
WILD
ABOUT
WATER

FITCHBURG PUBLIC SCHOOLS

In Collaboration With

The Fitchburg DPW & Water Resource Outreach Center

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Jeff Murawski, Deputy Commissioner of Wastewater

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WROC

Massachusetts Water Resource Outreach Center

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MEET THE RAIN WRANGLERS!

Cielo Sharkus: Biochemistry Major, Environmental Studies and Biology Minors

Cielo is a junior at WPI who loves the outdoors! Growing up she loved to explore the world around her, and learn all about biology. She loves to go white water rafting, mountain biking, and going on hikes. Exploring the natural world inspired Cielo to be a STEM major, so she can help out her local environment through her research. Cielo is also the President of two clubs and loves to be a leader.

Thomas Kouttron: Mechanical Engineering, Concentration in Design and Manufacturing

Tom loves mechanical design and has an appreciation for old equipment and automobiles. He also love music, playing the Tuba and singing Opera. When he was a child he had a passion for STEM because it allowed him to explore science, which fostered his interest in engineering.

"I encourage you to stay in the STEM field and learn more about science and engineering and what passions you can develop!"

MEET THE RAIN WRANGLERS!

Sean Burke: Civil Engineering, Concentration in Project Management and Structural Engineering

Sean is a Civil Engineering major who loves to swim in oceans and rivers. Whenever he goes to a new city, he loves to look at the bridges and buildings. He is interested in science and engineering because he wants to build sustainable infrastructure and reduce the carbon footprint of American cities.

Michael Cooke: Mechanical Engineering, Concentration in Design

Mike has always been interested in science and mechanical design. He is an Eagle Scout of the Boy Scouts of America and has completed many projects that are related to environmental stewardship.

> "Being in STEM is the most rewarding decision I have ever made. Imagining and creating things makes each day exciting!"

Runoff Randy and the Rain Wranglers

Howdy there! I'm Runoff Randy and I am so excited to introduce you to *Wild About Water*! Throughout this workbook you'll get to learn all about my passion: protecting the environment. Before I send you off on your journey to learn about the water cycle and all about stormwater, I want to teach you about something near and dear to my heart: being a scientist. Now I know I may not look like a typical scientist, but I'll tell ya I am! You can be a scientist too, if you follow these steps like me.

"Gee there sure is a lot of trash in the North Nashua River!"

Figure 1: Runoff Randy!

The first step to being a scientist is making an **observation**. Now when I first chose Fitchburg as my place to conduct my experiment, I had to first observe what was happening there. The first thing I noticed was that there was a lot of trash littering parking lots, and I even saw some of it flowing directly into the North Nashua River! That my friends is a problem, which brings us to our next step, forming a **scientific question**.

"Golly I wonder how it got there and how that affects the river?"

My first thought when I saw the trash flowing into the North Nashua River, was, "Golly, how did all that get there?" My second thought was also, "Gosh, how must all that pollution affect the river?" Well, that brings us to our next step in the scientific method, forming a **hypothesis**. Now a hypothesis is a fancy word for simply making an informed guess about the answer to our question. My hypothesis is that the North Nashua River is polluted because of us humans, and that it hurts the ecosystem.

"Gosh, the Nashua River must be polluted because of us,
and it must hurt the poor ecosystem."

The next step is my favorite! It is to conduct an **experiment**. Now, an experiment is basically just a way to test the hypothesis. It is carefully designed and controlled to prove the hypothesis right or wrong. In order for our experiment to provide true scientific proof, we need a **control**. Our control is one thing that is kept constant under control, and is not changed. Our experiment also needs to be reproducible so everyone can test it and see what we learned for themselves. This is the fun part! Here are the steps to my experiment about the North Nashua River:

1. Collect samples of water. For this step I took a sample of water from a river that ran behind McKay Arts Academy. It is a small river that runs off of the North Nashua River. Next, I took a sample of gross stormwater from the Central Valley Plaza in Fitchburg. Lastly, for my control, I used a sample of **distilled water**, which is a really clean type of water you can buy at the grocery store.

Figure 1: Runoff Randy with a Rain Wrangler at the river behind McKay Arts Academy

2. Next, I tested the water samples using a water pollution test kit. I used a simple pollution test kit from off the internet and it contains a few simple **solutions** that change color when in the presence of pollutants. This type of experiment is **qualitative,** meaning the data we get will not be numerical; it will be positive or negative. This type of data is also known as **categorical** because you can put the data into different categories.

