade Level: 5
Title of Topic	Evaporation, Condensation, Precipitation, and Stormwater Runoff	Time: 40-50 minutes	
Desired Outcome from Lesson: Students will be able to explain the process of the Water Cycle.			
Topic of Lesson: The water cycle is the process which water circulates between the Earth's oceans, atmosphere, and land. This cycle is made of stages such as precipitation, condensation, transpiration, and evaporation.			
Goals of the Day: Students will be able to know the differences between precipitation, condensation, and evaporation while also learning about the importance of runoff in the Water Cycle.			
Essential Vocabulary:			
<ul style="list-style-type: none"> ● <i>Water Cycle</i>- The natural sequence through which water passes into the atmosphere as water vapor, precipitates to Earth in a liquid or solid form, and ultimately returns to the atmosphere through evaporation. ● <i>Hydrosphere</i>- All the waters on the Earth's surface, such as lakes and seas, and sometimes including water over the Earth's surface, such as clouds. ● <i>Precipitation</i>- Rain, snow, sleet, or hail falling from the clouds. ● <i>Condensation</i>- Cooled water vapor (gas) that has turned into droplets of liquid. (Clouds are made up of water vapor, dust, and cool air.) ● <i>Evaporation</i>- The process in which liquid water becomes water vapor. ● <i>Stormwater Runoff</i>- Generated from rain and snowmelt events that flow over land or impervious surfaces, such as paved streets, parking lots, and building rooftops, and does not soak into the ground. 			
Extended Vocabulary:			
<ul style="list-style-type: none"> ● <i>Atmosphere</i>- The envelope of gases surrounding the Earth or another planet. ● <i>Biosphere</i>- The regions of the surface, atmosphere, and hydrosphere of the Earth (or analogous parts of other planets) occupied by living organisms. 			

Teacher Guideline

Overview:

This lesson plan connects stormwater to the water cycle. Usually, only “runoff” is mentioned when teaching the water cycle but we believe stormwater also should be incorporated.

Note to Educator:

This lesson plan is a complementary to the first lesson plan. This covers the Next Generation Science Standards and is also interactive activity.

Materials:

- Chalk Board
- Markers/Pens/Pencils
- 11x17 paper (or bigger)

Instructions:

Part 1:

1. Students split into groups, each group consisting of 3-5 students.
2. Initially, have the students take 5 minutes and write down all of the ways they use water. After some time has elapsed, have students raise their hand to compile the ideas on the board.
3. Have the students discuss with their groups if the water on Earth today is the same water dinosaurs used.
 - Answer: Yes, it is because water is a constant cycle.
4. Next, show the students this ~4 minute YouTube video called “The Water Cycle | Educational Video for Kids” which explains three stages of stormwater:
<https://www.youtube.com/watch?v=y5gFI3pMvol>
5. Then, show the students this ~2 minute YouTube video called “Stormwater Animation” on stormwater runoff: <https://www.youtube.com/watch?v=DYGDY3GYYyI>
6. Have a class discussion on how stormwater runoff relates to the three stages of the water cycle in the first video.

7. Now, let's do a scenario on the board. Have a student come up and draw a body of water. Start explaining that it is a warm summer day, and ask the class what is happening to the water? The student at the board can "Phone a Friend" if they do not know the answer.
8. Have another student come up and draw a cloud above the body of water, and have them answer how this happened. This can be a group collaboration to get to the answer.
9. Now have students explain what happens when a lot of condensation occurs and the water becomes "heavy". Have the next student explain and draw precipitation.
10. Finally, have a student come up to draw and explain how the stormwater returns to the body of water. Throughout this whole board exercise, make sure the students are writing the words "Evaporation, Condensation, Precipitation, and Stormwater Runoff" on the board so they can visualize what is occurring.

Part 2: (Possible homework if not enough time in class)

Next, pass out a blank piece of paper to every student (11x17 or bigger). Have the students make posters illustrating the stages of the water cycle. Be sure that they have a strong understanding of the four stages of the water cycle so they can incorporate it in their posters. The posters should include: evaporation, condensation, precipitation, and "stormwater" runoff. A possible grading rubric is below. The vocabulary list below can be handed out to students to help them with their poster.

Grading Rubric

4	3	2	1
Model is accurate and explains what is happening. Accurate descriptions of definitions are present.	Model is accurate, labeled and includes most of the major elements.	Model has some inaccuracies or is missing some major elements.	Model is inaccurate or is missing many major elements

Student Instructions

Water Cycle Poster

You will be creating a poster describing the water cycle. Create a drawing of the water cycle in pencil first and check with the teacher before moving forward. Once you have been checked off by the teacher, you can use colored pencils and markers to finish the poster and make it look colorful.

What to include:

- _____ Title (1pt)
- _____ Your Name (1pt)
- _____ Draw and label the Sun (1pt)
- _____ Draw, label and define Evaporation (2pt)
- _____ Draw, label and define Condensation (2pt)
- _____ Draw, label and define Precipitation (2pt)
- _____ Draw, label, and define Stormwater Runoff (Surface Runoff) (2pt)
- _____ Draw and label Collection/Accumulation (2pt)
- _____ Draw and label Transpiration (1pt)
- _____ Draw and label Groundwater (1pt)
- _____ Draw and label Aquifer (1pt)
- _____ Effort and Neatness (1pt)

16-17 points = 4	15 points = 3.5	13-14 = 3
11-12 points = 2.5	9-10 points = 2	0-8 points = 1

Vocabulary

Water Cycle: The natural sequence through which water passes into the atmosphere as water vapor, precipitates to Earth in liquid or solid form, and ultimately returns to the atmosphere through evaporation

Evaporation: The process in which liquid water becomes water vapor.

