You're Hired!

Measuring the impact of Stormwater Best Management Practices

Overview

Students will take on the role of a Stormwater Manager to clean up urban runoff using best management practices. They will measure the reduction of water runoff and revise a plan to improve water management.

Lesson Planner

Use the table below for lesson planning purposes.

Time Required	60 Minutes	
Key Concepts/Terms	Stormwater, Best Management Practices	
Setting	Classroom	
Materials **[You will need a set of all materials listed for each group]**	● 2 Aluminum Baking pans 9x13 *See preparation ● Dixie Cup or other small cup ● Play dough or modeling clay ● Toothpicks ● Masking Tape or address labels ● Sponges (3) ● Plastic or paper cup (greater than 8 oz)	"Pollutants" ● Coffee grounds or dirt ● Koolaid ● Baking Soda ● Sprinkles ● Liquid Soap ● Small Scraps of Paper ● BMP Cards ● "You're Hired" Activity Sheet ● Towel or Paper Towels ● (2) Graduated Cylinders
Materials Alternatives: • Make your own play-dough. • Choose just one of the pollutants and use to represent all situations.		

Learning Objectives

Students will be able to…

…..describe some examples of nonpoint source pollution.

…..identify possible solutions to manage stormwater runoff.

Preparation

- Prepare the baking pans by taking one pan per group and making a hole where the bottom meets the side at one end of the pan. This will allow water to run from one pan into the second when set at a slight incline. This will be your "**Watershed**."
- Cut sponges into approximately 1"x1" squares.
- *Make building markers by folding a piece of masking tape or address label over one edge of the toothpick. You can choose to label these or allow students to label their own buildings.
- In the bottom of each paper or plastic cup, create 4-5 holes to allow for

Preparation (continued)

water to drain. These will be your "**Rainshower Cups**." Be sure to make the holes as consistent as possible to allow for even flow.
- Cut off more than half of each Dixie cup so that a small "Rain Barrel" remains.
- Use dixie cups or other container to deliver pollutants to students. Label each cup or container to represent a type of pollution. For example: Coffee = fertilizer, Soap = oil from cars, Paper Scraps = litter.

Background Information

In this lesson, students will build a community to represent the basic needs of populated areas similar to Prince George's County. Each area included represents a potential for Nonpoint Source Pollution.

Sources of Nonpoint Pollution

A landfill could pollute stormwater by leaching of waste materials and uncaptured trash. In an extreme storm scenario, overflow from a wastewater treatment plant will add unfiltered sewage directly into bodies of water. A shopping center, with its large paved areas and roof space represent an opportunity for increased speed of runoff as well as oil, trash, and other pollutants found on the grounds.

A residential area and school can create similar problems. While the yards may not be paved, the soils around new and large developments are often compacted and do not allow for maximum infiltration. Furthermore, residential areas also increase the chance of pet waste pollution, hazardous materials being dumped, and litter. Farms or agricultural lands sometimes use fertilizers or pesticides that are considered harmful to the environment in large quantities. Also, some farming practices lead to erosion of soils. It is important to note that no one location is the sole party responsible for environmental degradation. Stormwater Best Management Practices can help to mitigate or eliminate the impact of stormwater runoff.

Best Management Practices

Stormwater Best Management Practices typically serve to address one of three purposes related to stormwater:

1. *Slow the water down.* By slowing the flow of stormwater, the likelihood of erosion and flooding are reduced. Also, the water is likely to pick up fewer pollutants.
2. *Allow the water to infiltrate.* Giving water the opportunity to seep back into the groundwater source helps to recharge aquifers and clean the water.
3. *Clean the water.* Stormwater carries pollutants directly into the waterways from which we access our drinking and everyday use water.