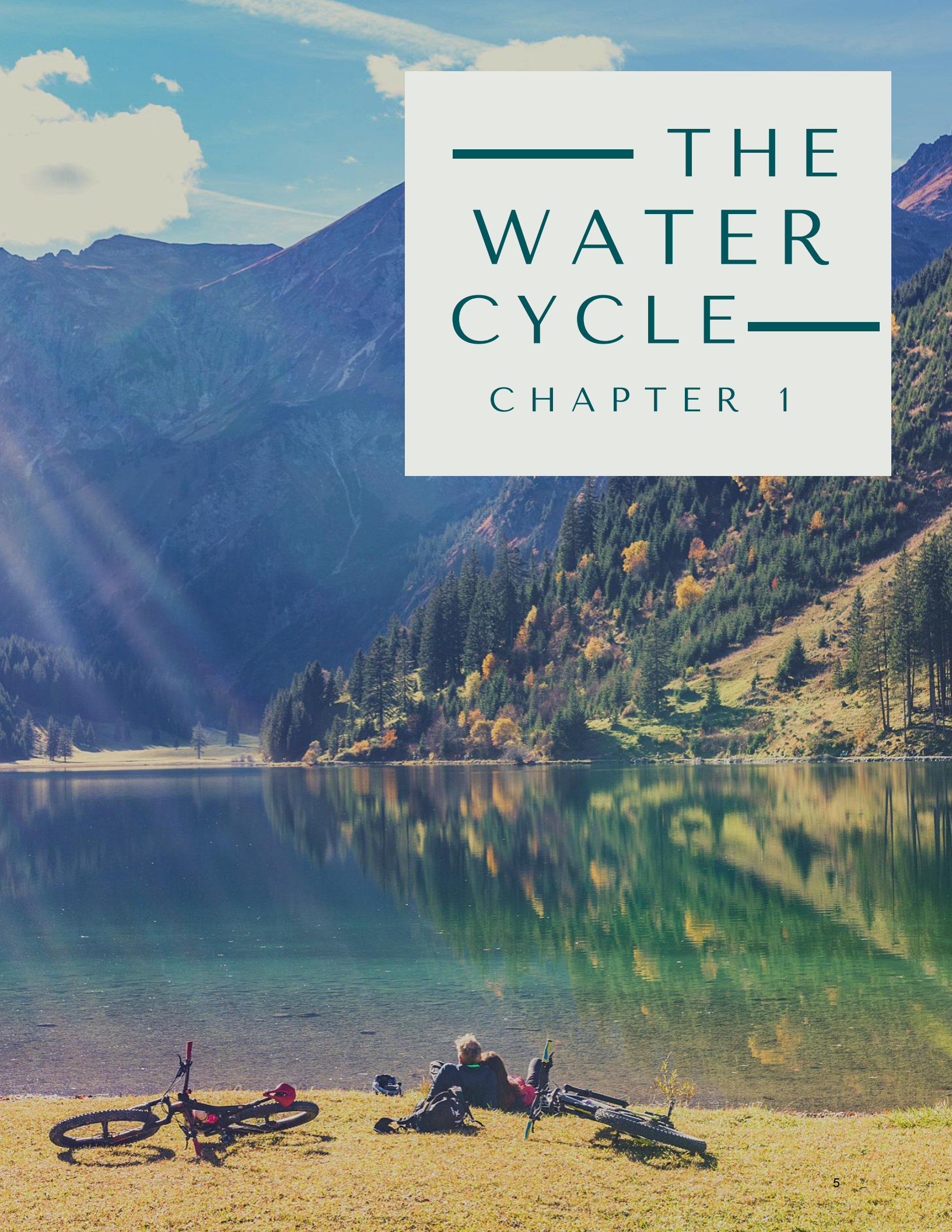
Figure 3: How to test water

3. The last step is to **analyze** the data! This is where you really learn something. For my test kit, if the water changed color when I put the test solutions into it, it meant that the water contained pollutants. From my experiments I found the stormwater from the Central Valley Plaza to be very polluted, and that the river behind McKay was also polluted. My control, the distilled water, was a good control because it wasn't polluted at all.

So what did we learn today! Well we learned a lot. What we just went over was something called the **scientific method**. The scientific method is something I would like you to think about throughout this entire workbook. Observe some environmental **phenomenon** in your neighborhood and think about a question and hypothesis you can form. Then, think about an experiment you could design to prove your hypothesis right or wrong. Well that's all for now. Catch y'all at the end of this workbook!

Vocabulary:

- **observation:** To inspect or pay attention to something with careful attention to details.
- **scientific question:** A question based on an observation.
- **hypothesis:** Making an informed guess about the answer to a scientific question.
- **experiment:** Using controlled conditions to test your hypothesis
- **control:** A part of an experiment that is kept constant and not changed.
- **distilled water:** A very pure type of water that does not have any other things in it, such as minerals.
- **solution:** A liquid in which something has been dissolved.
- **qualitative:** A type of data that describes something in detail rather than with numbers.
- **categorical:** Being able to assign something to a specific category based on patterns.
- **analyze:** To study something closely and carefully
- **The Scientific Method:** A process that scientist use to test ideas using experiments and careful observation.
- **phenomenon:** Something (an interesting event or fact) that can be observed or studied.

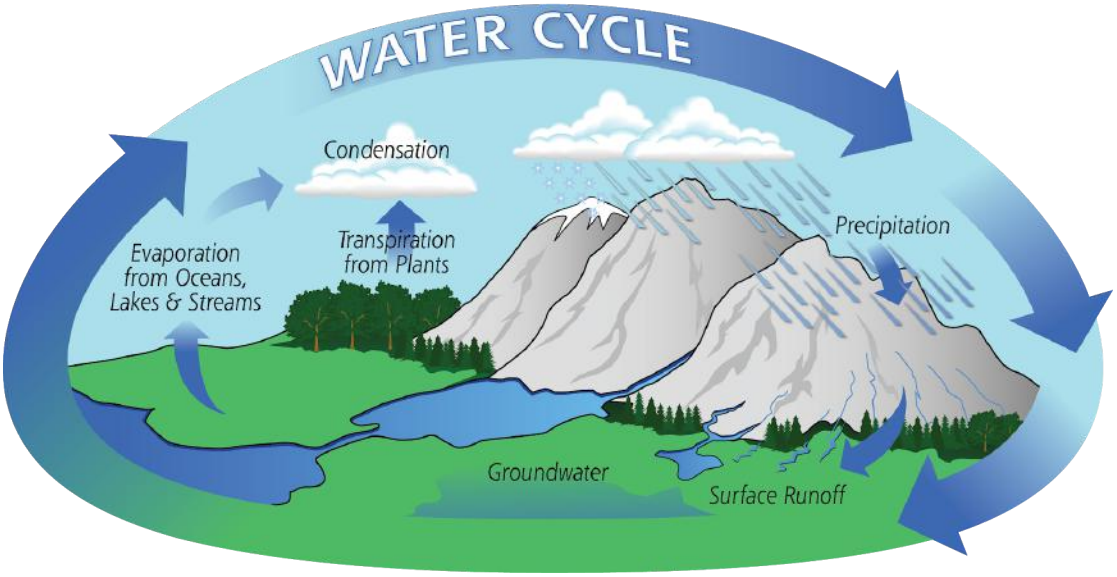


THE WATER CYCLE

CHAPTER 1

The Water Cycle:

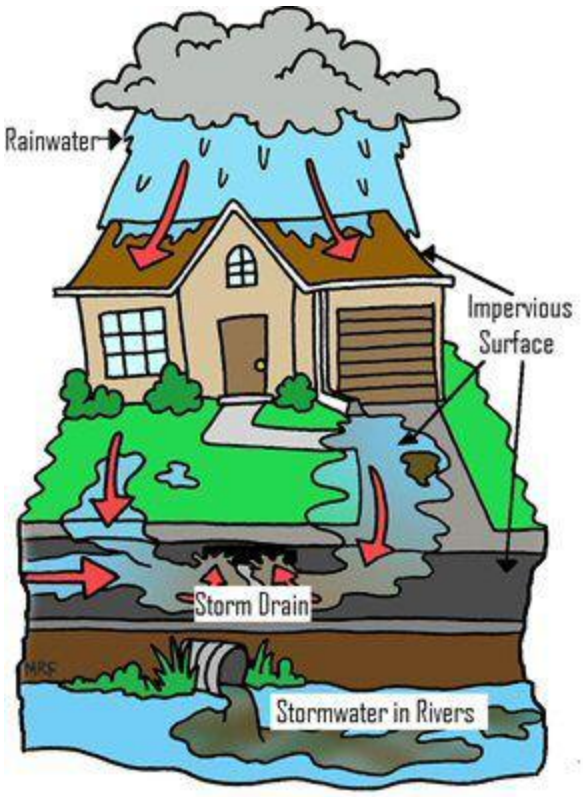
Water is everywhere around us, it is in our skin, in our bodies, in the air, really it's everywhere. So what is the water cycle? Well, it explains how a single drop of dihydrogen monoxide, or as we like to say H20, ends up being recycled for hundreds of years. In fact, some of the same water you are breathing in right now might have been around when the dinosaurs were here.



The water cycle is the process where Earth's water circulates between the oceans, land and atmosphere through **evaporation**, transpiration, precipitation and drainage.The sun is the driving force behind the water cycle because it causes ocean and ground water to heat up and evaporate. **Evapotranspiration** is when water is transported from land to the atmosphere by **evaporation** of water on the ground, and plant **transpiration**.This water vapor rises into the atmosphere, where it cools and condenses. This is when clouds form. When the air current moves or

the water particles get too large or collide, they fall from the sky as **precipitation** in several different forms depending on the temperature. Snowmelt and other runoff eventually goes back into the ground, streams, lakes and oceans where the process can start over again. Not all this runoff flows into rivers or streams though. Over time all of this water keeps moving, replenishing the water cycle endlessly.

Freshwater:



Freshwater is any water contained on Earth's surfaces that does not contain salt, and it can be found in icebergs, glaciers, ponds, rivers, lakes, streams and groundwater. Fresh water, also known as freshwater, is a very important resource on this Earth. We as humans use it to hydrate, bathe, cook, and clean. Animals and plants use freshwater in their ecosystems everyday.

Our freshwater is constantly on the move. As you know through the water cycle, our water is constantly replenishing and moving from rivers, lakes and streams. What happens though when this water becomes **contaminated**? **Contamination** of our freshwater happens typically by human interaction with stormwater, which we will discuss in the next chapter.

Vocabulary

- **Transpiration:** The process by which plants absorb water through the roots and then give off water vapor through pores in their leaves.

- **Evapotranspiration:** The process by which water is transferred from the land to the atmosphere by evaporation from the soil and transpiration from plants.

- **Freshwater:** Any water contained on Earth's surface that does not contain salt.

- **Precipitation:** Water released from clouds in the form of rain, freezing rain, sleet, snow, or hail.

- **Evaporation:** The process by which water changes from a liquid to a gas or vapor.

- **Contamination:** Any object, chemical or substance that pollutes water or makes it harmful to living organisms.

Activities

1. Using what you learned from this chapter, create a diorama of the water cycle, using any materials you can.

2. Think about what happens when it rains in your city. What happens to rainwater? Write a poem about what happens when it rains.

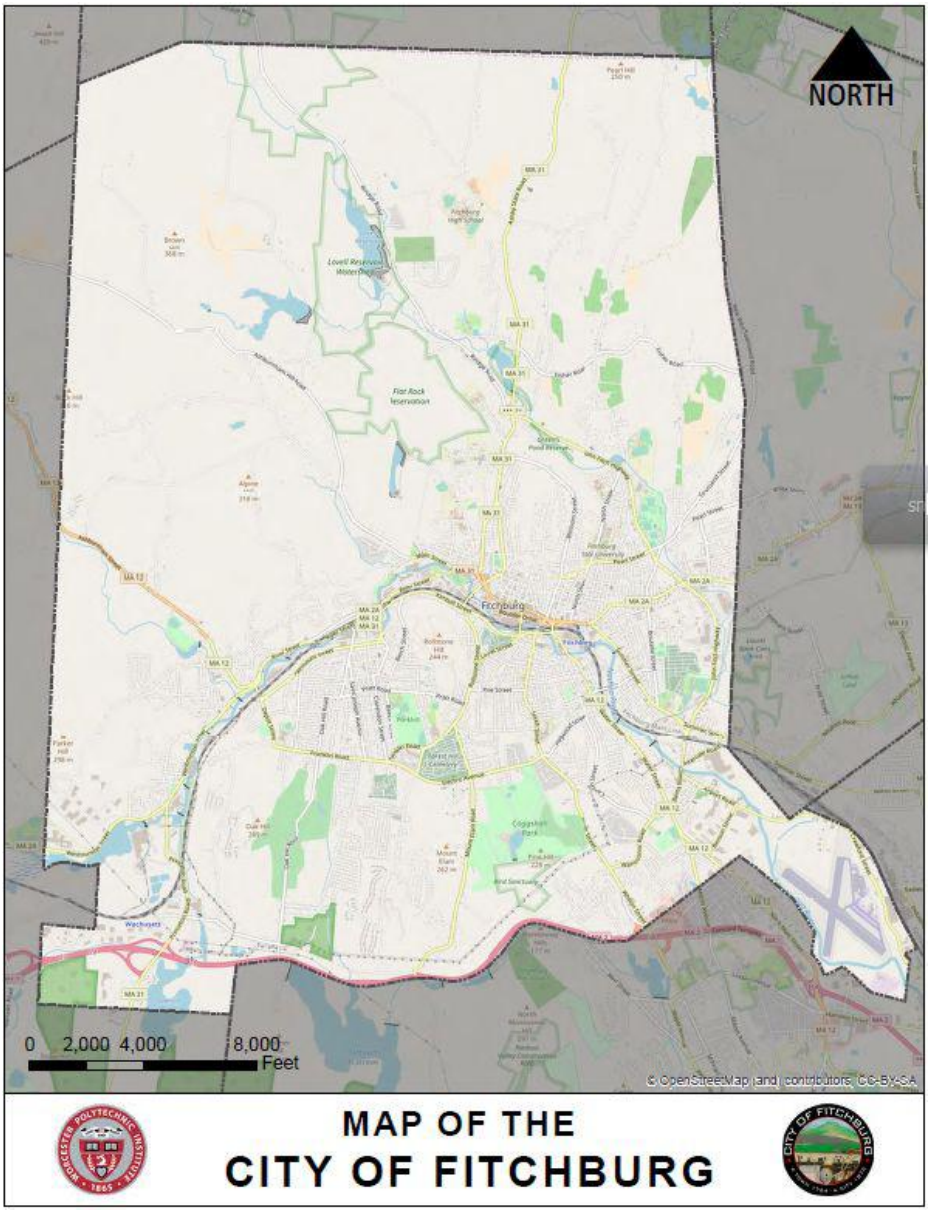
Activities cont.