Condensation: Cooled water vapor (gas) that has turned into droplets of liquid. (Clouds are made up of water vapor, dust, and cool air.)

Precipitation: rain, sleet, snow, or hail falling from the clouds

Accumulation/Collection: the process in which water pools in large bodies (like oceans, seas, and lakes).

Stormwater Runoff: generated from rain and snowmelt events that flow over land or impervious surfaces, such as paved streets, parking lots, and building rooftops, and does not soak into the ground.

Transpiration: the process in which some water within plants evaporates into the atmosphere through its leaves.

Groundwater: Water that moves down into the ground (due to gravity) passing between particles of soil, sand, gravel, or rock until it reaches a depth where the ground is filled, or saturated, with water.

Aquifer: A collection of groundwater.

Extra Vocabulary to Use if Wanted

Water Vapor: Water in the form of a gas

Dew Point: the point at which water vapor turns back into a liquid

Humidity: the amount of water vapor in the air

Lesson 3: Pollution's Effects on Water

Introduction

Chapter	Watershed	Day 3	Grade Level: 5
Title of Topic	Pollution's Effect on Water	Time: 40-50 minutes	
Desired Outcome from Lesson: Students will be able to model the process in which pollutants reach bodies of water and how it impacts the water cycle/ environment.			
Topic of Lesson: There are many ways pollutants can enter bodies of water, the soil, and the air. Students will learn the dangers human life can cause the watershed and why it is important to minimize pollution.			
Goals of the Day: Students will identify different pollutants and understand how they negatively affect human life and water quality.			
Essential Vocabulary:			
<ul style="list-style-type: none"> ● <i>Groundwater</i>- Water that moves down into the ground (due to gravity) passing between particles of soil, sand, gravel, or rock until it reaches a depth where the ground is filled, or saturated, with water. ● <i>Stormwater Runoff</i>- Generated from rain and snowmelt events that flow over land or impervious surfaces, such as paved streets, parking lots, and building rooftops, and does not soak into the ground. ● <i>Watershed</i>- An area or ridge of land that separates waters flowing to different rivers, basins, or seas. ● <i>Pollutant</i>- A substance that causes harm to the environment, especially water or the atmosphere. 			
Extended Vocabulary:			
<ul style="list-style-type: none"> ● <i>Non-point source pollution</i>- Caused when rainfall or snowmelt, moving over and through the ground, picks up and carries natural and human-made pollutants, depositing them into lakes, rivers, wetlands, coastal waters and ground waters. ● <i>Point source pollution</i>- Any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch, ship or factory smokestack. 			

Teacher Guideline

Overview: Youth will describe and identify the link between land use activities within a watershed and water quality.

Note to Educator: Students will evaluate the quality of a “water sample” (a bag of skittles), graph their results, and form a hypothesis about the land use near the location their “sample” was collected.

Materials:

- Candy (skittles) or colored beads
- Plastic sandwich bags
- Graph paper
- Colored pencils or crayons
- Pollutant labels (provided)

Experimental Steps:

Teacher preparation

1. Divide the candy into the sandwich bags (you may want to manipulate the bags so that the assortment of candy represents a particular land use area by adding more of a certain type of pollutant, rather than relying on a random mix. See table at end of lesson.)

Pollutant labels:

Sediment	Pesticides	Fertilizers
Oil and Gas	Toxic Waste	

2. Prepare one bag (30 pieces) per student or one bag per group of students. Each bag represents a water sample from a watershed.

In Class:

3. Ask students what a pollutant is. Tell them that each color of skittles represents a different kind of pollutant.
PURPLE = Sediment, RED = Pesticides, GREEN = Fertilizers,
YELLOW = Oil and Gas, ORANGE = Toxic Waste
Discuss each of these pollutants with the students. Ask the students where the pollutants come from, and the positive and negative impacts they have.
4. Distribute the graph paper to each student or group. Tell the students that they will be drawing a bar graph to show the number of pollutants found in their “water sample.” Have the students label the x-axis with the pollutant types and the y-axis with the amount of pollutants.
5. Give each group a “water sample.” Tell the students to separate and count the number of each pollutant and graph them on the paper. Remind the students that they cannot eat the skittles until they are finished with their graph!
6. Ask the students to try and determine what activities are occurring in their watershed according to the “water sample.” For example, a water sample from an area with a lot of agricultural use may have more sediment, fertilizer, and pesticides.
7. Discuss how each water sample is different. While some samples might contain an abundance of one type of pollution, almost all types of pollutants can be found in every sample (even if they are small amounts). Discuss strategies to reduce pollution. How can the students do this on a large scale (in their community) or small scale (in their own home)?

In the Community:

- Talk to friends and neighbors about what they have learned.
- Pick up trash in your neighborhood.
- Recycled littered plastics and papers.

In home:

- Encourage parents to fix leaky cars.
- Talk to parents about using less fertilizers and pesticides.
- Recycle items at home.
- Do not dump oil, gas, or other pollutants in the storm drains.