NGSS Standard Correlation

MS-ESS3-4	**HS-ESS2-5**
MS-ETS1-1	**HS-ESS3-4**
MS-ETS1-2	**HS-ETS1-2**
MS-ETS1-3	**HS-ETS1-3**
MS-ETS1-4	

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Procedure

Follow the steps in the table below to conduct the activity. **Sentences in bold are suggestions of what a teacher might say to students.** *Items in italics are possible student responses.*

Phase	Step	Action
Engage	1	Hire students to become community planners. They will be given time to create a community in their "Watershed." All communities must include these locations: a school, a wastewater treatment facility, a landfill, a farm, a residential area, and shopping center.
	2	Each location should be created using a small amount of play-dough to support a toothpick/masking tape marker for the necessary community components. They will build this "community" into the tray with a hole. Students should set this community tray into the second tray, with one side propped up so that the end with a hole is at the bottom of a slope. **"What do you think the second tray might represent when we add water to our watershed?"** *This second tray represents the creeks, streams, lakes, rivers, bays, and oceans that catch the runoff from communities.*
	3	Have students make an observation about the surface of their tray and predict what will happen if it rains on their community. **Where will the water flow?** *Downhill.* **What type of land cover does the surface of the paint tray represent?** *Impervious surface, cement, compacted soil.* **How much water will evapotranspire, runoff, or infiltrate?** *None will infiltrate. All will runoff.* **What does the bottom tray (or bottom of paint tray) represent?** *Rivers, lakes, bays, oceans, other bodies of water where runoff collects.* Have students measure one cup (237ml) of water with a graduated cylinder. Direct them to use their hold their "rainshower" cup above their community and pour the water into their rainshower cup. They should move the cup around to have the storm hit all parts of the community. After their cups are empty, have students remove their community (top) tray and measure the amount of rainfall that "ran off" into the second tray. **How is this surface different from a natural area?** *Humans have disrupted the natural water cycle by reducing impermeability by introducing hard surfaces that are not penetrated by water, impervious surfaces. The natural water cycle has also been disrupted by reducing infiltration by removing native vegetation and trees that would have taken in some of that water.* **Record this amount on your activity sheet as the "Run Off" for the baseline.** The students should find that the amount of runoff remained the same because the entire surface is impervious. **Answer the question, "Where did your water go?" Does this watershed model directly reflect our community?** *No, our community is not entirely impervious.*

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Procedure continued

Phase	Step	Action
Explore/Explain	4	Hand out the Best Management Practices cards to students. In a group, student must choose up to 4 of the BMP's and follow the directions on the card. Make sure they reference the back of the card for real-world application costs and considerations. There is also a card that provides them with more information about how to use the best management cards. **Record the BMPs you selected and where you placed them on your activity sheet.**
	5	Repeat the procedure of pouring one cup of water into the "rainshower cup" over top of the watershed. **After pouring your water, squeeze out all sponges and empty rain barrels into one graduated cylinder. Record this as your amount "Captured" for Trial 1. Carefully, remove your community tray and pour the water runoff into the second graduated cylinder. Record this as your water "Runoff."** In the table, students should record the best management practices used, where they applied them, and how much water ran off. *You may want to talk with students about the way some BMPs only capture the water (rain barrel) while others help it to infiltrate (gardens).*
	6	After clearing all water from the watershed, have the students choose an entirely different arrangement of BMPs or swap out some of the BMPs from the first round and attempt the experiment a second time. Again, students should record the best management practices used, where they applied them, and how much water ran off and was captured. **Record these results as Trial 2.**
Elaborate	7	As a class, have each group share which trial was most effective in capturing runoff in their watershed and identify which best practices were utilized. If possible, make a list on the board to show the amount of runoff and BMPs from each group. Then, encourage students to make observations about any trends they see. **Does it seem like any one BMP was used more than others? What BMPs do you think would be most effective in real-world scenarios? Are any BMPs less effective? Why was there no sponge associated with the Community Cleanup or Trash Trap cards? Do you think that these BMPs have value?**