3. Think about all the freshwater in the world. How would you find out exactly how many gallons of freshwater fall annually on the United States? When you are finished, compose a short story about the journey of a drop of water from the sky, to the North Nashua River.

4. What would happen to our supply of freshwater if the water cycle were to be broken? Write a short story about a fictional city that used up all their freshwater.

Activities cont.

5. On this diagram of Fitchburg, circle the bodies of water. Do you think Fitchburg is a watershed? How do you think the Fitchburg DPW manages rainwater? Choose 2-3 partners in your class and create a small poster about how to deal with rainwater in Fitchburg.



6. Create a diorama with 2-3 classmates to help learn about groundwater. Construct a box out of cardboard and fill it up ¾ full with sand, dirt, *or* rocks. Record whichever material you choose, and then pour different types of materials over it: Water (this is rainwater), Cocoa Powder (Dog poop), Coffee grounds (motor oil). Explore how the different types of textures affect how water and pollutants are absorbed.

STORM WATER

CHAPTER 2

Stormwater

So what exactly is **stormwater runoff**? Well stormwater runoff is any form of precipitation that flows over an **impervious surface**. This typically happens when rain falls on a roof or paved surface such as a parking lot, or driveway, that does not allow water to soak into the ground. This water then flows into storm drains located on the side of the road, and enters into a maze of underground pipes. This system of storm drains and underground pipes is called an MS4 (Municipal Separate Storm Sewer System) and it transports water directly to our local rivers, streams, and wetlands. Stormwater runoff does not just pose a risk to the tiny critters taken away by the flow of rushing water. This water picks up and carries many different pollutants that are found on paved surfaces such as pet waste, lawn fertilizers, bacteria, oil, grease, pesticides, and heavy metals. In fact, these pollutants can be so bad that stormwater runoff is considered to be a big polluter of the North Nashua River.

Pollutants in stormwater don't just come out of thin air. They are a direct result of human activity. For example, harmful bacteria can enter water bodies from pet waste that is left on the ground. Heavy metals can enter water bodies simply from washing your car in your driveway. Lastly, many more pollutants can enter your local water body from just dumping trash down your local storm drain.

Figure 1: Pollution of a Storm Drain. University of Rhode Island, Stormwater Solutions

Now you may be wondering, where does this water go? As stormwater flows along an **impervious surface**, it eventually winds up in something called a **storm drain**. Once inside of the storm drain, the water travels through an MS4 and is released into **catch basins** and **outfalls**. Catch basins are located on roadways along shoulders, which collect runoff and are then emptied into water bodies through an outfall. **Outfalls** are are a **point source** of pollution, since polluted stormwater flows from here.