Suggested Combinations of Skittles for Different Land Uses:

Land Use	Purple	Red	Green	Yellow	Orange
Agriculture	8	5	5	2	0
Golf Course	5	5	8	2	0
Factory/Industrial	5	2	5	5	10
Construction	10	0	0	5	0
Neighborhood	2	5	8	5	0

Lesson 4: Different Types of Surfaces; GIS Mapping

Introduction

Chapter	Stormwater Runoff	Day 4	Grade Level: 5
Title of Topic	Urban Vs. Rural Runoff	Time: 40-50 Minutes	
Desired Outcome from Lesson: Students will be able to identify different surfaces and their effect on stormwater runoff.			
Topic of Lesson: Using your school's landscape, students will understand how stormwater acts differently when it comes in contact with porous and impervious surfaces. They will begin to visualize how polluting our environment can pollute our stormwater.			
Goals of the Day: Students will understand and model the difference between porous and impervious surfaces in an urban and rural environment.			
Essential Vocabulary:			
<ul style="list-style-type: none"> ● <i>Impervious Surfaces</i>- Surfaces, such as asphalt, roofs, and sidewalks, where water cannot readily absorb into the ground. ● <i>Porous Surfaces</i>- Surfaces where water can readily absorb into the ground. ● <i>Stormwater Runoff</i>- Generated from rain and snowmelt events that flow over land or impervious surfaces, such as paved streets, parking lots, and building rooftops, and does not soak into the ground. ● <i>Catch basin</i>- A reservoir or well into which surface water may drain off. ● <i>Urban Environment</i>- A human settlement with high population density and infrastructure of built environment such as cities, towns, or suburbs. ● <i>Rural Environment</i>- Open land that has few homes or other buildings, and not very many people. 			
Extended Vocabulary:			
<ul style="list-style-type: none"> ● <i>Discharge Point</i>- The point where stormwater which has been collected in catch basins is released into our bodies of water or into our environment ● <i>Storm Drain Network</i>- The network of underground pipes which stormwater travels from the catch basin to the discharge point 			

Teacher Guideline

Overview: This lesson is for students to understand the difference between porous and impervious surface by relating it to the surroundings of their schools. The use of Google Maps will be helpful during this lesson as students will have a better understanding of the aerial view.

Note to Educator: This lesson plan relates the surroundings of your perspective school in order to gain the interest from students. The aerial view that you see below is a Google Earth screenshot of Sherwood Middle School in Shrewsbury, MA. You can access a screenshot of your school on Google Earth if necessary. Although this specific lesson plan has topographic maps, storm drain network and catch basin locations of Sherwood Middle School, we encourage teachers to reach out to their local DEP or Town Engineer to have maps made for your specific school. Town Engineers would love for this to happen and teachers should take advantage of this community tool that they have in front of them. Most of the time, Town Engineers would be willing to come into your classroom and teach about their expertise.

Materials:

- Google Earth Screenshot print outs
- Markers/Pencils/Highlighters
- Topography Maps/Catch Basin Map

Instructions:

Part 1

- 1) Start off this class by giving definitions of porous and impervious surfaces
 - a) Ask around the classroom to see if any students can give you examples- if not provide them with examples. (Roads, roofs, sidewalks etc..)
- 2) Next, show this YouTube “Dr. Drain the Rain Brain Stormwater 101 Video” which further explains the difference between impervious and porous surfaces:
<https://www.youtube.com/watch?v=4XXMKaLgX6Y>
- 3) Once they have an understanding of what the difference is, hand out the Google Earth Satellite maps of your surrounding school and have them highlight the different surfaces (impervious or porous) surrounding the school. (An example is attached below)
 - a) Have them pick two different colors for impervious and porous.

- 4) After they have completed this, project the same blank copy of the map on the board (better with a smart board) and have each student come up and fill in/highlight one of the surfaces until the map is complete.
 - a) This is a chance to provide the students with the correct answers so they can fix their own drawings.
- 5) Next, explain what happens on impervious surfaces.
 - a) No water infiltration
 - b) Stormwater pollution from human interaction
 - i) Oils, garbage, animal waste, fertilizers, pesticides.
 - c) All of these bacteria are discharged into lakes and streams that they play in during the summer.
- 6) End the lesson with an Exit Ticket: 2 questions with 2-4 sentence answers.
 - a) What are two definitions that you learned from today's exercise?
 - b) What can you do to help make stormwater cleaner?

Part 2

- 1) If there is another day that you have available, reach out to your local Town Engineer to come in and take the students on a field trip outside of your school.
 - a) You can get ahold of them through your local stormwater coalition and/or DEP.
- 2) If the Town Engineer is unable to visit your classroom, you can do an outdoor lesson by yourself.
 - a) You can reach out to the DEP of your town and ask for maps of your surrounding areas.
 - b) These maps are as follows.
 - i) Topographic maps, Storm Drain Network and Catch Basin Locations with Discharge Points.
- 3) In the maps provided, you will see that catch basins are highlighted along with discharge points.

- 4) Take your class out and explain that when it rains, water is drained into these catch basins and picks up any human pollution that happens between the rainfall and the catch basin.
- 5) Explain that it then travels throughout these Storm Drain Networks and all of the pollution is discharged into rivers and lakes that they swim in during the summer.
 - a) Walk the storm drain network with the students if possible.
- 6) This is an interactive opportunity to take your students outside on a sunny day and have them interact with the outdoors.