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Procedure continued

Phase	Step	Action
Elaborate	8	So far, you have looked at how BMPs can slow water down or help it to infiltrate. Ask students to think about ways that their community could become polluted. **Consider each part of your community and imagine sources of pollution.** Hand out the pollutant materials. These should already be labeled. Have students apply the following pollutants to their community, being sure to identify the pollutant by what it represents ○ Coffee grounds or dirt at the farm *(loose soil and/or fertilizer)* ○ Koolaid at the residential area and shopping center *(oil and other things leaked from cars and dumped out from households)* ○ Baking Soda at the wastewater treatment facility *(sewage overflow)* ○ Sprinkles or scraps of paper at the school and landfill *(micro trash/litter)* ○ Liquid soap (*Oil from cars, households, and more)*
	9	Have students measure one cup of water and use the rainshower cup to simulate a storm event over their watershed. Ask them to describe what happened to the water and its appearance. **"Even though the water has left the community and gone to the basin, this is water that will eventually be used for drinking and daily use. It will need to be cleaned at a water treatment facility, which can be costly to the taxpayers in this community. Did any areas become polluted by a pollutant from another source? When the pollutants reached the water, is there any way to "point" at where the dirty water came from? Are the separate pollutants still identifiable in the water? This is nonpoint source pollution." Which BMPs would be effective at helping to clean the water?**
Evaluate	10	Guide students to complete the "BMPs on a Budget" section and ask them to describe how they would use that budget to reduce stormwater runoff on their campus. If you would like to provide students with a map of the campus, they may also draw the location of the chosen BMP's on the map to indicate location.
Extensions	11	http://www.cacaponinstitute.org/CILearning/SC/SC.html In this simulation, students apply best management practices to an agricultural area to mitigate the impact of stormwater runoff. http://wikiwatershed.org/ At Wiki Watershed, students have access to a variety of tools to model watersheds, monitor water quality, and some DIY activities. http://app.wikiwatershed.org/ Students can map their own watershed and run various scenarios. https://micro.app.wikiwatershed.org/ Students can use this activity to investigate the infiltration rate of various soil hydrologies and storm events.

Name _____ Date _____

"You're Hired"

Stormwater Best Management Practices

"Congratulations! You are the new manager(s) of the community you designed."
What is the name of your new community?

_____

Design your community using the play dough and flags. Your community must include:

- ▢ a school
- ▢ a wastewater treatment facility
- ▢ a landfill
- ▢ a farm
- ▢ a shopping center
- ▢ a residential area

Directions for modeling a storm event:

1. Measure one cup (237mL) water in a beaker or other measuring tool. Making sure that you are working over the surface of your community only, pour water into your Rainshower Cup to model a storm event across the whole community.
2. Carefully remove your community to a towel after allowing all water to drain from the community into the **basin**.
3. Empty the water from all of your Best Management Practices into one graduated cylinder. Record that number as the amount of water **captured.**
4. Measure the water that has **run off** into your **basin** in a second graduated cylinder. Record that number in the table as the amount of water **runoff**.

	Stormwater Best Management Practices	Site	Water Runoff	Water Captured
Baseline				
Trial 1	1._____ 2._____ 3._____ 4._____	1. _____ 2. _____ 3. _____ 4. _____		
Trial 2	1._____ 2._____ 3._____ 4._____	1. _____ 2. _____ 3. _____ 4. _____		

Draw Conclusions

Where did your water go after a storm event?

What are some possible sources of **nonpoint source pollution** in your community?

Best Management Practices... on a Budget

You have $200 to implement Stormwater Best Management Practices in the community you created. Below are some hypothetical costs of BMP's. What would you do to reduce runoff of pollution and erosion in your community? Why did you choose those BMPs?

Rain barrel	$ 50.00	Pervious Pavement	$200.00
Rain Garden	$150.00	Riparian Buffer	$100.00
Filter Strip	$ 50.00	Green Roof	$100.00
Wetland	$200.00	Community Action	Free

Best Management Practices (BMP) Cards

Directions: Print out cards (two-sided) and cut one set for each group.

Green Roof

A green roof makes use of an impervious surface as a base for vegetation. The vegetation can then work to absorb stormwater, reducing the rate and amount of runoff from a building during a rainfall event. If constructed properly, a green roof can also improve the quality of runoff water. However, it may take five or more years to reach an efficient level of pollutant removal.

Directions: Place one sponge near your wastewater treatment facility, school, residential area, or shopping center.