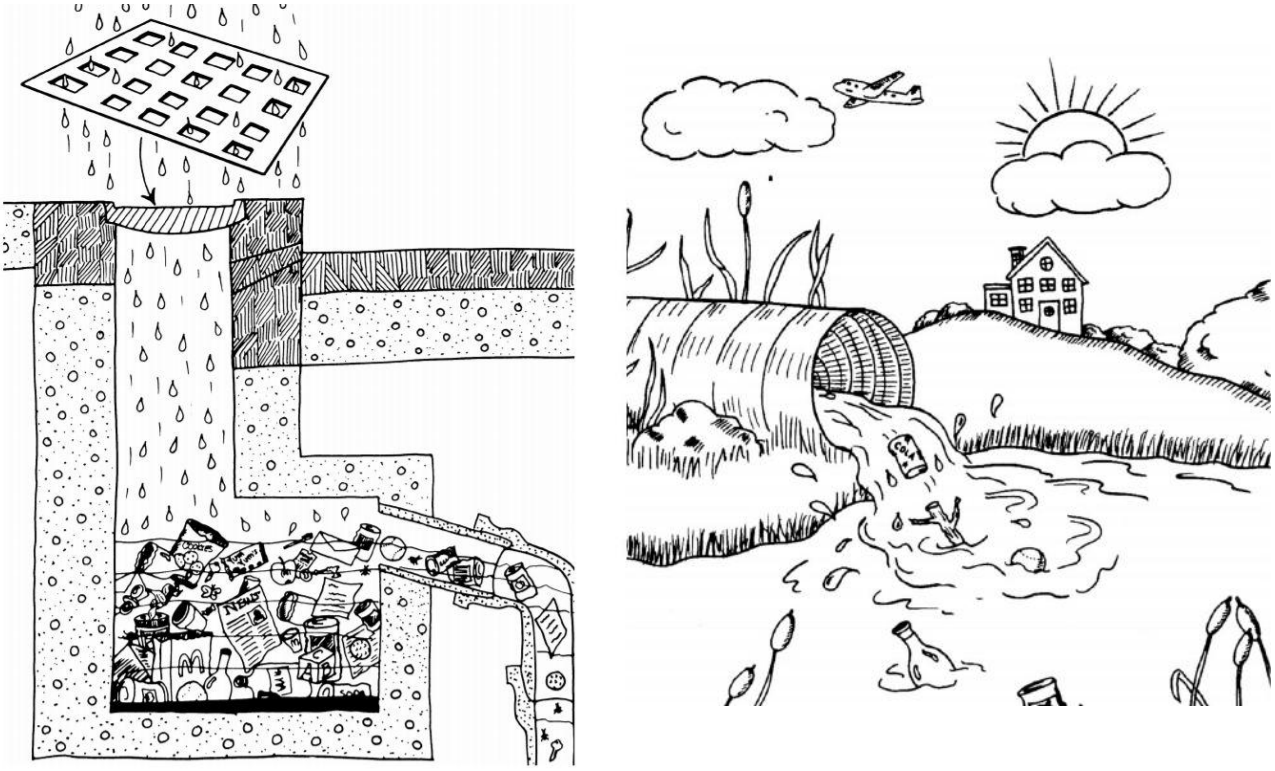


Figure 2: (Left) A catch basin filled with trash. (Right) An outfall pouring trash into a water body. Massachusetts Water Resource Authority: Dwayne the Storm drain

Runoff and urban pollutants

Natural landscapes have porous surfaces such as dirt and soil,which allow rainwater and snowmelt to slowly filter into the ground. Man made environments and structures such as roads, rooftops and pavement are **impervious surfaces** that don't allow runoff to seep into the ground and

allows it to collect into larger quantities. This also allows for more time for the contaminants to collect and concentrate. Some of these pollutants include oil, pesticides, viruses and bacteria, salt, heavy metals and pet waste. If pollutants make their way to larger bodies of water, they can harm fish, wildlife and vegetation, as well as contaminate drinking water.

Human driven water pollution and its effects

As the number of people on Earth increases, a lot of land is being transformed into **impervious surfaces**. The removal of vegetation and soil reduces the natural filtration of runoff, leading to more pollutants ending up in our water. Chemicals and waste products end up in storm drains in urban areas because of more impervious surfaces. Higher amounts of these pollutants entering our water bodies can overwhelm current pollutant removal systems and cause localized flooding and contamination of freshwater. Fertilizer that contains phosphorus and nitrogen can also enter into the environment as stormwater washes it from the surface of lawns into storm drains. All of these pollutants can contaminate or block the stormwater pollutant removal systems, which can contribute to other issues such as flooding and the spread of bacteria and chemicals.

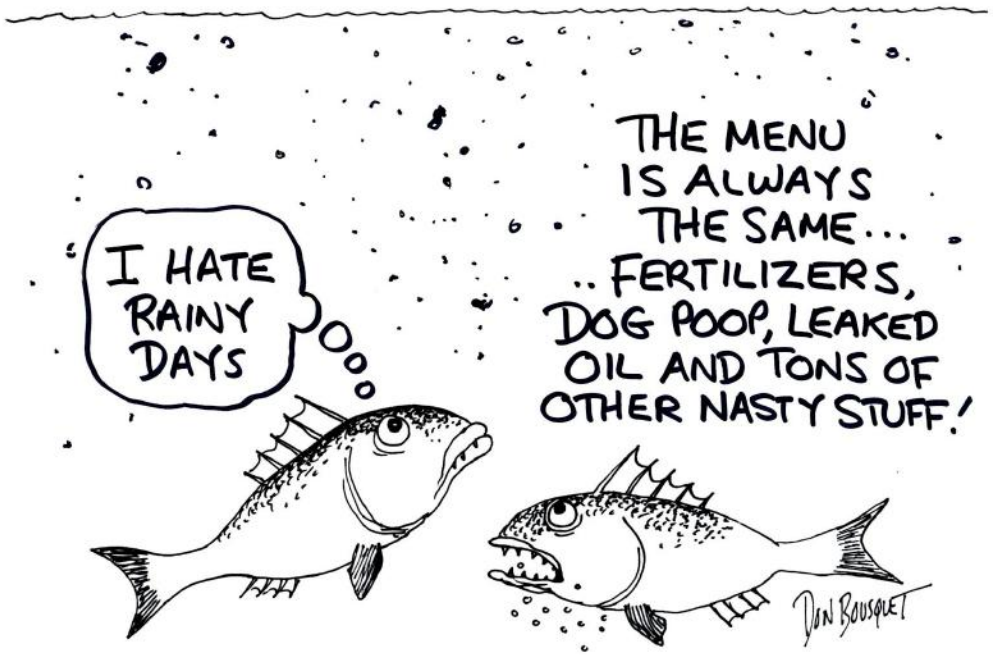


Figure 3: Fish discussing pollution. University of Rhode Island, Stormwater Solutions

Vocabulary

- **Stormwater:** Any surface water that is on the ground as a result of precipitation.
- **Impervious surface:** Any surface that water can not filter through such as blacktop and certain types of concrete.
- **Storm drain:** A holding tank designed to remove excess water from impervious surfaces in order to prevent flooding. Not to be confused with sewers.
- **Catch basins:** A structure that stormwater runoff flows into, it allows heavy debris in the stormwater to settle out and floating debris to be trapped in the structure.
- **Outfalls:** The point where a storm drain empties into the environment.
- **Point source:** One single source of pollution, like a pipe.

Activities

1. Imagine you are a rubber duck. Using what you learned about stormwater from this chapter, create a song about where you would go if you were dumped down the storm drain. When you are done, draw a diagram that describes how stormwater flows through the MS4 system and into a water body.

2. Using what you know about common types of pollutants, draw and label a storm drain filled with pollutants like the one in figure 2. Draw and label as many as you can. When you are done, compare with 2 classmates, and create a poster about the types of pollutants you found together.

