Sewage and You: Data Analysis, Graphing, and Interpretation

Overview: What happens when you flush the toilet or when water runs down the sink drain? Does this wastewater impact our local waterways? This lesson allows students to learn the basics about sewer systems and how water quality can be impacted through data analysis.

TEACHER INFO

New York State Science Learning Standards:

Middle School

MS-ESS2: Earth's System

- Students will be able to develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

MS-ESS3: Human Impacts

- Students will be able to apply scientific principles to design a method for monitoring and minimizing the impact of human-designed sewer systems on the environment.
- Students will be able to construct an argument supported by evidence about the impact of climate change and human-designed sewer systems on Earth's systems and local water quality.

MS-ETS1: Engineering Design

- Students will be able to explain green/living infrastructure as a potential solution to combined sewer overflows by analyzing and graphing local water quality and weather data and understanding the potential impacts on people and the natural environment.

High School

HS. ESS2: Earth's Systems

- Students will be able to analyze and graph local water quality and weather data and construct an argument based on evidence that Earth's systems, specifically the water cycle, are impacted by human-designed sewer systems and climate change.
- Students will be able to make an evidence-based forecast of the impacts of climate change on their local communities and Earth's systems.

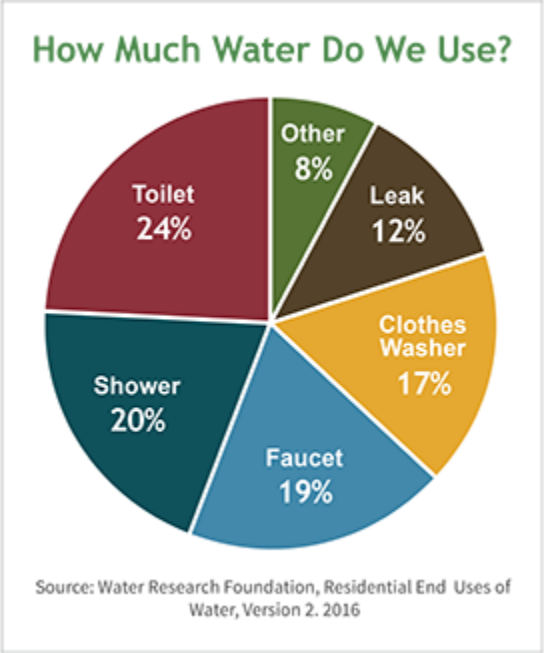
HS-ESS3: Human Sustainability

- Students will be able to construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
- Students will be able to evaluate a solution (green/living infrastructure)- to the issue of combined sewer overflows to mitigate the human impacts to Earth's natural systems.

HS-ETS1: Engineering Design

- Students will be able to develop a solution to a complex real-world problem in their local community – combined sewer overflows– through designing green infrastructure solutions to be used at their home or school.

Background information:



Less than 1% of water is available for human use. Most of the water on the earth is salt water while most of the freshwater is frozen in ice caps, not accessible.

According to the USEPA, the average American family uses more than 300 gallons of water per day at home. Much of this water ends up going down the drain (down the toilet, down the sink drain, etc) and becomes **wastewate**r. This wastewater can contain many pollutants that can negatively impact the environment and human health.

Sewer systems are a network of pipes and pumps that collect wastewater from homes, businesses, and industries. Before sewer systems wastewater was often discharged untreated into waterways resulting in many health and environmental issues including water-borne diseases. Today, sewer systems bring wastewater to wastewater treatment plants. These plants take the wastewater through many complex processes to remove large debris and fecal waste and smaller pollutants before discharging the cleaned **effluent** into a waterway.

In older cities, including Buffalo and Niagara Falls, the sewer systems were designed to collect and transport both the waste from homes and business as well as **stormwater**. These types of sewer systems are known as **combined sewer systems**. During wet weather events, like a heavy rainfall, a lot of stormwater enters the sewer system and can be too much water for the sewer system to handle. These wet weather events trigger **combined sewer overflow** (CSO) events. By design, combined sewer systems have overflows or outfall pipes. This is an opening into a local river or stream that allows waste to overflow and exit the sewer system. This design prevents waste from backing up into basements. However, these overflow events bring untreated wastewater into waterways. This increases the number of harmful bacteria in the water, often making it unsafe to swim or engage in other water recreation. In areas where there is a lot of **impermeable** surfaces, the likelihood of a CSO increases as excess stormwater enters the system from parking lots and roadways.