Lesson 5: Best Stormwater Management Practices

Introduction

Chapter	Stormwater Runoff	Day 5	Grade Level: 5
Title of Topic	Best Management Practices (BMPs)	Time: 40-50 minutes	
Desired Outcome from Lesson: Students will be able to identify different practices and designs that help protect Earth's resources and the environment.			
Topic of Lesson: Students will learn how runoff can be reduced through best management practices while using a model, sketch, drawing, or other representation of a BMP to solve a stormwater runoff problem in an urban setting.			
Goals of the Day: Students will understand what Best Management Practices are and how they can naturally filter water. Then, they will engineer a BMP model to incorporate into a scenario and use scientific writing to back their reasoning for their design.			
Essential Vocabulary:			
<ul style="list-style-type: none"> ● <i>Stormwater Runoff</i>- Generated from rain and snowmelt events that flow over land or impervious surfaces, such as paved streets, parking lots, and building rooftops, and does not soak into the ground. ● <i>Best Management Practice</i>- A type of water pollution control. ● <i>Urban Environment</i>- A human settlement with high population density and condensed houses/buildings such as cities, towns, or suburbs. ● <i>Rural Environment</i>- Open land that has few homes or other buildings, and not very many people. ● <i>Impervious Surfaces</i>- Surfaces, such as asphalt, roofs, and sidewalks, where water cannot easily absorb into the ground. ● <i>Porous Surfaces</i>- Surfaces where water can easily absorb into the ground. 			
Extended Vocabulary:			
<ul style="list-style-type: none"> ● <i>Rain Barrel</i>- A water tank used to collect and store rainwater runoff, typically from rooftops via pipes. ● <i>Rain Garden</i>- A planted depression or a hole that allows rainwater runoff from impervious urban surfaces the opportunity to be absorbed. 			

Teacher Guideline

Overview:

This lesson plan is for students to learn how stormwater runoff pollution can be reduced through the best stormwater management practices. It will also force them to interpret a scenario and come up with what they think would be the best management practice for that scenario.

Note to Educator:

This lesson plan covers the Next Generation Science Standards and also is interactive. This lesson lets the students think like engineers as they have to design their own best management practice for two different scenarios.

Materials:

- Printed handouts (provided)

Instructions:**Part 1**

1. Play video 1 (Rain Gutter)
 - a. https://www.youtube.com/watch?v=EbzLT7dR_1A
2. Now play video 2 (Rain Barrel)
 - a. a. <https://www.youtube.com/watch?v=QJdKECi1cAg>
3. Ask the students what they see is happening at the end of each video
4. Explain to the students that what they see is a rain barrel, a barrel used to collect and store rainwater runoff, typically from rooftops via pipes.
5. Explain that a rain barrel is an example of a best management practice, a type of water or pollution control. The rain barrel is an example of pollution control because it collects pollutants from gutters on roofs and can be used as irrigation that naturally gets filtered in the ground. It also prevents water from turning into runoff and further flowing across impervious surfaces.

Part 2

1. Ask the students if they can describe what best management practices are.
 - a. A BMP is a type of water pollution control
2. Ask if they can think of examples of best management practices
3. Once they cannot think of any more examples, show them the pictures below of examples of the best management practices.
 - a. Ask students what they think the picture is
 - b. Then tell/show them the definition

	<p>Bioswale- landscape elements designed to concentrate or remove debris and pollution out of stormwater runoff water. A bioswale is most commonly found in neighborhoods as it collects pollutants running down impervious surfaces.</p>
	<p>Rain Garden- is a garden of native shrubs, perennials, and flowers planted in a small depression, which is generally formed on a natural slope. It is designed to temporarily hold and soak in rain water runoff that flows from roofs, driveways, patios or lawns. These are most effective in cities, but can also work in other environments.</p>
	<p>Rain Barrel- is a water tank used to collect and store rainwater runoff, typically from rooftops via pipes. A rain barrel works best at the bottom of a house's gutter in a typical neighborhood. These catch the rain that runs off the roof of your house!</p>

	<p>Permeable Pavers- pavement that is cut into squares and has breaks between them so that water can filter through. These can be most commonly found in neighborhoods or cities that have a lot of impervious surfaces.</p>
	<p>Signage- Making people aware of where pollutants flow too. These are usually found in cities with a lot of impervious surfaces are, but can work in other environments.</p>
	<p>Aggregate Strip-a material or structure formed from loosely compacting rocks. The rocks are able to slow down the flow of stormwater because water is able to leak into and through the loosely packed rocks. This type of BMP works in most environments but is especially effective in rural environments.</p>

Part 3

1. Pass out each provided handout to the students
2. Have half the class work on scenario one and have the other work on scenario two (Pass out each handout).
3. Lead a discussion on each scenario that gives the students ideas of which BMP to design.
4. Next, in the first blank rectangle, have the students engineer (Draw) the whole scenario including their BMP with labels of parts.
5. Then, in the second blank rectangle, have the students use the Claim-Evidence-Reasoning thought process to discuss whether they agree or disagree with Town Engineer Smith.

- a. For the Farm
 - i. The Town Engineer, Mr. Smith, believes the aggregate strip is the best management practice for the farm. Do you agree?
 - 1. Claim - Evidence - Reasoning
 - a. The claim should be 1 sentence.
 - b. Evidence should be 2 sentences.
 - c. Reasoning should be 3+ sentences.
- b. For the neighborhood
 - i. The Town Engineer, Mr. Smith, believes the rain barrel would be the best management practice for the neighborhood. Do you agree?
 - 1. Claim - Evidence - Reasoning
 - a. The claim should be 1 sentence.
 - b. Evidence should be 2 sentences.
 - c. Reasoning should be 3+ sentences.