Rain Barrels and Cisterns

These tools are often used to capture rainwater runoff from the roof of a building. The water can be held for a period of time and then reused to water gardens during a dry period or for other purposes. However, once a barrel or cistern is full, water will continue to runoff as before.

Directions: Place a Dixie cup next to a place in your watershed.

Rain Gardens

Rain gardens, also called Bioretention, usually consist of a small depression to collect water and improve water quality. These areas are vegetated with specially selected native plants that are native to the area and can adapt to varying conditions from dry to flooded. Soil that is too compacted will need to be amended before planting a rain garden in order to improve infiltration.

Directions: Add two sponges anywhere in your watershed.

Pervious Pavement

Pervious pavement exists in many forms but is mostly used to address the rate of flow during a rain event. To be considered pervious, the surface must allow water to percolate through the top layer. In some forms, this allows water to infiltrate to groundwater systems. A general outcome is that runoff is slowed and possibly minimized.

Directions: Add two sponges to your residential, school, or shopping area to represent a pervious parking lot.

Best Management Practices (BMP) Cards

Directions: Print out cards (two-sided) and cut one set for each group.

Rain Barrels and Cisterns

Cost

- Rain barrels range from $80 - $200.
- Cisterns vary depending on material. They can range from $88 for 64-gallon capacity to $10,516 for 12,000-gallon capacity.

Construction and Maintenance Considerations:

- Developing a use schedule would be helpful to ensure the most runoff capture.
- Cisterns may require flushing to remove sediment.
- During the winter, water will need to be drained to avoid freezing.

Effectiveness:

Volume Reduction:	Med/High
Recharge:	Low
Peak Rate Control:	Low
Water Quality:	Medium

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Green Roof

Cost

- Cost will be impacted by height of the building, accessibility to the structure by large equipment such as cranes, and size of the project. A typical range is $8-$15 per square foot with additional cost for maintenance.

Construction and Maintenance Considerations:

- Green roofs require waterproofing and the ability to bear a lot of weight and must be accessible in order to maintain.
- A roof with too much slant will need additional measures to prevent sliding of materials.
- Plant selection must include plants that are drought-tolerant.

Effectiveness:

Volume Reduction:	Med/High
Recharge:	None
Peak Rate Control:	Low
Water Quality:	Medium

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Pervious Pavement

Cost

- The cost of pervious pavement includes the top layer, as well as the underlying stone bed and stormwater management system. On average, this pavement will cost $2,000-$2,500 per parking space.

Construction and Maintenance Considerations:

- Construction of pervious pavement is fairly susceptible to failure due to compaction of soil and other problems with the under layers.
- The pavement must be maintained to prevent clogging from fine sediments and should be vacuumed with a special cleaning unit.
- When properly installed and maintained, pervious pavement can have a life span of more than 20 years.

Effectiveness:

Volume Reduction:	Medium
Recharge:	Medium
Peak Rate Control:	Medium
Water Quality:	Medium

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Rain Gardens

Cost

- Rain gardens cost approximately $5 to $7 per cubic foot to construct.
- Costs will vary depending on source of vegetation used in garden.

Construction and Maintenance Considerations:

- Native vegetation will that can tolerate conditions from drought to flood will have the most success.
- Soil will likely need to be modified.
- Requires maintenance to ensure long-term functioning

Effectiveness:

Volume Reduction:	Medium
Recharge:	Med/High
Peak Rate Control:	Low/Med
Water Quality:	Med/High

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Best Management Practices (BMP) Cards

Directions: Print out cards (two-sided) and cut one set for each group.

Filter Strip

Filter strips are areas used to slow down the flow of water impervious surfaces. These strips can also act as a cleaning device as the water runs through the vegetation and even infiltrates the ground. They provide a simple solution but may not be able to manage extreme storm events and are highly dependent on having low soil compaction.

Directions: Place one sponge in your watershed.