There are several ways to address CSO's.

- **Storage Tanks:** Underground storage tanks that capture and store excess combined sewer flow. During dry weather periods these retention basins can be pumped out and the sewer flow can be directed to the wastewater treatment plant.

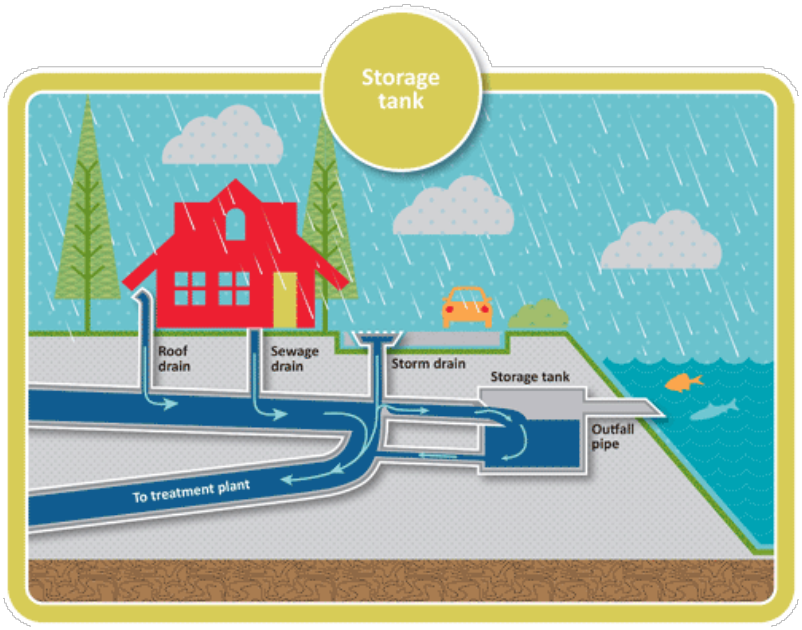


Image: www.kingcounty.gov/

*The following are **Green/Living Infrastructure** examples which uses vegetation, soils, and other elements to manage water in a way that mimics the natural water cycle. These examples keep stormwater from entering the sewer system, helping to prevent CSOs.*

- **Bioswales:** Bioswales or vegetation swales (sometimes called rain gardens) are channels or depressions in the earth that are designed to capture, and filter stormwater. These are typically vegetated to assist with water absorption. There is often a pipe allows for excess stormwater not absorbed through the system to exit, cleaner than when it entered the bioswale.

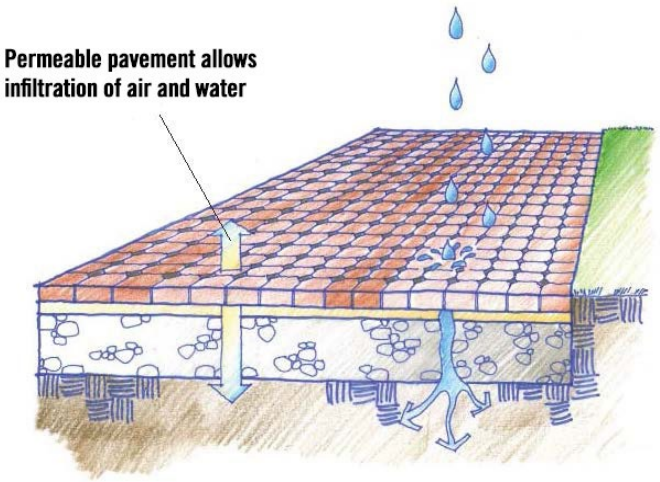
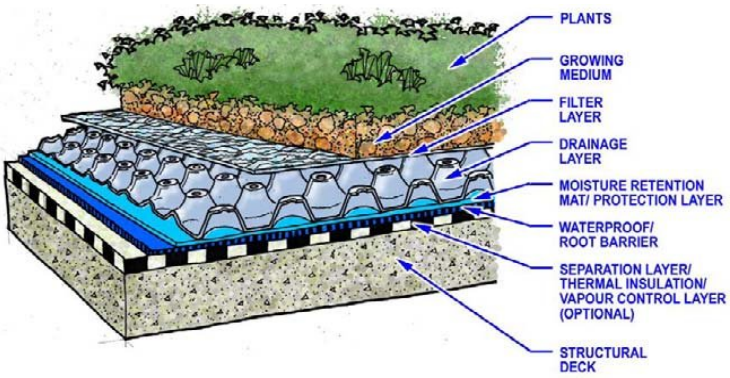


Image: www.cityofdubuque.org

- **Pervious Pavement:** pervious or permeable pavement can be used on streets, sidewalks, or parking lots. The porous design allows rainwater to soak into the earth and not runoff into a storm drain.