Name: _____

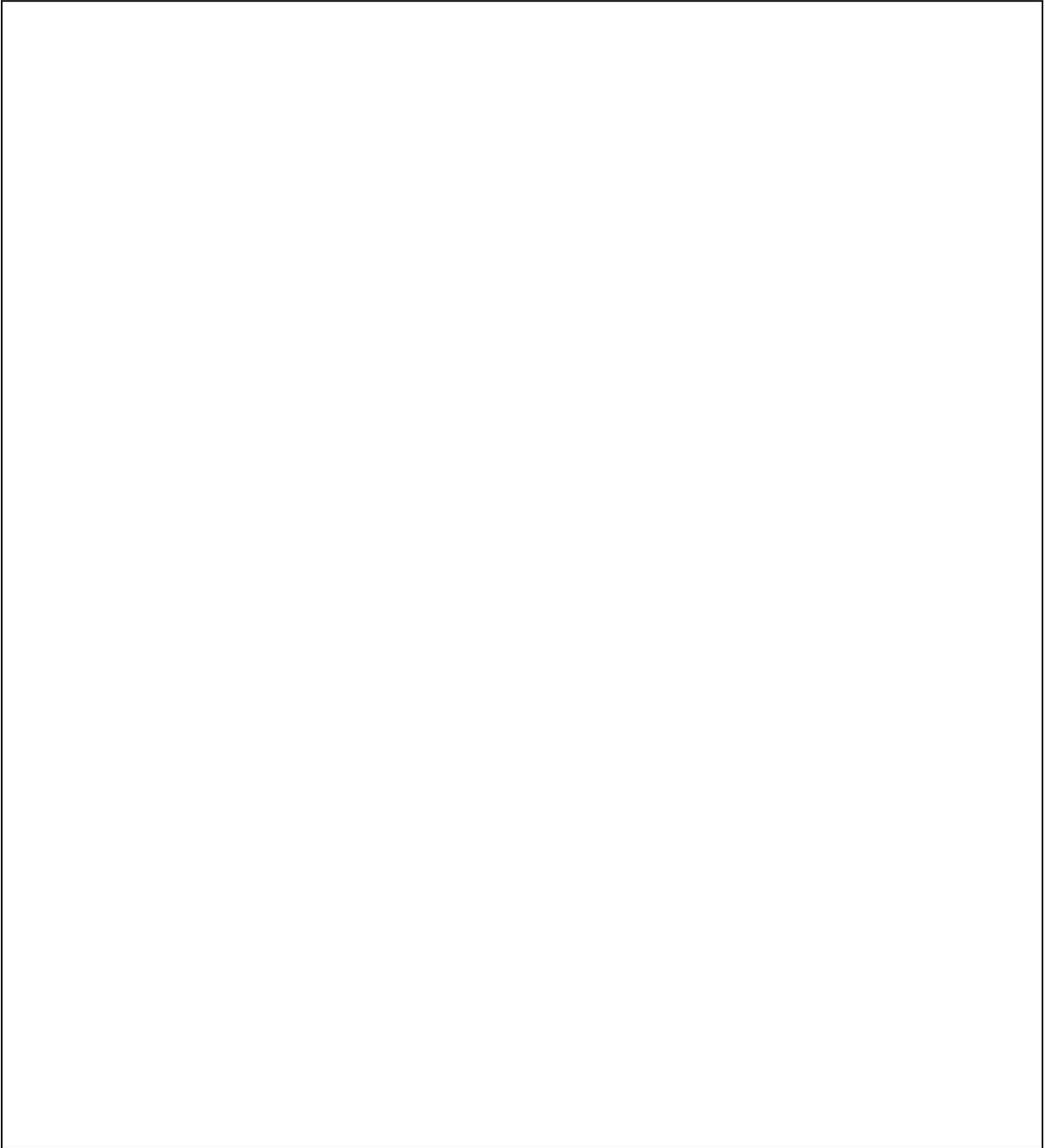
Lesson 5: Engineering a Best Management Practice

1. Farmer Joe owns a farm at the very top of a hill overlooking a town. This farm includes many animals, chemically treated plants, and loose soil. There was a large rainstorm last week and the stormwater runoff carried fertilizer, chemicals, animal droppings, and soil to a river nearby. Farmer Joe calls you, the Town Engineer, for help to prevent polluting the storm water runoff in future storms.

2. Lawyer Laura just bought a new house in a nice neighborhood in Worcester, MA. When it rains, the stormwater flows from the roof of her house to the gutters. The gutters pour onto her driveway which flows into the streets. People in the neighborhood walk their dogs without picking up after them, drop food wrappers, and do not clean up oil spills from their cars. There was a large rainstorm last week and pollutants were carried by the stormwater runoff down storm drains that discharge directly into Indian Lake in Worcester. Lawyer Laura calls you, the Town Engineer, for help to prevent polluting the storm water runoff in the future.



Engineer the **BEST** Management Practice model to incorporate into a scenario. Sketch your design in the box below.

A large, empty rectangular box with a thin black border, intended for sketching a management practice model. The box occupies most of the page's vertical space below the instruction.