Wetland

Installing a wetland is a very big and expensive undertaking but is also a very effective stormwater management practice. A wetland ecosystem is nature's way of storing and filtering large quantities of water. The areas are a combination of hydric soils and vegetation, meaning they are capable of withstanding permanent or seasonal saturation. This ecosystem is very much like a sponge.

Directions: Place a group of three sponges anywhere in your watershed.

Bioswales

A bioswale is very similar to a rain garden. However, they are frequently designed to capture and filter larger volumes of water. To do so requires more deliberate engineering of soils and layers. The plants in a bioswale will be able to withstand different levels of water once established. These areas are usually located near impervious surfaces.

Directions: Add a row of three sponges anywhere on your watershed.

Riparian Buffer

A riparian buffer can be developed along the edge of an area of great runoff or along the edge of a water source such as a stream or a river. The placement of a forested area acts as a buffer, filtering runoff on the land before it reaches the water. This can reduce pollution of the water and reduce erosion as well by slowing down the runoff.

Directions: Place a row of three sponges along the lowest point of your watershed.

Best Management Practices (BMP) Cards

Directions: Print out cards (two-sided) and cut one set for each group.

Wetland

Cost

- Costs for construction range from $30,000 to $60,000 per acre.
- There may also be associated maintenance costs.

Construction and Maintenance Considerations:

- Wetlands require engineering by professionals.
- The vegetation chosen should tolerate drought and flood conditions. However, the wetland should still be able to maintain a relatively stable water level to reduce stress on the plants.
- These areas should be sized relative to the area of land draining through this wetland.

Effectiveness:

Volume Reduction:	Low
Recharge:	Low
Peak Rate Control:	High
Water Quality:	High

Filter Strip

Cost

- The cost of seed or sod can total between $13,000 and $30,000 for an acre of filter strip if the area has previously been impervious.

Construction and Maintenance Considerations:

- Filter strip must be inspected for buildup of trash, overgrown vegetation, and standing water.
- These areas usually need to be mowed.
- The filter strip will be more effective if designed at a slight slope and at least 25 feet long to provide water quality treatment.

Effectiveness:

Volume Reduction:	Low/Med
Recharge:	Low/Med
Peak Rate Control:	Low
Water Quality:	Low/Med

Riparian Buffer

Cost

- One cost estimate for installation of a riparian buffer averages $3,000 per acre.

Construction and Maintenance Considerations:

- Riparian buffers are most effective when located adjacent to a water feature.
- These areas can be difficult to establish when faced with threats such as deer browsing, invasive species, and human disturbance.
- A buffer will take many years to become established and mature.

Effectiveness:

Volume Reduction:	Medium
Recharge:	Medium
Peak Rate Control:	Low/Med
Water Quality:	Med/High

Bioswales

Cost

- Cost is dependent upon size, design, materials cost, and more.
- Averages can range from $8.50 to $50.00 per linear foot.

Construction and Maintenance Considerations:

- Vegetation should be water-resistant and drought and salt tolerant for maximum filtering effectiveness.
- The designed area should be able to withstand excessive rain events.
- Relatively low maintenance requirements once established.

Effectiveness:

Volume Reduction:	Low/Med
Recharge:	Low/Med
Peak Rate Control:	Med/High
Water Quality:	Med/High

Best Management Practices (BMP) Cards

Directions: Print out cards (two-sided) and cut one set for each group.

Community Action

Organizing a community cleanup is a great way to stop litter from being carried off to a body of water and becoming marine debris. People come together to clean the place where they live. While this does not reduce runoff or erosion, it helps to keep our water clean and free of debris. A cleanup event can also raise awareness of stormwater issues.

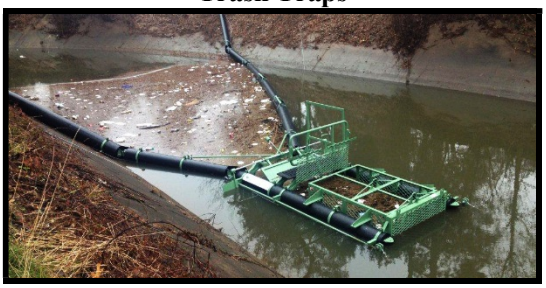
Directions: This card has no impact on your community watershed model.