- **Green Roofs:** Green roofs encompass plants, layers of soil and other materials installed on top of a building. There is an important membrane and drainage layers to protect the building. Green roofs absorb rainfall and also help with air quality.

Green Roof Detail:



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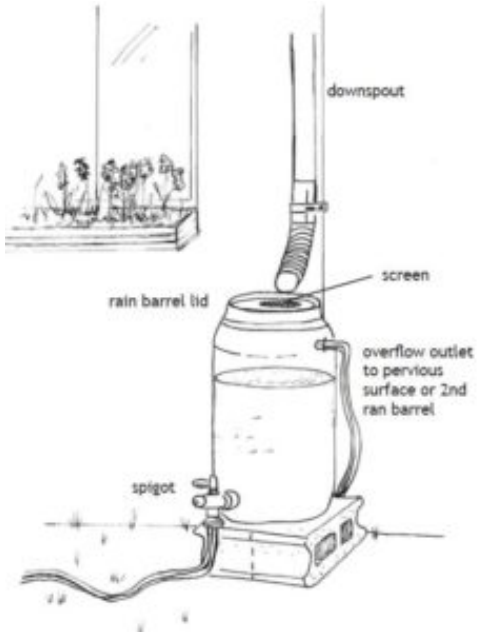
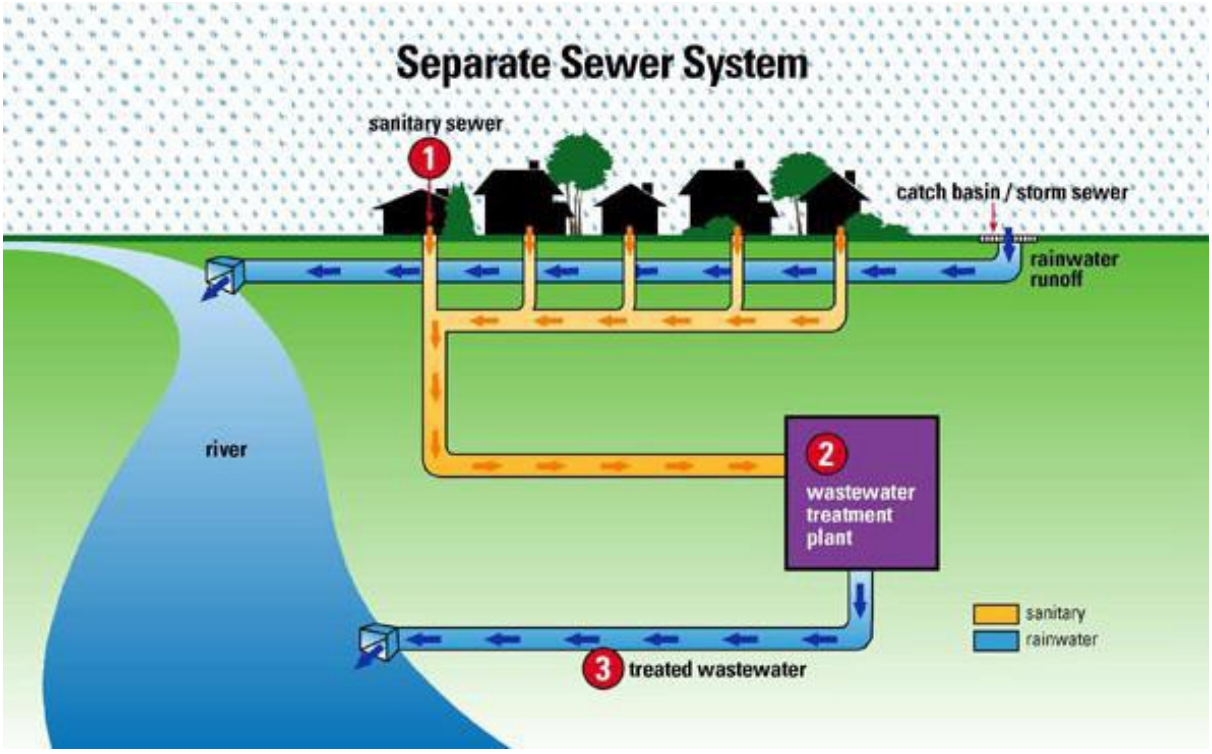
- **Rain Barrels:** Rain barrels are containers that collect and store rainwater for future uses (like watering a garden) while decreasing the amount of stormwater runoff that leaves your property. A rain barrel is placed under the downspout to channel rainwater into the barrel for later use.