Town Engineer Smith believes that the aggregate strip would be the **BEST** Management Practice for Joe and the rain barrel would be the BMP for Laura. Use Claim Evidence Reasoning to explain if you agree or disagree with Mr. Smith for the situation you chose.

Claim:
Evidence:
Reasoning:

Lesson 6 Part 1: Enviroscope Demonstration

Introduction

Chapter	Watershed / Stormwater Runoff	Day 6	Grade Level: 5
Title of Topic	Mapping How Water Flows / Enviroscope Presentation	Time: 40-50 minutes	
Desired Outcome from Lesson: Students will be able to use maps and sketches to identify local watersheds and the bodies of water they flow to.			
Topic of Lesson: As it precipitates, water flows downhill into bodies of water. Students will learn the importance of understanding and identifying your watershed and where your water comes from.			
Goals of the Day: Students will be able to explain and map how bodies of water connect to larger bodies of water in their watershed.			
Essential Vocabulary:			
<ul style="list-style-type: none"> ● <i>Groundwater</i>- Water that moves down into the ground (due to gravity) passing between particles of soil, sand, gravel, or rock until it reaches a depth where the ground is filled, or saturated, with water. ● <i>Stormwater Runoff</i>- Generated from rain and snowmelt events that flow over land or impervious surfaces, such as paved streets, parking lots, and building rooftops, and does not soak into the ground. ● <i>Watershed</i>- An area or ridge of land that separates waters flowing to different rivers, basins, or seas. ● <i>Pollutant</i>- A substance that causes harm to the environment, especially water or the atmosphere. ● <i>Non-point source pollution</i>- Caused when rainfall or snowmelt, moving over and through the ground, picks up and carries natural and human-made pollutants, depositing them into lakes, rivers, wetlands, coastal waters and ground waters. ● <i>Point source pollution</i>- Any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch, ship or factory smokestack. 			

Teacher Guideline

Overview: Youth will describe and identify how water flows over impervious surfaces and takes pollutants to local bodies of water.

Note to Educator: If looking to purchase an Enviroscape table, contact your local DPW official or regional stormwater coalition. Enviroscape tables can also be borrowed for free from local watershed groups or DEP locations. Students will be able to visualize and investigate how stormwater runoff travels on impervious surfaces.

Materials:

- Enviroscape
- Baking Soda
- Food coloring
- Cocoa powder
- Water and spray bottle
- Cups

Instructions:

Teacher preparation

1. Setup enviroscape by placing animals, houses and trucks on the landscape.
2. Fill spray bottle with water.
3. The baking soda, food coloring, cocoa powder, etc. represents the different pollutants.
 - a. Ex: food coloring= pesticides/herbicides, cocoa powder= animal waste
4. Place pollutants in different cups and label each pollutant.

In class

1. Describe the enviroscape to the students.
2. Place pollutants in different areas on the landscape and describe them to the kids.
3. Pose the question, “What do you think will happen when it rains?”
4. Let kids work in groups to come up with answers.
5. Use the spray bottle and spray the landscape.

6. Ask what they see. “Why is the water flowing on the streets? Why isn’t it being absorbed?”
7. Explain to the students the difference between porous and impervious surfaces.
8. Ask the students where the water flows to.
9. Ask them if they can come up with examples of each:
 - a. Porous: grass, dirt
 - b. Impervious: streets, roads (any pavement)
10. Continue spraying until pollutants end up in the river.
11. Ask the students if they can explain why this happened
 - a. Answer: stormwater runoff, water flows over impervious surfaces picking up pollutants on the roads, flowing down storm drains and entering local bodies of water.

Lesson 6 Part 2: Impervious vs. Porous Surfaces

Teacher Guideline

Overview: Urban and Rural environments have different effects on stormwater runoff. One main factor being increased impervious surfaces in urban environments.

Note to Educator: As a facilitator, force the students to derive the essential questions by asking triggering questions.

Materials:

- 2 Paint Pans per Group
- Markers
- 2 8oz. Cups of Water
- Sponges (or Green Felt)

Instructions:

Teacher preparation

1. First break the students into groups of 3-5.
2. Show *Dr. Drain the Rain Brain Stormwater 101 Video*. (If not shown with 1st lesson)
 - a. This video is easily found on youtube.com by searching “Dr. Drain the Rain Brain Stormwater 101”.
3. Have two clear paint pans to demonstrate the difference between impervious and porous surfaces (This can also be done in groups of 4).
4. Have the students draw an urban community in one of the paint pans with the bottom of the paint pan representing a body of water.
 - a. This will represent impervious surfaces.
5. Have the students fill their other paint pan with green sponges (or green felt). This is made to represent the forest.
6. Now have a student come to the front of the class and pour 8 oz. of water on the top side of each pan.

- a. Ask a driving question of in which environment the water reached the bottom of the pan first. Why? (Explain to the students that these two pans represent different environments, one being a rural environment and one being an urban environment.)
7. Show the students two photos on the worksheet and pass out the worksheet, one being an urban setting, another being a rural setting:
- a. Have the students investigate with their group and discuss the differences of what will happen when it rains.
 - b. Have the groups identify various things that create an increase/decrease in stormwater runoff in each environment.
 - c. Have the student's think of items stormwater runoff could pick up along its way to a storm drain in an urban environment.



LESSON 6



What will happen when it rains?

Where does all the stormwater go?

List pollutants that rainwater could pickup?

**LESSON 6
ANSWER
KEY**



What will happen when it rains?