Urban Tree Canopy

Planting trees in an urban landscape can contribute to a reduction of stormwater runoff and pollutants in the waterways. The tree canopy acts as a buffer, storing rain. The roots support infiltration by creating soil that is less compacted. These trees also act as filters for any water they use and reduce the rate of runoff.

Directions: Add <u>one sponge</u> to your watershed.

Trash Traps



Trash traps do not slow down water or help it to infiltrate. However, they are fairly effective at removing marine debris from rivers and other flowing water as it heads downstream. The litter trap pictured above is just one example. Any trash trap requires the commitment of an organization to continuously remove captured litter. Trash traps can be purchased fully built, but there are also do-it-yourself options.

Directions: Add <u>one sponge</u> to your watershed. *Remember that a Trash Trap does <u>not</u> actually capture or slow down rain water.*

About Best Management Practice (BMP) Cards

Cost refers to construction and/or installation of best management practices. This does not include the added value of having these BMPs in place and the reduced costs of cleaning and managing polluted water.

Construction and maintenance must be taken into consideration when selecting an appropriate best management practice.

Effectiveness of a BMP is determined on different levels use a scale of None (no impact), Low, Medium, and High with High being the most effective.

Volume Reduction: The BMP's ability to reduce the amount of stormwater runoff
Recharge: The BMP's ability to support infiltration of stormwater runoff
Peak Rate Control: The BMP's ability to slow down stormwater runoff
Water Quality: The BMP's ability to remove pollutants from stormwater

Best Management Practices (BMP) Cards

Directions: Print out cards (two-sided) and cut one set for each group.

Urban Tree Canopy

Cost

- Trees can range from $75 to $200.
- If not designed or maintained properly, costs can be lost very easily.

Construction and Maintenance Considerations:

- City or municipal code must be understood before installing trees.
- Trees will require upkeep until established.
- Larger trees require larger volumes of soil. A tree's mature size must be taken into consideration.
- An understanding of tree planting must be established before implementing the project.

Effectiveness:

Volume Reduction:	Medium
Recharge:	Low
Peak Rate Control:	Low
Water Quality:	Medium

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Community Action

Cost

- The only materials you will need for a community cleanup will be trash bags and gloves for participants.

Construction and Maintenance Considerations:

- Determine who will dispose of the collected trash and where it will be taken.
- Plan to sort out recyclables from trash collected to limit impact on landfills.

Effectiveness:

Volume Reduction:	None
Recharge:	None
Peak Rate Control:	None
Water Quality:	Low

C

On the back of each card you will find one or more of the following to indicate the main purpose of each Best Management Practice (BMP). Note that a BMP may serve multiple purposes.

C — This BMP cleans stormwater.

S — This BMP slows stormwater down.

I — This BMP helps stormwater to infiltrate.

Resources:

- http://www.elibrary.dep.state.pa.us/dsweb/Get/Document48477/07_Chapter_6.pdf
- https://doee.dc.gov/service/bandalong-litter-trap
- https://www.epa.gov/sites/production/files/2015-11/documents/stormwater2streettrees.pdf
- http://www.cbtrust.org/atf/cf/%7BEB2A714E-8219-45E8-8C3D-50EBE1847CB8%7D/Urban%20Tree%20Canopy_Fact%20Sheet%20and%20Guidelines.pdf
- http://www.princegeorgescountymd.gov/DocumentCenter/Home/View/4788
- http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Filtering%20Practice/Grassed%20Filter%20Strip.htm

Trash Traps

Cost

- Do-it-yourself options can cost be done for about $5,000 plus the cost of labor.
- A pre-built trash trap can cost $55,000.

Construction and Maintenance Considerations:

- When installing a trash trap, care must be taken to not disturb habitat and/or ecosystems.
- Maintenance is key to the success of a trash trap. A plan must be laid out to determine who will clean out the trap and with what frequency.

Effectiveness:

Volume Reduction:	None
Recharge:	None
Peak Rate Control:	None
Water Quality:	Medium

C