A different type of sewer system is a **separate sewer system**. In this system water from homes, businesses, and industries are collected separately from stormwater. Sanitary sewer systems can also experience overflows when sewer pipes get clogged, pumping stations break down, if a sewer line is broken, of because of illegal tie=ins of home downspouts and sump pumps to the sanitary sewer. These overflows may occur at manholes on the street, pipes leaking underground, or at home (sewage backup). Sanitary sewer overflows can also result in water quality issues.



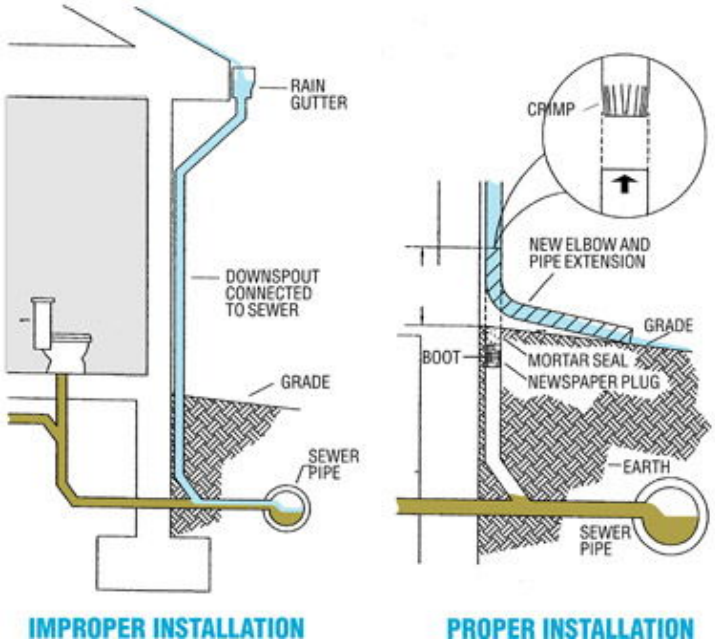
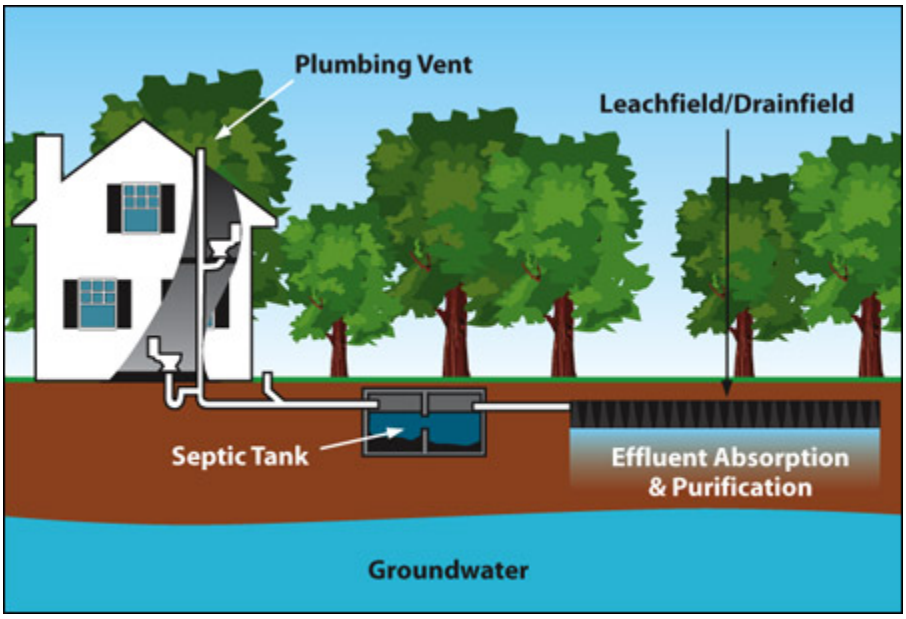


Image: www.munciesanitary.org/

If you live in a rural community your home may have a septic tank to collect wastewater. Regular maintenance is required to prevent system failures, which can negatively impact groundwater.