- **Water will flow from roads, sidewalks, roofs into storm drains.**

- **Water will infiltrate the ground through absorption. Some water will flow on top of the grass into puddles or small ponds.**

Where does all the stormwater go?

- **The stormwater goes into the storm drains and flows through pipes into a local body of water.**

- **Stormwater will absorb back into the water table or flow naturally into bodies of water.**

List pollutants that rainwater could pickup?

- **Water Bottles, leaves, trash, salt and sand, oil and gas.**

- **Fertilizers, paint, animal waste.**

Lesson 6 Part 3: Water Filtration

Teacher Guideline

Overview: Students are asked to design methods to filter water using ordinary materials. They will also learn about the importance of water and its role in our everyday lives.

Note to Educator: This lesson plan will draw an Engineering Connection as the students will be designing their own filtration. This will open the eyes of the students and show them how polluted water is unhealthy to drink, swim in, and use.

Materials:

- 1 liter of water (Prepared in advance)
- 3 test tubes prepared with the water standards A, B, and C.
- Cotton balls
- Gauze squares
- Netting
- Tissue
- Paper towels
- Coffee filters
- Gravel
- Sand
- 3 test tubes per student group
- Graduated Cylinder
- Worksheet

Instructions:

Teacher preparation

1. Gather materials and print copies of worksheet.
2. Make the liter of water dirty with mulch/dirt.
3. Filter out tubes A, B, and C.
 - a. A is filtered through grass and a strainer, B is filtered through a coffee filter and a strainer, and C is filtered through 2 coffee filters with a paper towel and a strainer.
 - b. These all should be different colors. The students will use these as a guide to base their filtered water off of.

In class

1. Create an Engineering Opportunity: Tell the students that they are an Engineering Firm and they have to solve a problem in their town from a drought that has occurred. Show them the three test tubes prepared and how: C is almost ready for human use, B is almost ready for animal use, and A is almost ready for plant use. They will receive money for the amount of filtered water they supply.
2. Have the students fill out the worksheet provided to make sure they understand the purpose and to start thinking like an Engineer.
 - a. Think of three different filtration methods.
3. Provide students with the materials and let them decide on what materials they want to use to filter their water.
 - a. Provide them with a budget and make unit prices for each material.
 - b. Make the budget low so they can think about how to maximize their materials.
4. Have students draw schematics of their filtration process to think like an Engineer. Once this is completed provide them with 25mL of dirty water.
 - a. They have to come up with a filtration process to match the first shown tubes. (A, B, and C).
5. Once this is complete, they will compare their filtered water results to the ones provided and then answer the last question on the worksheet.

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https://www.teachengineering.org/activities/view/water_filtration

Appendix B:

Dawson Elementary School in Holden, MA: Interview Questions

1. What experience/understanding do you have of stormwater and its environmental effects?
2. How do you find curricula generally, and stormwater specifically? Repositories?
 - What websites do teachers/you use to find curricula? (key word searches, etc.)
 - What makes you want to reuse a curriculum? What makes a good curriculum stick?
 - How do you design/approach your lesson plans?
 - Do teachers share information/lesson plans with one another? How do they do this?
3. How do you decide to go with one curriculum plan over another?
 - For an idea, then create your own?
 - Powerpoint? Lesson Plan?
4. What do you feel has been the best way to assess your students learning?
 - Hands on/projects approach?
 - Multiple choice quizzes/short answer responses?
5. What curriculum do you use currently involving stormwater?
 - Do you use any of the curriculum that the 2018 Water Education team made for Holden and Shrewsbury? If not, why?
 - What did you like and dislike about that curriculum?
6. How easy do you find teaching this type of material?
 - Make it more beneficial?
 - Shared with other teachers?
7. What resources do you have?
 - What do you have access to that we can use to present our lesson plans?
 - What exactly can we relate stormwater to in your current curriculum guides?
8. Does Dawson Elementary have any Earth Day opportunities for us to come and demonstrate an activity?

Sherwood Middle School in Shrewsbury, MA: Interview Questions

1. What experience/understanding do you have of stormwater and its environmental effects?
2. Feedback on 2018 curriculum
 - Lesson plans good bad?
 - In depth breakdown
 - Have you used any of these lesson plans?
3. How do you find curricula generally, and stormwater specifically? Repositories?
 - What websites do teachers/you use to find curricula? (key word searches, etc.)
 - What makes you want to reuse a curriculum? What makes a good curriculum stick?
 - How do you design/approach your lesson plans?
 - Do teachers share information/lesson plans with one another? How do they do this?
4. What can we do to make our curriculum appealing to you and other teachers?
 - What NGSS should we focus on
 - Number of lesson plans.
5. What do you feel has been the best way to assess your students learning?
 - Hands on/projects approach?
 - Multiple choice quizzes/short answer responses?
 - “Exit tickets”?
6. What curriculum do you use currently involving stormwater?
 - Is stormwater involved at all?
 - How should we incorporate it more? Water cycle... etc
7. How easy do you find teaching this type of material?
 - Make it more beneficial?
 - Shared with other teachers?
8. What resources do you have?
 - What do you have access to that we can use to present our lesson plans?

- What exactly can we relate stormwater to in your current curriculum guides?
9. Does Sherwood Elementary have any Earth Day opportunities for us to come and demonstrate an activity?