Activities cont.

3. Your friend, Motoroil Mike, just told you that dumping oil down the storm drain is ok because it gets treated in the sewer treatment plant. Is he correct? Compose a short speech to Motoroil Mike about what really happens when you dump down the storm drain, and what he can do instead.

4. Design a scientific investigation, just like Runoff Randy did in the introduction chapter, about how you would test the North Nashua River for bacteria contamination. Think about the steps you would need to go through. When you are done, put together a diagram or poster about how bacteria contamination is harmful and how we can stop it from happening.

Activities cont.

5. People in your city or town are complaining of contaminated drinking water. They have been experiencing severe dehydration and headaches. This is a common symptom of heavy metal contamination. How would you test the local watershed to see if it was contaminated with heavy metals?

6. Draw a diagram of Fitchburg that includes major water bodies, factories, gas stations, and farms near you. Use a map if you need help. Using this diagram, explain how pollutants from different areas can enter the North Nashua River.

Activities cont.

7. A lot of people do not know where the storm drain is located and also do not know that it is separate from the sewer system. Use onomatopoeia to create a poem about this separate sewer storm system.

8. A healthy ecosystem contains a variety of animal, plant, and fish species, making it biodiverse. Having a biodiverse ecosystem is very beneficial to both the environment and humans. Using what you learned about ecosystem services, describe how a clean and biodiverse ecosystem is important for humans.

GREEN SOLUTIONS

CHAPTER 3

Human impact on the environment:

We all live within a watershed, which is the area of land that drains into a waterway such as a river, lake, stream, wetland, or ocean. Watersheds are essential, not only for our ecosystem, but also to supply drinking water, sustain life, and provide us with outdoor activities. Watersheds also provide many different **ecosystem services**, which are services an ecosystem provides that would be costly to replace. In fact, watersheds provide approximately $450 billion of services each year to the economy, such as providing CO2 removal from the atmosphere, providing food, and providing medicines.

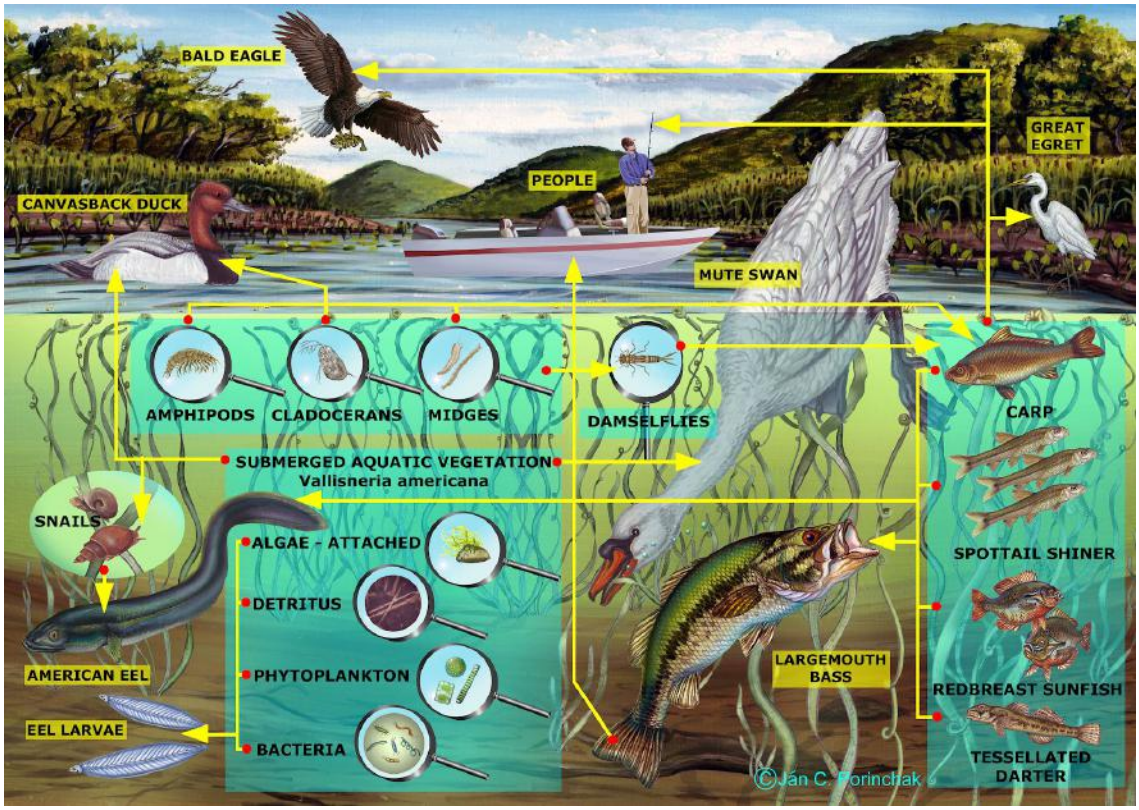


Figure 1: A river ecosystem. J. Porinchak from the Cary Institute of Ecosystem Studies

The **watershed approach** describes a way of protecting our watersheds by using **stakeholders** to help protect a watershed. What do our watersheds need protection from? Why humans of course. The current era of human

activity, or **anthropocene**, is negatively affecting watersheds, causing **positive feedback loops** to occur. When humans lower water quality enough to affect plant life, a **trophic cascade** can occur, causing animal species to decline and therefore causing large predators to decline as well. This negatively affects humans by decreasing the amount of ecosystem services offered and also by decreasing **biodiversity.**

Many human activities, including the contamination of our waterways through stormwater pollution, may affect the watersheds in some way. Being a **stakeholder** in your environment and your community allows for the strategic protection of our waterways. There are several means of doing this, including regulatory methods such as the enforcement of **MS4 Permit**s, community based **environmental stewardship,** and using **adaptive management.** Some examples of adaptive management include the utilization of best management practices, or **BMPs**. A type of **BMP** is the implementation of **green infrastructure**, or stormwater solutions, which we will talk about in the next section.