When untreated sewage flows into waterways during overflow events, bacteria, chemicals, and other pollutants enter the waterway.

Bacteria are single-celled organisms that occur in a variety of forms and have a wide range of properties. Some cause disease while others decompose decaying organic material and serve as food for other organisms in the food chain.

Pathogenic (disease-causing) bacteria, viruses, and protozoans are often found in fecal waste. These pathogens can cause a variety of illnesses and diseases when ingested during recreational contact or consumed in contaminated water and shellfish. Fecal waste from humans or other warm-blooded animals may enter a waterbody from various sources including:

- faulty wastewater treatment plants
- livestock, wildlife, or pets
- malfunctioning septic systems
- untreated sewage discharge
- stormwater runoff
- boat waste.

The presence of indicator species suggests the presence of fecal waste that may include pathogenic microorganisms that pose a health risk. In addition to possible health risks associated with elevated levels of fecal material, it can also cause cloudy water, nutrient enrichment, unpleasant odors, and an increased oxygen demand.

Escherichia coli (*E. coli*) is a species within the fecal coliform group that is specifically associated with the fecal waste of warm-blooded animals. Buffalo Niagara Waterkeeper collects water samples at various

sites throughout the Niagara River Watershed and tests the water for *E. coli.* Results of the water tests are presented as # of colony forming units per 100mL of water. The higher the # of colony forming units, or CFUs, the more *E. coli* in the water. When *E. coli* levels are elevated water recreation is not safe. The Environmental Protection Agency (EPA) has a Beach Action Value of 235 CFUs/100mL of water that can be used by states to make beach notification decisions (like closures).

Materials:

- Photos of combined sewage system and separate sewage system
- Photos of green/living infrastructure
- Video: https://vimeo.com/238134756

Discussion Topics:

Start by reviewing the water cycle – be sure to include the concept of runoff! Ask students what happens when water soaks into lawns or gardens. Ask students what happens when water lands on roadways or parking lots.

Watch this video with students to enforce terms like permeable/pervious and impermeable/impervious and to introduce the concept of sewer systems: https://vimeo.com/238134756

Discuss the differences between combined sewer systems and separate sewer systems. What system is in your local community? Where is the wastewater treatment facility located? Ensure students understand what causes CSOs and how they impact water quality of streams and rivers. Discuss potential solutions to combat CSOs.

Explain the activity to the students. They will graph 2 sets of data: Bacteria data collected by Buffalo Niagara Waterkeeper and weather data collected at regional weather stations. Using these graphs students will answer several questions to ensure their understanding of CSOs.

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STUDENT GUIDE

Objectives:

- Analyze and graph bacteria and weather data.
- Interpret the data to understand the impact of Combined Sewer Overflows (CSOs) on local water quality.
- Reflect on potential infrastructure improvements and consider applications for specific locations.

Materials:

- Pencil
- Graph paper (provided)

Background:

According to the USEPA, the average American family uses more than 300 gallons of water per day at home. Much of this water ends up going down the drain (down the toilet, down the sink drain, etc) and becomes **wastewate**r. This wastewater can contain many pollutants that can negatively impact the environment and human health.

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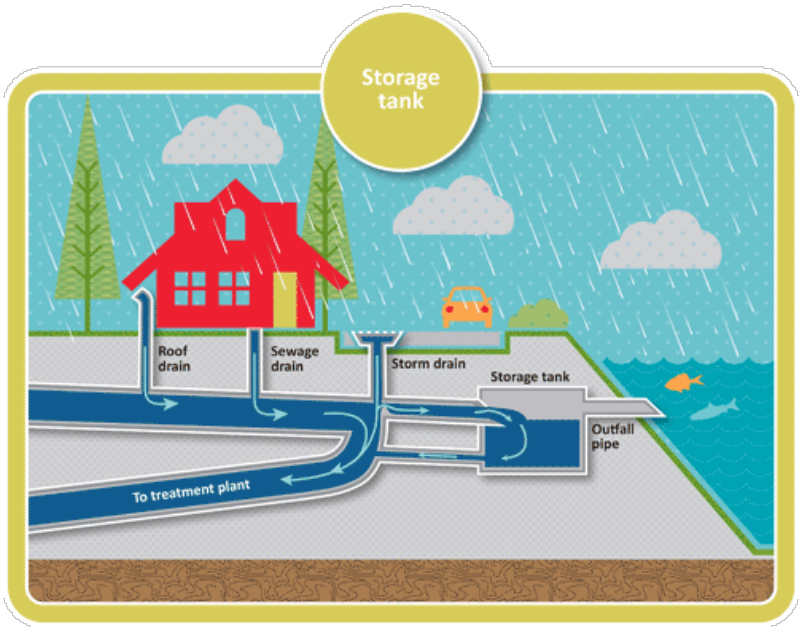