Hopkins Elementary School in Hopkinton, MA: Interview Questions

1. What experience/understanding do you have of stormwater and its environmental effects?
2. How do you find curricula generally? Have you looked into stormwater curricula specifically? Repositories?
 - What websites do teachers/you use to find curricula? (key word searches, etc.)
 - What makes you want to reuse a curriculum? What makes a good curriculum stick?
 - How do you design/approach your lesson plans?
 - Do teachers share information/lesson plans with one another? How do they do this?
3. How do you decide to go with one curriculum plan over another?
 - For an idea, then create your own?
 - Powerpoint? Lesson Plan?
4. What do you feel has been the best way to assess your students learning?
 - Hands on/projects approach?
 - Multiple choice quizzes/short answer responses?
 - What are some teaching methods you like to use/you've seen work best?
5. Do you use currently use a curriculum that (if at all) involves stormwater?
6. What made you want to get your school on board with this stormwater curriculum?
7. How easy do you find teaching this type of material?
 - Is it not taught because it is hard to teach? Or because standardized tests do not test on it?
8. What resources do you have?
 - What do you have access to that we can use to present our lesson plans?
 - What exactly can we relate stormwater to in your current curriculum guides?

9. Does Hopkinton - Hopkins Elementary have any Earth Day opportunities for us to come and demonstrate an activity?

Charlton Middle School in Charlton, MA: Interview Questions

1. What exactly do you teach within the Charlton elementary school system?
2. What experience/understanding do you have of stormwater and its environmental effects?
3. How do you find curricula generally? Repositories?
 - What websites do you use to find curricula? (key word searches, etc.)
 - What makes you want to reuse lesson plans? What makes good lesson plans stick?
 - How do you design/approach your lesson plans?
 - Do teachers share information/lesson plans with one another? How do they do this?
4. How do you decide to go with one curriculum plan over another?
 - For an idea, then create your own?
 - Powerpoint? Lesson Plan?
5. What do you feel has been the best way to assess your students learning?
 - Hands on/projects approach?
 - Multiple choice quizzes/short answer responses?
 - What are some teaching methods you like to use/you've seen work best?
6. Do you currently use a curriculum that (if at all) involves stormwater?
7. What made you want to get your school on board with this stormwater curriculum?
8. How easy do you find teaching this type of material?
 - Is it not taught because it is hard to teach? Or because standardized tests do not test on it?
9. What resources do you have?
 - What do you have access to that we can use to present our lesson plans?
 - What exactly can we relate stormwater to in your current curriculum guides?
10. How do you think we could incorporate reading/writing/language arts into a lesson plan

like this?

11. Does Charlton Elementary have any Earth Day opportunities for us to come and demonstrate an activity?

Massachusetts Water Resource Authority: Interview Questions

1. What made the “School Program” possible and relevant?
 - I.e : did teachers reach out? Are they having trouble making lesson plans?
2. What activities that were given on your website have received the best feedback?
 - 5th grade range
3. Did you reach out to any teachers when developing these activities?
4. Would we be able to use these activities in our own curriculum?
5. Do teachers take advantage of the Teacher Training Workshops?
6. Miscellaneous questions

“Westford Living Lab”: Interview Questions

1. How long have you been the science curriculum coordinator for Westford elementary schools?
2. Do you find that teachers are having to change their lesson plans/curriculum due to the new science standards?
3. Are the Westford teachers currently incorporating stormwater into their science classes?
 - If so, where are they getting their lesson plans/curriculum for this?
 - If not, why?
4. What do you think is the most important thing to incorporate into a science curriculum for 5th graders?
 - I.e: Hands on activities, field trips.
5. How long do you think is a feasible amount of time for a teacher to spend on a stormwater/watershed/water cycle curriculum?
 - Number of lessons, days, weeks?
6. What was your approach to designing and implementing the Westford Living Lab?

7. Where did your funding come from for the living lab before it got cut?
 - How hard is it for teachers/educators to get funding from their towns?
 - What is the process they have to go through? (who to contact, etc.)
8. What type of feedback were you looking for from the teachers and students after visiting the lab?
 - Were students tested on their visits to the lab or was it more of just an experimental experience?
9. Do you have any other resources that you will be looking to use now that the living lab funding has been cut?

Boston Water and Sewer Commission: Interview Questions

1. How did you approach designing the curriculum the way you did?
2. What feedback have you received from the Boston Water & Sewer Stormwater Curriculum?
 - What did teachers/schools like and what did they dislike? Why?
 - We know there are three different types of investigations (activities) in the curriculum. Are all three used the same amount? Is one used more than others?
3. How important was it to relate to other classroom topics (such as the water cycle) and to the Science Standards?
4. Do you think that relating the curriculum topics to the local bodies of water (such as the Boston Harbor) and their schoolyards was important/useful?
5. What experience do you have working with teachers?
 - What do you think could help us when dealing with teachers at our project schools?
 - How did you sell this curriculum to the teachers to want to use?

- What steps should we take to be successful?

Appendix C:

Name: _____

4/22/19

Email: _____

Grade: _____

- 1) What is the best way that we can spread our curriculum? Would you be willing to send it to other teachers/colleagues for us?

- 2) Where do you find your curriculum? Websites etc...

- 3) Do you have any prior experience of getting one of your lesson plans on a website?

- 4) How long do you use a lesson plan for? Multiple years?

- 5) How do we get into professional development days?
 - a) What time of the year do teachers go to professional development days?
Summer/Winter Break etc..

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