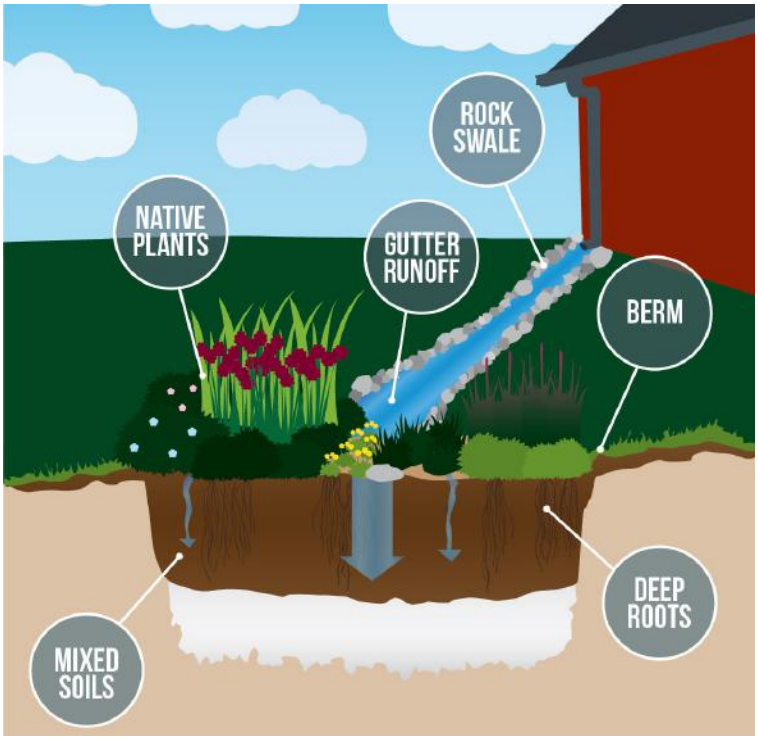


Figure 2: Lake Simcoe Region Conservation Authority

Reducing Human Impact:

There are many methods to reduce human impact on our ecosystems. Some include gathering community help and inviting watershed organizations to help monitor water quality. Human impact can also be reduced by implementing eco-friendly designs when creating homes.

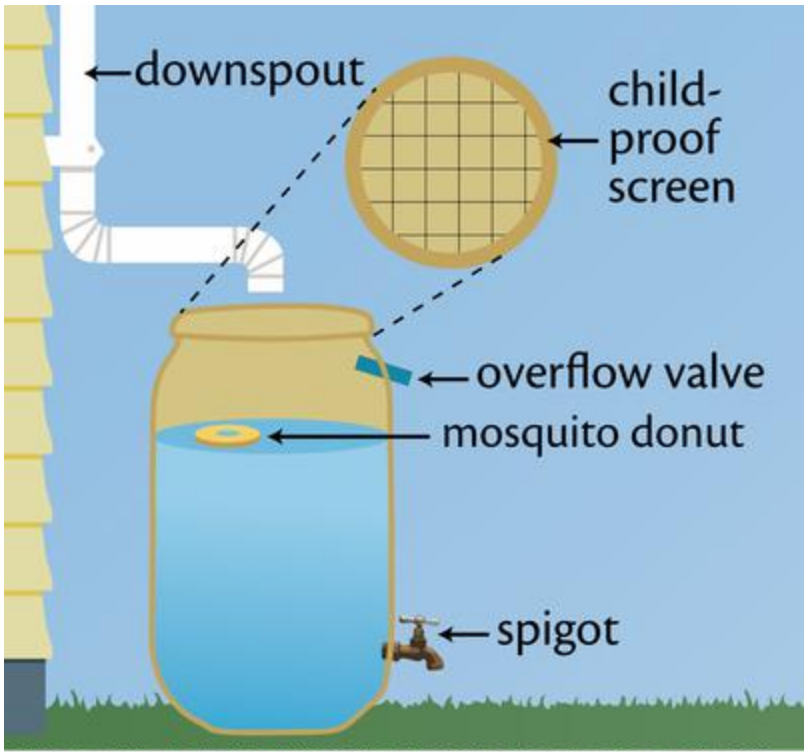


Figure 3: Examples of a rain barrel. Massachusetts Wildlife Climate Action Tool

One essential method of reducing human impact on our wetland ecosystems is by implementing **stormwater solutions** into community planning and renovation. There are several types of stormwater solutions that may be implemented into community planning that help prevent stormwater pollution, local flooding, and increase **infiltration** into the ground. One method is by replacing cement pavements with **permeable pavement**, which allows for rainwater and runoff to seep through the pavement and infiltrate groundwater beneath the surfaces. Another method is using **rain gardens** and **rain barrels** to manage rainwater**.** Rain gardens utilize stormwater to reduce local flooding and to absorb sediments, chemicals,

and pollutants before they runoff into the storm drain. Rain barrels help collect water from the rooftops of homes to reduce local flooding and pooling of stormwater. Many stormwater solutions offer safe and cost-effective ways for reducing human impact on our ecosystems, thus helping preserve water quality and ensuring the protection of biodiversity.

Vocabulary:

- **ecosystem services:** The many and varied benefits that humans freely gain from the natural environment and from properly-functioning ecosystems.

- **The watershed approach:** The method of collaborating with different people to support a watershed, by reducing a community's impact on stormwater pollution.

- **stakeholders:** A person who is invested in and provides support for an event, such as a watershed cleanup.

- **Anthropocene**: The era of human impact on the environment directly relating to the degradation of the environment.

- **positive feedback loop**: When one event or small disturbance on a system increases the magnitude of the problem.

- **trophic cascade:** When an entire food chain is disturbed by one event.

- **biodiversity:** The variety of life in the world or in a particular habitat or ecosystem.

- **MS4 Permits:** Specific permits given out by the EPA that direct how to manage stormwater.

- **adaptive management:** The process of being able to adapt to a changing situation, focusing on being able to manage large projects.

- **Best Management Practice (BMP):** A practice that aims to prevent or reduce the amount of pollution from stormwater.