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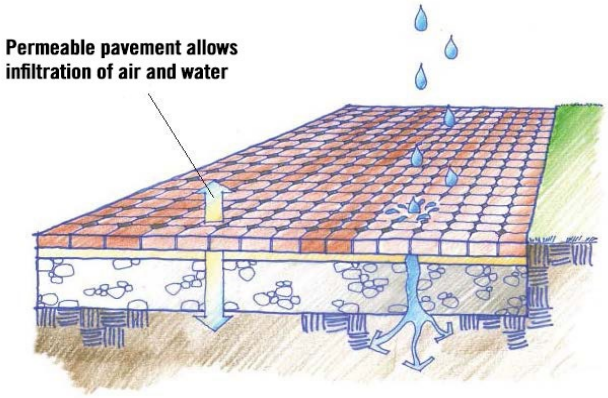

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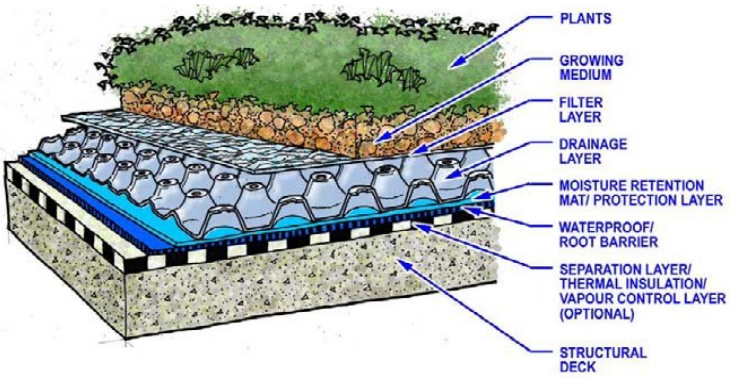

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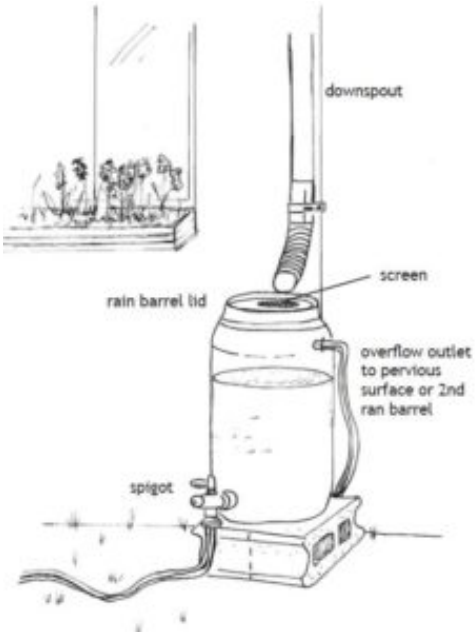

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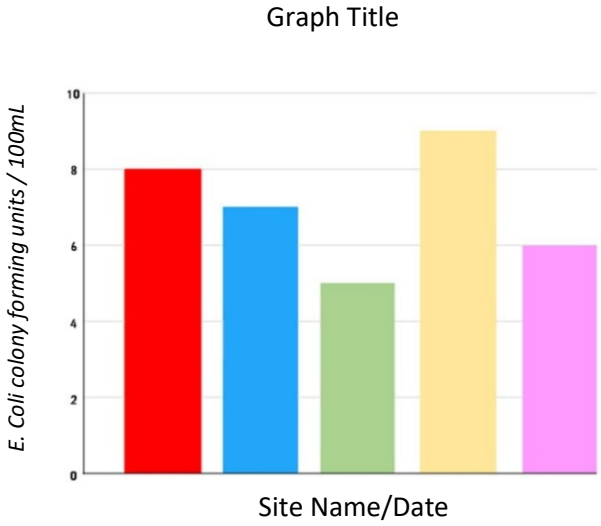
Before moving onto the activity, please watch these videos:

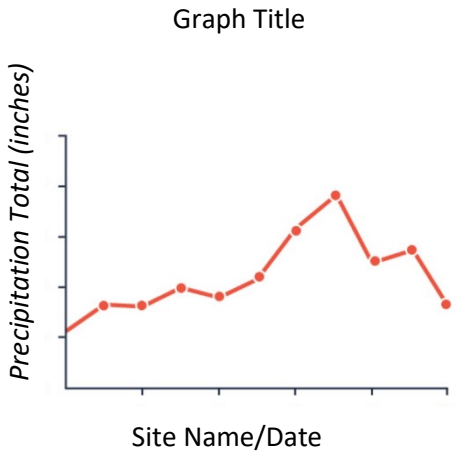
- https://vimeo.com/238134756
- https://www.youtube.com/watch?v=U6pR7wNFSe4&feature=youtu.be

Activity:

Using the following 2 data sets (Bacteria and Weather) create a graph of each, separately, on the graphing paper provided. Create a bar graph for the bacteria data and a line graph for the weather data. Be sure to label the x and y axis and create a descriptive title for each graph.

Example graphs:





Bacteria Data:

DATE	SITE	Coordinates	*E. coli* colony forming units /100mL
5/18/2020	Cazenovia Creek at Southside Parkway	42.859502, -78.822733	2900
6/9/2020	Cazenovia Creek at Southside Parkway	42.859502, -78.822733	200
6/9/2020	Hyde Park Lake	43.099997, -79.023319	200
7/17/2020	Hyde Park Lake	43.099997, -79.023319	600
9/21/2020	Buffalo River at Riverworks	42.869795, -78.871293	0
9/30/2020	Buffalo River at Riverworks	42.869795, -78.871293	2900

Weather Data:

Source: Weather Underground https://www.wunderground.com/

Date	Weather Station Location	Precipitation Total (inches)
5/18/2020	Buffalo, NY	0.56
5/18/2020	Niagara Falls, NY	0.39
6/9/2020	Buffalo, NY	0.00
6/9/2020	Niagara Falls, NY	0.00
7/17/2020	Buffalo, NY	0.89
7/17/2020	Niagara Falls, NY	0.42
9/21/2020	Buffalo, NY	0.00
9/21/2020	Niagara Falls, NY	0.00
9/30/2020	Buffalo, NY	0.80
9/30/2020	Niagara Falls, NY	0.32

Questions:

Answer the following questions based on the bacteria data, weather data, and the two graphs you created.

1) Did precipitation values impact the level of *E. coli* in the waterway? Explain how or how not.

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2) What do you believe to be the source(s) of the *E. coli* at these locations? Do you believe the sources are the same at each site or different? Why?

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3) What type of Sewer System is in your community? (combined or separate) Where is the Wastewater Treatment Plant Located? Review this list for some assistance. Look for a facility located in your town or nearby. Use the name of the facility as a clue! If you get stuck, use the internet to search for more information about your local treatment facility. https://bit.ly/3cS2SvW

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4) In a combined sewer system what is 'combined'?

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_____

5) Are you aware of any locations that experience Combined Sewer Overflows? What evidence do you have to support your answer?

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6) How does the type of land surface impact a combined sewer system? Compare highly developed land and a forest. Utilize this website to help support your answer: https://runoff.modelmywatershed.org/

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7) Do certain types of surfaces increase the chances of CSOs? If so, which ones and why?

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8) If you could choose one type of green/living infrastructure to incorporate at your home or school, which would it be and why?

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9) What would be the most effective way to make green/living infrastructure mandatory in cities?

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10) Scientists predict that climate change will cause an increase in severe weather events like hurricanes, increased precipitation in the Northern United States, and increased flooding. As the world's climate continues to change, what will be the impact on combined sewer overflows?

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11) The locations where Combined Sewer Overflows may take place are mapped and can be viewed here: https://maps.waterreporter.org/5c91b0349a8af8ba/ Do you notice any patterns or similarities in their distribution? Do you think that there are some communities that are more likely to be exposed to polluted waterways than others?

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