- **stormwater solutions:** An approach to water management that protects, restores, or mimics the natural water cycle.

- **infiltration:** The process of a liquid being able to soak into something.

- **rain gardens:** A modified landscape that collects rainwater from a roof, driveway or street and allows it to soak into the garden, therefore filtering sediments and chemicals.

- **rain barrels:** A simple way to store rain and stormwater runoff, typically from rooftops via pipes.

- **permeable pavement:** A type of pavement that allows water to infiltrate the ground beneath it.

Activities

1. A lot of people use fertilizers rich in phosphorus and nitrogen to help the plants grow. Unfortunately phosphorus and nitrogen runoff can cause algae blooms in rivers and streams, causing plants and animals to die. Using what you know about green infrastructure, in a small group brainstorm several practices people can do to reduce their impact on the water quality of the North Nashua River. When you are done brainstorming, put together a quizlet that you can show your classroom about green practices.

2. At Memorial Middle School there is a parking lot that is prone to flooding. Using what you know about green infrastructure, propose how you would help alleviate stormwater runoff and drainage issues in this parking lot. Set up a diorama modeling how you plan to fix the problem.

Activities cont.

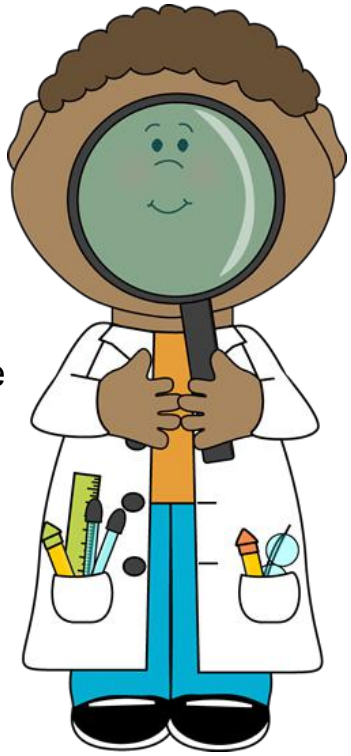
3. There are many ways in which humans can contribute to pollution of our freshwater besides through agricultural, industrial, and chemical means. Using the information you've gathered so far, construct a poster-board presentation about ways your community members, peers, and family members can reduce stormwater runoff in their daily lives. Use a combination of graphs, and diagrams to detail this information.

4. Divide up your classroom into teams of 4 and play Runoff Randy Jeopardy to see how far you've come in learning about stormwater.

Activities cont.

5. From the data we have gathered, it seems like creating a rain garden at your school would be beneficial for the surrounding ecosystem. Form a team of 4-6 students and assign yourselves to be the following: engineers, mathematicians, scientists, and community residents. Create a scientific report about why you think this would be good for your school using arguments, inferences, data, and claims from evidence. Present your findings in a poster-style presentation.

Congratulations!!!



Thank you for completing the environmental education workbook. Due to your success and hard work throughout this workbook you have just become a Rain Wrangler. What is a Rain Wrangler you ask? Well they are *community scientists*. That's right, right here in your own neighborhood you are someone who is watching out for the future of our environment. Rain Wranglers are also *community leaders*. Whenever you see someone harming the environment in anyway, go ahead and spread the message about what polluted water does to your ecosystem. Lastly, Rain Wranglers are *community healers.* How you might ask? Well, they make a conscious effort to reduce their community's impact on the environment from pollution.

In order to become a full fledged Rain Wrangler, say the pledge and cut out your badge!!

I pledge to be a community scientist

I pledge to take care of my surrounding environment.

I pledge to spread awareness among my friends and family about stormwater pollution.

References

Introduction:

Bakermans, M. “The Scientific Method.” Biodiversity. Worcester Polytechnic Institute.

Cool Water, 2011. Get Your Feet Wet. Retrieved from: http://getcoolwater.com/get-your-feet-wet

Merriam-Webster’s collegiate dictionary (10th ed.). (1999). Springfield, MA: Merriam-Webster Incorporated.

Chapter 1:

“Freshwater Quality.” EPA, Environmental Protection Agency, 14 Mar. 2017, www.epa.gov/salish-sea/freshwater-quality .

Merriam-Webster’s collegiate dictionary (10th ed.). (1999). Springfield, MA: Merriam-Webster Incorporated.

Perlman, Howard, and USGS. “Summary of the Water Cycle.” The Water Cycle Summary, USGS Water Science School, water.usgs.gov/edu/watercyclesummary.html.

“Welcome to an Engaged Community.” *Steamboat Springs, CO - Official Website - Stormwater Management*, www.steamboatsprings.net/stormwatermanagement.

Chapter 2:

"Cartoons." *Rhode Island Stormwater Solutions*, web.uri.edu/riss/stormwater-managers/educational-materials/quick-easy-materials/cartoons/.

MWRA School Program - "Dwayne the Storm Drain", www.mwra.state.ma.us/02org/html/dwayne.htm.

Perlman, Howard, and USGS. "Runoff (Surface Water Runoff)." *Runoff (Surface Water Runoff), USGS Water Science School*, water.usgs.gov/edu/runoff.html.

Chapter 3:

"Build a Rain Garden." *Lake Simcoe Region Conservation Authority*, www.lsrca.on.ca/Pages/Build-a-Rain-Garden.aspx.

Derry, Devara-Teguh. "Learn_for_Knowledge." *River Habitat (Riparian Habitat)*, 1 Jan. 1970, dedethe.blogspot.com/2011/02/river-habitat-riparian-habitat.html.

Hopkins, Kristina G., et al. "Influence of Governance Structure on Green Stormwater Infrastructure Investment." *Environmental Science and Policy*, 28 Mar. 2018, pubs.er.usgs.gov/publication/70196242.

"Massachusetts Fish and Wildlife Climate Action Tool." *The Northeast Region and the Climate Challenge*, necsc.umass.edu/projects/massachusetts-fish-and-wildlife-climate-action-tool.

"The Watershed Approach." *EPA*, Environmental Protection Agency, 2 May 2017, www.epa.gov/nps/watershed-approach.